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CORN-IT: A KNOWLEDGE-BASED SYSTEM FOR CORN GROWERS

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Abstract

Agriculture assumes a significant function in improving one's economy. It is an essential spring of living for some individuals around the globe. In the Philippines, corn next to rice is the staple agricultural product. Using different strategies and methods of planting corn, farmers in the corn industry will generally expand their profitability and cause corn growers to produce a high range and quality of corn products. With the introduction of new agriculture advancements, corn growers are coping-up with these developments from manual to automated systems and equipment farming. This study intended to design, develop, and evaluate a knowledge-based mobile system for upgrading corn yield productivity for the corn growers of Ilocos Sur, Philippines. The developed knowledge-based system is a mobile application name "con-IT," which helps corn growers in their farming activities, explicitly selecting corn variety, identifying and managing pests, weeds, and diseases, and journal during corn planting season. The developed system's assessment on the extent of compliance to ISO 25010: Software Quality Standards was assessed with "Very Great Extent" with the mean rating of 4.41. Rapid Application Development (RAD) was the methodology adopted by the researchers. Data collection also included interviews and Focus Group Discussion (FGD).

Keywords: high yield, corn, information technology, mobile application

Introduction

Agriculture plays a crucial role in the global economy. It serves as the backbone of every economic system that provides food, raw materials, job opportunities, the critical source of life, and provides humanity's basic needs and the raw materials required for industrial development. In the Philippines, corn is the second most important cereal crop after rice, both as a source of livelihood and as a staple food for human consumption. Presently, the greater demand for corn poses a challenging task for corn growers to increase the yield of their crop. To realize the corn crop's maximum productive potential, corn growers need to follow the corn crop's growing practices during the planting season, from land preparation to harvesting [1].

With all the issues of corn growers, the strategic direction for agriculture set by [2] towards globalization and the Philippine Agriculture (PA) 2020 vision for poverty reduction and the achievement of food security, global prosperity, sustainability, justice, and peace in the field of agriculture served as a guide in the development of a mobile application for corn growers called "corn-IT." The development of corn-IT mobile application then hopes to provide the information needed by corn growers to help them become productive in their farming activities, and also serve as their guide in solving different problems encountered in planting corn.

Poor quality corn varieties and low marketing and logistic networks are one of the major problems faced by corn growers [3]. Choosing the best corn variety will enable corn growers to harvest higher yields. Pests such as

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bacterial wilt, corn smut, corn leaf blight, earworm, corn borer, sap beetles, aphids, corn maggot, and many others can also affect the growth of corn. The presence of weeds at an early age can hinder the root development of corn and absorb the nutrients assigned to it. In the study conducted by [4] he believed that worms living inside the corn stalk could negatively affect corn development and growth.

On the other hand, proper nutrition is essential for the overall growth and development of any plant. For a good crop full of nutrients, farmers need to work with healthy soil because soil nutrients deficiency leads to low agricultural productivity affecting food supply to feed the worlds' population. The high yield, applying the right types and quantity of fertilizers to supply the right nutrients is necessary. The benefits of fertilizers could improve plant growth, maturity acceleration, and increase resistance to any corn disease will ensure that the plant grows smoothly [5-7].

Despite of the numerous technical approaches and assistance from national and local governments to increase corn production, corn production is still far from being self-sufficient. Corn growers have many issues with corn production such as to what kind of fertilizer their crops need, what particular pesticides they need to spray when insects and diseases strike, what is the best way to eradicate and control weeds, and monitoring of their corn planting activities.

In today's society, information technology plays a significant role in various sectors to modernizes world and become tools for efficiency and productivity. An expert system is considered an essential tool for solving agriculture problems with all the corn production challenges wherein it attempts to replicate one or more human experts' output. The developed mobile application on the study has a support feature that helps the corn growers identify and control pests, diseases and weeds. It could also provide assistance to corn growers on which fertilizers could be best apply to particular corn varieties based on the experts' inputs and enables corn growers to enter all their farming activities to easily monitor and manage their farm better.

A. Conceptual Framework

The researchers adopted the Rule-Based Classifier model as the system's algorithm. The model has a knowledge based that contains rules about the subject at the hand. The algorithm provides mechanics that generate rules by concentrating on a specific class at a time and maximizing the probability of the desired classification.

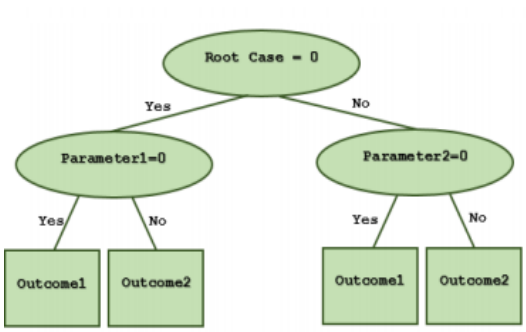

Fig. 1: The Rule-Based Classifier Model

The rule-based classifier model was used as basis in the development of the decision support feature of the developed system. The decision support feature includes the alternative solutions offered to the user of the developed system on what pesticides, herbicides, and fertilizers would be best for the corn plant given certain conditions or parameters.

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B. Objectives of the Study

The purpose of this study is to design, develop, and evaluate a knowledge-based system (a mobile application for corn growers) for optimizing the productivity of corn yield in Ilocos Sur. Specifically, the study sought to address: 1) the challenges and needs of corn growers; 2) to develop a system that can address the problems and needs encountered by corn growers; and 3) to evaluate the extent of compliance of the developed mobile application on ISO 25010 Software Quality Standards in terms of functional sustainability, performance efficiency, compatability, usability, reliability, security, maintainability, and portability. The researchers adopted the Rule-Based Classifier Model as the study framework and the Input-Process-Output (IPO) model to reflect the study paradigm.

The developed knowledge-based system mobile application is called "corn-IT" which means the it is the integration of Information Technology in planting corn. The developed mobile application allows corn growers to provide the information they might need to help them become effective in their farming activities. It will also serve as a guide for the solution of various problems encountered in planting corn wherein it has a support feature that identifies and manage pests, diseases, and weeds.

METHODOLOGY

The researchers used a descriptive and developmental approach based on the methods used by [8]. Descriptive research was used to gather information on farmer-participants' needs and problems, which later served as the basis for system design and development. However, development research has been used to develop and install new processes, systems, and facilities or resolve the farmer-participants' established needs and problems. This approach is used in the development of the mobile application "corn-IT." The researchers adopted the Rapid Application Development (RAD) methodology, which was the most suitable for mobile system development because it accelerated the mobile system's development and ensured the optimum output.

C. Software Methodology.

The RAD methodology is divided into four phases: requirements planning, user design, construction, and cut-over/implementation.

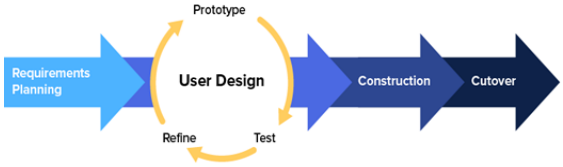

Fig. 2: Rapid Application Development Methodology

At the **requirements planning** stage, the system's complexity and other specifications of the developed system were identified through interviews with agriculturists and Focus Group Discussion with corn growers to gather the data needed to identify the various procedures and problems of the proposed system. The second stage is the **user design,** in which the data and procedures of the system have been modelled and developed on the system's prototypes. The developed system modelled using different diagrams to present the system's activities, such as system architecture, case diagrams, activity diagrams, data flow diagrams, the design of databases, and the flow of processes involved. The third stage is the **construction** planned to complete the developed system's comprehensive design and build and test the software that implements the developed system. In this step, the researchers wrote the system codes in collaboration with end-users. System testing and input integration were performed in building the entire system. Lastly, the **cut-over** process involves final user testing and training, data transfer, and application system implementation.

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D. Research Locale and Participants of the Study

The sample respondents to the developed system consisted of three categories, with a total of one hundred and forty-five (145) participants were chosen using Purposive Sampling. One hundred twenty (120) corn growers came from selected municipalities. The top 12 corn landowners and tenants of the developed system were chosen as the most appropriate participants. Fifteen (15) agriculturists have acted as system evaluators. They assessed the functionality and functionalities of the proposed system using the ISO 25010. This group of participants included corn growers from Department of Agriculture Office (DA) or Municipal Agriculture Office (MAO) of selected municipalities. Ten (10) Information technology (IT) experts have also acted as system evaluators. The expert participants were IT instructors, IT billing analysts, and computer technicians.

E. Data Gathering Procedures

To obtain full details and a detailed understanding of the corn production processes at the DA, MAO, and corn growers' activities, the researchers used the questionnaire, the interview guide, and the compilation of secondary data and forms. Among the issues to be discussed were the problems faced by corn growers in planting corn, improving the quality of corn yield. The ISO/IEC 25010 instrument was used to evaluate the effectiveness of the proposed knowledge-based mobile application.

F. Data Analysis

The data collected were tabulated, evaluated, interpreted, and summarized using descriptive statistics, such as frequency counts, percentages, and weighted mean used in the study. The weighted mean was used to assess the extnt of compliance of the developed system.

TABLE 1

SCALE FOR DETERMINING THE SYSTEM'S EXTENT OF COMPLIANCE WITH ISO 25010 SOFTWARE QUALITY STANDARDS

Mean Range	Descriptive Interpretation
4.20 - 5.0	Very Great Extent
3.40 - 4.19	High Extent
2.60 - 3.39	Moderate Extent
1.80 - 2.59	Little Extent
1.0 - 1.79	Very Little Extent

Table 1 displays the Likert Scale of interpretation used to determine the level of compliance of the developed system with ISO 25010 evaluation, which is interpreted to a very great, compliant to a great extent, compliant to a moderate extent, compliant to a little extent, and complaint to a very little extent.

RESULT AND DISCUSSION

Based on the data obtained, the following are the significant findings of the study:

G. Corn Growers' Challenges and Needs.

Pests and diseases attack the corn which lessen farmers' yields. There is a need for the farmers to determine the pests that attacked their corn and the best practices to control these pests. The presence of weeds on the corn crop is inevitable. The farmers need to identify the types of weed and which procedure is best to control them.

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Some farmers lack technical knowledge on corn production. Sufficient information on how corn, fertilizers, pests, weeds, pesticides, and herbicides can be used in corn production is needed. Some farmers are uncertain whether their farm activities would generate income or loss. Lastly, there is high agricultural inputs for seedlings, fertilizers, pesticides, herbicides, labor cost, machinery, and other inputs.

H. The Developed System

The corn-IT mobile application serves as accessible guide for corn growers which provides documented knowledge on their corn-production activities and concerns. It has a feature for pest identification and suggestions on how to control the pest, including the pesticides recommended to be used. It includes weeds identification, provides information on how to control the weeds, and suggests possible herbicides to be applied. It has a knowledge-based feature that supplies information on corn, fertilizer, disease, weed, pesticides, and herbicides and provides knowledge on how to manage corn crop. The farmers using the developed system can add farming journal to record and keep track of their day-to-activities. Finally, the developed system has a 24/7 mechanism to aid the needs of corn growers and no need for agriculturists to physically monitor their daily corn farming.

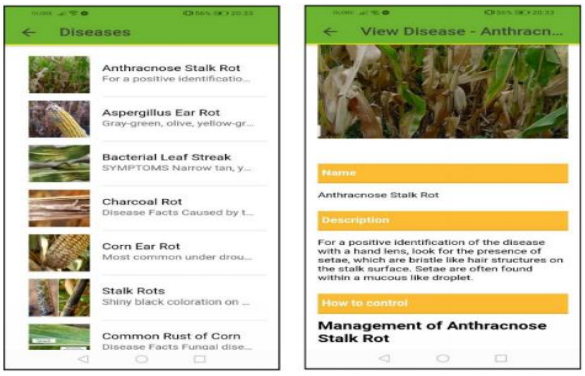

Fig. 3: The Developed System on Disease Identification

Fig. 4: The Developed System on Pests and Weeds Knowledge

I. Extent of Compliance of the Developed System

The developed system was evaluated using different attributes using the tool ISO 25010 evaluation in terms of functional sustainability, performance efficiency, compatability, usability, reliability, security, maintainability, and portability which were all assessed as compliant with ISO required standards to a "Very Great Extent."

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TABLE 2

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERM of FUNCTIONAL SUSTAINABILITY

Criteria	**Weighted Mean**	**DI**
1. Functional Completeness. The system covers all the specified tasks and user objectives.	4.28	Very Great Extent
2. Functional Correctness. The system provides the correct results with the needed degree of precision.	4.36	Very Great Extent
3. Functional Appropriateness. The system facilitates the accomplishment of specified tasks and objectives.	4.35	Very Great Extent
Category Mean	4.33	Very Great Extent

Table 2 shows that the IT experts' average estimate on the developed system's functional sustainability varies from 4.28 to 4.36. among the three indicators under those criteria, the participants' highest-rated is 4.28; both were compatible with "Very Great Extent." The system's functional completeness with a mean of 4.33, defined as "Very Great Extent." It ensures that the developed system protects all specified tasks and user goals. It also provides the correct result with the required degree of precision and helps accomplish specified tasks and objectives. This finding is confirmed by [9] which highlighted the method's completeness, correctness, and appropriateness.

TABLE 3

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of PERFORMANCE EFFICIENCY

Criteria	**Weighted Mean**	**DI**
1. Time Behavior. The system's response and processing time and throughput rates when performing its functions meet requirements.	4.42	Very Great Extent
2. Resource Utilization. The system's amounts and types of resources used when performing its functions meet requirements.	4.44	Very Great Extent
3. Capacity. The system's maximum limits parameter meets requirements.	4.36	Very Great Extent
Category Mean	4.39	Very Great Extent

Table 3 presents the system's performance evaluation developed of the three (3) indicators; Time Behavior has the highest mean (4.42). At the same time, Capacity is the lowest mean (4.36), both graded as "Very Great

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Extent." Besides, the table shows that the system is ISO 25010 compliant with the "Very Great Extent" for Performance Efficiency, with a mean of 4.39. This finding validates the study's findings by [10], which stressed that the developed system had a quick response time during the system's execution and performed the requested task. Therefore, the developed system is significant enough to perform tasks.

TABLE 4

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of COMPATABILITY

Criteria	**Weighted Mean**	**DI**
1. Coexistence. The system can efficiently perform its required functions while sharing a mutual environment and resources with other products without a detrimental impact on any other product.	4.41	Very Great Extent
2. Interoperability. The system can exchange information and use the information that has been exchanged.	4.45	Very Great Extent
Category Mean	4.43	Very Great Extent

Table 4 indicates the mean participants' evaluation of the compatibility of the said system. The indicators Coexistence and Interoperability obtained a weighted mean of 4.41 and 4.45, respectively, defined as "Very Great Extent." Also, the category means of 4.43 means that the developed system complied with the compatibility criteria of ISO 25010 with the "Very Great Extent" criterion. The rating of users means that the developed system is operational and useful in efficiently performing its desired purpose. This result is confirmed by [11], which highlighted the developed system's coexistence and interoperability.

TABLE 5

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of USABILITY

Criteria	**Weighted Mean**	**DI**
1. Appropriate Recognizability. The system allows users to recognize if it is appropriate for their needs.	4.80	Very Great Extent
2. Learnability. The system can be used by specified users to achieve specified learning goals to use the application with effectiveness, efficiency, freedom from risk, and satisfaction in a specified context use.	4.43	Very Great Extent
3. Operability. The system has attributes that make it easy to operate and control.	4.46	Very Great Extent
4. User Error Protection. The system protects users against making errors.	4.35	Very Great Extent

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5. User Interaction Aesthetics. The system's user interface enables pleasing and satisfying interaction for the user.	4.49	Very Great Extent
6. Accessibility. The system can be used by people with the broadest range of characteristics and capabilities to achieve a specified goal in a specified goal in a specified context of use.	4.40	Very Great Extent
Category Mean	4.45	Very Great Extent

Table 5 presents the mean evaluation of the participants on the usability of the developed system. Of the six (6) indicators, the highest rated among the participants was Appropriate Recognizability with a mean of 4.56. On the other hand, the item ranked the lowest with a weighted mean of 4.35, which was "User Error Protection." The table also indicates that the mean evaluation in all indicators is interpreted as "Very Great Extent" with a category mean of 4.45. As evaluated by the user-participants, the "Usability" function of the developed system reflects studies by [12] and [13] that perceived the system as easy to identify, read, operate, and access.

Table 6 shows that the mean evaluation of participants on the reliability developed system's reliability varies from 4.26 to 4.46. Of the four (4) indicators, recoverability has the highest weighted mean of 4.46; maturity has the lowest mean of 4.26, both are defined as "Very Great Extent." Moreover, the 4.34 category means that the system has complied with the "Very Great Extent" Reliability criterion. The developed system meets the criteria for reliability under normal conditions and is operational and usable.

TABLE 6

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of RELIABILITY

Criteria	**Weighted Mean**	**DI**
1. Maturity. The system meets the needs for reliability under standard operation.	4.50	Very Great Extent
2. Availability. The system is operational and accessible when required for use.	4.50	Very Great Extent
3. Fault Tolerance. The system operates as intended despite the presence of hardware or software.	4.50	Very Great Extent
4. Recoverability. The system can recover the data directly affected and re-establish the desired state.	4.70	Very Great Extent
Category Mean	4.34	Very Great Extent

This finding confirms that of [14], which highlighted the system's maturity, availability, fault tolerance, and ability to recover.

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TABLE 7

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of SECURITY

Criteria	**Weighted Mean**	**DI**
1. Confidentiality. The system ensures that data are accessible only to those authorized to have access.	4.46	Very Great Extent
2. Integrity. The system prevents unauthorized access to or modification of computer programs or data.	4.49	Very Great Extent
3. Non-repudiation. The system can be proven to have taken place so that the events or actions cannot be repudiated later.	4.48	Very Great Extent
Category Mean	4.48	Very Great Extent

As shown in Table 7, the mean Security evaluation of participants in the developed system ranges from 4.46 to 4.49. The Integrity variable was ranked the highest among participants with a weighted mean of 4.49. On the other hand, the lowest predictor was Confidentiality (mean = 4.46). These indicators are described as "Very Great Extent." The table also indicates that the average category of 4.8 means that the developed system has complied with the "Very Great Extent" security criteria. The findings support the [15] report, which highlighted security features such as confidentiality, honesty, non-repudiation, accountability, and authenticity. It ensures that the developed system is safe, ensuring that it is accessible only to approved users. Moreover, in the study of [16], security is one of the significant challenges which limit users from accessing the system.

TABLE 8

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of MAINTAINABILITY

Criteria	**Weighted Mean**	**DI**
1. Analyzability. The system can be possible to assess the impact of an intended change to one or	4.46	Very Great Extent
2. Modifiability. The system can be quickly and efficiently updated without introducing defects or the deterioration of existing product quality.	4.49	Very Great Extent
3. Testability. The system's test requirements can be identified, and tests can be carried out to determine if those criteria have been met.	4.48	Very Great Extent
Category Mean	4.48	Very Great Extent

As reflected in Table 8, the Maintainability criterion consists of three (3) indicators, namely Analyzability, Modifiability, and Testability, all of which have an average of 4.46, 4,49 4.48, respectively. These indicators are

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all perceived as being "Very Great Extent" compliant. Moreover, category 4.48 means that the developed system has usually complied with the "Very Great Extent" maintainability criterion. Analyzability, modifiability, and testability of the system are required, as assessed by the study's user-participants. The study's finding is analogous to that of [17-18], highlighting the developed system's maintainability as an attribute. It implies that the developed system can be managed and updated simply and efficiently.

TABLE 9

THE EXTENT of COMPLIANCE of the DEVELOPED SYSTEM WITH ISO 25010 in TERMS of PORTABILITY

Criteria	**Weighted Mean**	**DI**
1. Adaptability. The system can be effectively and efficiently be adapted for different or evolving hardware, software, or other operational or usage environments.	4.43	Very Great Extent
2. Installability. The system can be successfully installed and uninstalled in a specified environment.	4.31	Very Great Extent
3. Replaceability. The system replaces another specified software product for the same purpose in the same environment.	4.29	Very Great Extent
Category Mean	4.34	Very Great Extent

Table 9 presents the participants' assessment of the Portability criterion of the developed system. The Acceptability, Installability, and Replaceability indicators obtained the weighted average rating of 4.43, 4.31, and 4.29, all listed as "Very Great Extent." Based on the overall assessment of that criteria, the mean category of 4.34 means that the device has a "very Great Extent" of compliance with ISO 25010 software quality standards.

TABLE 10

SUMMARY of EXTENT OF COMPLIANCE of the DEVELOPED SYSTEM with ISO 25010: SOFTWARE QUALITY STANDARDS

Criteria	Weighted Mean	DI
1. Functional Suitability	4.33	Very Great Extent
2. Performance Efficiency	4.39	Very Great Extent
3. Compatibility	4.43	Very Great Extent
4. Usability	4.45	Very Great Extent
5. Reliability	4.34	Very Great Extent
6. Security	4.48	Very Great Extent
7. Maintainability	4.48	Very Great Extent

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8. Portability	4.34	Very Great Extent
Category Mean	4.41	Very Great Extent

Table 10 describes the system's assessment as it complies with ISO 25010: Software Quality Standards. The system was evaluated using various attributes such as functional sustainability, performance efficiency, compatibility, usability, security, maintainability, and portability, all of which were assessed as ISO-compliant, the "Very Great Extent" required requirements. The developed system has an overall mean of 4.41, which means that the system is generally compliant with ISO 25010 for "Very Great Extent." The use of the ISO 25010 evaluation tool helps assess the quality of the system's different parameters [19].

CONCLUSION

Based on the study results, the researchers concluded that corn growers faced challenges and needs in their corn farming activities, which could be addressed through a knowledge-based system. The developed system "corn-IT" mobile application provides a knowledge-based support system for corn growers to control their operations. The developed knowledge-based system is functional, useful, compatible, simple, accessible, reliable, secure, maintainable, and portable.

RECOMMENDATION

Based on the results and conclusions, the researchers recommend that MAO and DA consider implementing a "corn-IT" mobile knowledge-based system among corn growers. Corn growers can use the developed system. Training for users of the system will be carried out once the system has been developed. The developed system can be incorporated into the social media platform so that corn growers can sell their goods online. Future researchers need to develop and implement system improvements, as suggested by the participants. It is also recommended that the plant pathologists and entomologists should also evaluate the reliability of the developed application. Further research will be undertaken to assess the overall performance of the developed system.

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