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Design and Development of a Soil Quality Evaluation Device and Software for Enhancing Sweet Potato (Ipomoea Batatas) Cultivation

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ABSTRACT

Philippines is widely known and composed of rich agricultural land. Many Filipinos in rural areas still rely on agriculture for their livelihood. Rice, corn, coconut, sugarcane, banana, pineapple, mango, abaca, coffee, root crops and tobacco are among the country's principal agricultural crops, according to Nations Encyclopedia. In the study of Farabe A., Islam M., Rahman M. et al. (2021) they have created a device with few sensors which will help users to detect components like - moisture, temperature, amount of nutrients and pH level of the soil to produce good quality crops. Generally, their study focuses in helping farmers easily identify what crop should they cultivate in their land or soil that have been analyzed by the device. In another study conducted by Alasco R., Domdoma E.A., Doria K.A. et al. (2018), the development of the Arduino-based prototype that fully automated the soil analysis and fertilizer recommendation was operative and reliable during series of tests conducted. Based on the results and findings of the research, the project was found to be fully functional and proven to be 96.67% accurate. In addition, the study of Upendra R, Ahmed M, Omkar A et al. (2021) highlighted the importance of different smart soil fertility measurement methods such as conductivity-based sensors, electrochemical based sensors, Optical based sensors, and smart hybrid approaches such as Photo matric based electrochemical sensors.

1. INTRODUCTION

Philippines is widely known and composed of rich agricultural land. Many Filipinos in rural areas still rely on agriculture for their livelihood. Rice, corn, coconut, sugarcane, banana, pineapple, mango, abaca, coffee, root crops and tobacco are among the country's principal agricultural crops, according to Nations Encyclopedia. In the study of Farabe A., Islam M., Rahman M. et al. (2021) they have created a device with few sensors which will help users to detect components like - moisture, temperature, amount of nutrients and pH level of the soil to produce good quality crops. Generally, their study focuses in helping farmers easily identify what crop should they cultivate in their land or soil that have been analyzed by the device. In another study conducted by Alasco R., Domdoma E.A., Doria K.A. et al. (2018), the development of the Arduino-based prototype that fully automated the soil analysis and fertilizer recommendation was operative and reliable during series of tests conducted. Based on the results and findings of the research, the project was found to be fully functional and proven to be 96.67% accurate. In addition, the study of Upendra R, Ahmed M, Omkar A et al. (2021) highlighted the importance of different smart soil fertility measurement methods such as conductivity-based sensors, electrochemical based sensors, Optical based sensors, and smart

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hybrid approaches such as Photo matric based electrochemical sensors. As for the basis that was used in the study, the researchers utilized the findings and conclusion of a related study conducted by G. Paneque Ramirez (1992). He concluded that among different regions and types of sweet potato, the condition that favors the development of vegetive part of sweet potato include an 80% relative humidity and moist soils. It is also stated in his study that the appropriate pH value needed to cultivate good quality sweet potato is preferably light acids or neutral soils, with an optimum pH value being between 5.5 and 6.5.

Among root crops in the country, sweet potato is the most well-known product in the category. Due to that reason, sweet potato being a prominent and staple crop in the country and in the locality of the researchers, they have decided to utilize this subject matter for the development of an emerging device. A device named SoilQA (Sweet Potato Soil Quality Analyzer) that can analyze certain components of soil and recommend if the analyzed soil is suitable for sweet potato plantation. This study proposed significance to the community for the reason that it tackles important things in crop production that relatively promotes benefit to the country being an agricultural-centered one. The main focus and reason why the researcher choose this kind of study, is that they aim to help local farmers in choosing appropriate soil for sweet potato production.

Philippines being an agriculture-centered nation and due to its terrain and tropical climate condition, farming has been one out of the many sources of livelihood in the country. Production of root crops, specifically sweet potato is known all over the country. As the researchers noticed that sweet potato is a widely known and a patronized root crop around their locality, mainly in Maydolong, Eastern Samar. The researchers made use of it as an advantage and decided to developed a device that will help farmers in Maydolong avoid committing mistakes and easily identify suitable soil for sweet potato plantation by developing an Arduino-based device that can analyze soil components such as the level of humidity and pH or acidity value that are vital factors of soil in producing sweet potato.

Objectives:

- To develop a device that can analyze and determine the humidity level and pH value or acidity of a soil. And also, to develop a desktop application that can approve or recommend if a soil is appropriate for sweet potato plantation.
- To develop a desktop application that can identify the gathered properties of the soil and recommend if it's suitable for sweet potato plantation utilizing the findings of G. Paneque Ramirez's study as the basis.

2. METHOD

The proposed method involves development of the device, retrieving the soil variables through the developed device and evaluation of the quality through the use of the developed desktop application.

Hardware

The researchers developed an Arduino based microcontroller to evaluate compatibility of the soil with the soil potato. Fig.1 shows the schematic diagram of the device. A design of the developed device is presented in Fig 2.

A. Schematic Diagram

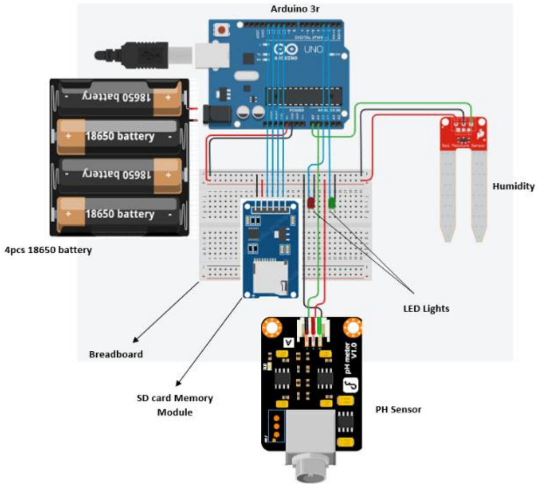


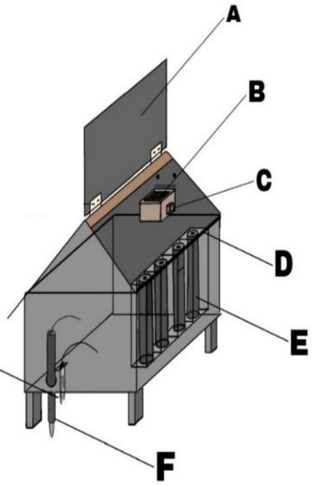
Fig. 1 Schematic Diagram

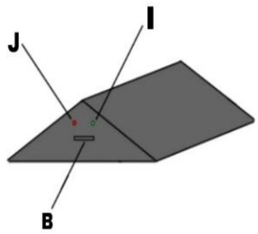
B. Lay-out Plan

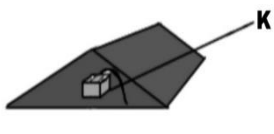
Following are the modules used in the development of the device:

A. Roof (Opening)
B. SD Card Module
C. Switch
D. Slot Battery Holder
E. Battery
F. PH Sensor
G. Soil Humidity Sensor
H. Led (Green) IN
I. Led (Red) OUT
J. 1x1 Wood (SD Card Slot)

Fig







l the following
veet potato.

PHL – pH Level value retrieved from the pH Level Sensor
PHLA – pH Level Average

SHA = (SUM of 120 SH)/120
PHLA = (SUM of 120 PHL)/120

INPUT PARAMETER			
	SHA	**PHLA**	**FINDINGS**
Case 1	Greater than 80	Greater than 5.5 and Less than 6.5	RECOMMENDED
Case 2	Greater than 80	Less than 5.5	NOT RECOMMENDED
Case 3	Greater than 80	Greater than 6.5	NOT RECOMMENDED

Case 4	Less than 80	Greater than 5.5 and Less than 6.5	NOT RECOMMENDED

Soil pH Level – pH Level is one of the essential variable that the study needs. Moreover, soil pH level deals with the level of acidity that a particular soil contains which will be gathered by the device made for the study through the use of soil sensor. The acidity or pH level of a soil plays an important role when it comes to sweet potato plantation as it affects the overall quality of the crop.

Soil Moisture – Soil moisture mainly refers to the volume or amount of water a particular soil have. As much as soil pH level, soil moisture is also needed in this study as it affects the growth of sweet potato overtime. Furthermore, this essential variable will also be gathered by the device with the use of soil humidity sensor.

Software

The researchers developed a desktop application that will be used in analyzing data. A memory card from the SoilQA device will be inserted in the computer and the system will upload the file from the memory card.

Evaluation

In the data collection process, purposive sampling will be used to select the evaluators. These evaluators will include representatives from the Department of Agriculture in Maydolong, Eastern Samar, as well as local farmers. They will be asked to complete the System Usability Scale (SUS) questionnaire to assess the system. Developed by John Brooke in 1986, the SUS has been widely applied across various sectors to evaluate different systems and applications. It is a flexible tool that is not tied to any specific technology, consisting of ten questions with responses ranging from "strongly agree" to "strongly disagree." Incorporating the SUS in usability testing for systems and websites offers several significant benefits (Hinchliffe et al., 2020).

Research Locale

The study will take place in Maydolong, Eastern Samar. The municipality spans 399.63 square kilometers (154.30 square miles), accounting for 8.66% of Eastern Samar's total land area. According to the 2020 Census, Maydolong has a population of 15,314, representing 3.21% of the province's population and 0.34% of the overall population in the Eastern Visayas region. With these figures, the population density is approximately 38 inhabitants per square kilometer or 99 inhabitants per square mile (Retrieved from: https://www.philatlas.com/ August 15,2024).

Figure 3.0 Map of Maydolong Eastern Samar (Retrieved from Google Map)

Research Respondents

The respondents of the study will include the twenty-five (25) local farmers of Maydolong, and five (15) Department of Agriculture employees. These evaluators will use scorecards to rate the performance of the developed system.

Research Instruments

The system was evaluated using the System Usability Scale. The SUS is described as "a straightforward, ten-question scale that provides an overall perspective on subjective usability assessments". Each question offers five response options, ranging from "strongly agree" to "strongly disagree." The SUS generates scores between 1 and 100, with 68 being regarded as the average score. These scores can be influenced by the complexity of both the system and the tasks users must complete before answering the SUS (Hinchliffe et.al, 2020).

Scoring

The System Usability Scale is a Likert scale consisting of 10 questions that website users will respond to. Research Respondents rate each statement on a scale of 1 to 5, where 5 indicates strong agreement with the statement and 1 signifies strong disagreement. Table 1 shows the scoring method for the System Usability Scale (SUS), which uses a Likert scale with 10 questions. Respondents rate each question on a scale from 1 to 5, reflecting their level of agreement with the statement. A score of 5 indicates "Strongly Agree," while a score of 1 indicates "Strongly Disagree." The table provided clarifies the qualitative descriptions corresponding to each score, ranging from strong agreement (5) to strong disagreement (1). This method is designed to quantify users' subjective assessments of a system's usability, providing a consistent way to measure user satisfaction of the website.

Table 1 METHOD OF SCORING

Rating Scale	**Qualitative Description**
5	Strongly Agree
4	Agree
3	Slightly Agree
2	Slightly Disagree
1	Strongly Disagree

Computation

Step 1: Convert the scale into numbers for each of the 10 questions:

1. Strongly Disagree: 1 point
2. Disagree: 2 points
3. Neutral: 3 points
4. Agree: 4 points
5. Strongly Agree: 5 points

Step 2: Calculate:

- X = Sum of the points for all odd-numbered questions – 5
- Y = 25 – Sum of the points for all even-numbered questions
- SUS Score = (X + Y) x 2.5

Interpretation

SUS score will be able to tell the website's usability performance in the aspects of effectiveness, efficiency, and overall ease of use. Although each response yields a score on a scale of 0–100. The interpretation is shown in Table 2.

Table 2 Survey Result Interpretation

SUS Score	Grade	Adjective Rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Retrieved from (https://uiuxtrend.com/measuring-system-usability-scale-sus/)

A. RESULT AND DISCUSSION

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Discussion

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B. CONCLUSION

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C. ACKNOWLEDGE

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