GROUND CALIBRATE: AN IOT-BASED SOIL MANAGEMENT SYSTEM

Ralph Jade M. Cadevida[1], Bern Homer M. Nebran[2], Dunwill C. Vidas[3], and Richard Vincent E. Misa[4]

UM Tagum College, Philippines
[1,2,3]Students, Department of Arts and Sciences Education
BS Computer Science Program
[4]Faculty, BS Computer Science
UM Tagum College, Philippines
[1,2,3,4]rpctagum@umindanao.edu.ph

ABSTRACT

Not being able to know the status of the soil of the farm is a big factor in the farming industry, the levels of soil acidity and affects the yield of the crops, too low or too high acidity level can result in the death of the crops being planted in the farm, same thing applies to the soil moisture too much dryness and too much wetness in the soil can result on bad harvest for the farmers. With this problem, the proponents developed a system consisting of mobile application and IoT device named Ground Calibrate that aimed to detect soil pH level, and moisture of the soil and suggested suitable crops for the soil based on the soil pH level and suggest fertilizer using Flutter, and Arduino microcontroller. During the phase of testing the system, the proponents conducted several tests such as Mobile compatibility testing, RAM testing, Wi-Fi distance testing, Usability testing, and Module testing. Based on the results of alpha and beta testing, the users of the system were satisfied. The beneficiaries' gathered feedback shows their expectations were met by the system.

Keywords: *BS Computer Science, soil moisture, alkalinity; acidity, agriculture, Philippines.*

INTRODUCTION

The pH of soils can be used to determine whether they are naturally acidic or alkaline. For optimal plant growth, the ideal pH is crucial. The nutrients and chemicals that are available to plants depend on the pH and moisture of the soil [1]. A study conducted by U.S. Department of Agriculture has stated that organically enriched soil has a direct impact in achieving higher crop yield. However, various environmental challenges could affect the soil quality and production yield. Soil erosion, habitat disruption and depletion of soil-nutrient are among the few, which can have long-term and costly impacts to soil quality and production yield [2].

The effects of inadequate soil moisture and pH monitoring have been the subject of numerous studies. In some crops, improper soil pH during the early stages of growth reduces growth rates and yields. Without adequate soil monitoring systems, soil moisture and pH might move to adverse values, resulting in eventual loss of plant health [3] By that means the soil acidity level is crucial for farmers, the soil acidity kills beneficial microorganisms that is crucial to plant growth thus making plant yield lesser [4].

According to the National Action Plan 2004–2010 for the Philippines, 30–50% less soil production resulting from the degradation of 5.2 million kg/ha (quintals per hectare or metric tons per hectare) of soil, upon a conducted assessment of the soil quality of existing land use types is needed to come up with solutions for land management and for achieving sustainable use of the land. Soil health is a crucial indicator of a sustainable management of the land and can be evaluated through the use of Soil quality index as a measure of sustainable land management (SQI). For example, in which the farmers invade the vulnerable and marginal places in the uplands used for cultivation without the proper interventions. preventing crop growth, and productivity are some of the adverse impacts of degraded soil in the Philippines [5].

In the remote corners of the Philippine landscape, a poignant saga unfolds, as smallholder farmers grapple with the ever-shifting tides of a changing climate. Amidst their vulnerable existence, their survival and livelihoods intricately woven with the fabric of the environment, they navigate treacherous waters with limited technology and scarce farming supplies. The tempestuous forces of nature wreak havoc upon their lands, relentless in their assault. Extended bouts of wetness, scorching heat, and parched dryness conspire to ravage their crops, leaving a trail of destruction in their wake. The farmers bear witness to a harrowing dance of drought, their lives punctuated by the unforgiving rhythm of excessive precipitation, the drying of rivers, dams, and wells, while the seasons themselves mutate in timing and pattern, altering the very essence of their existence [6]. It is crucial to maintain the proper amount of moisture needed by the crop throughout its whole growth [7].

In the bountiful land of Davao region, being dubbed as the "fruit basket of the Philippines," in which agriculture place an important role in the whole region. Here, on the verdant island of Mindanao, the provinces of Davao del Norte, Davao del Sur, and Davao Oriental converge, anchoring their economy upon the fertile soil that supports their very existence, mainly base their economy to agriculture, in which employing over 40% of the country's total population, an investigation on the traits of soil testing facilities in the Philippines' Davao Region and how local Crops growers feel about soil analyses services would be great if they had good quality soil pH and soil moisture to each of their farm/crop fields that is accessible through mobile phones[8].

This shows the lack of modern equipments, and modern technologies for the farmers to manage their farms. Furthermore, in Kidapawan City, Engr. Sustines Balanag, a North Cotabato provincial agriculturist, had stated in a Philippine news agency that, "All the farmer needs to do is submit air-dried soil samples from their farms to the station's laboratory and come back for the results after a few days." Because most of the local farmers have no mobile soil pH

sensor devices to use so he urged farmers to take advantage of the Department of Agriculture's Amas Research and Experiment Station's free-soil analysis, for the farmers to know the status of their soil they will need to go through a long process and travelling which is also not accessible all the time because the farmers lack the ability to know more about the status their soil [9].

These problems led to the proposal of Ground Calibrate: An IOT-based soil Management system that is going to benefit farmers in Mindanao and help them manage their crops through monitoring soil moisture and pH level for better crop production.

Research Gap

Based on the related literature, a few limitations are identified in the existing research that attempts to address this study.

Table 1. Comparison of Related Studies

Features	Studies						
	Soil PH Sensor Commercialized, n.d.	Chandrapabha et. al	Raut et. al	Suchithra et. al	Valencia et al.,	Oberoi et. al	Ground Calibrate
Identify the soil PH level	✓	✓	✓	✓	✓	✓	✓
Suggest crops suited for the soil	✓	×	✓	✓	✓	×	✓
Suggest fertilizer base on the desired crop	×	×	×	×	×	×	✓
Moisture Detector	×	×	×	×	×	×	✓
Soil Data Analysis	×	×	✓	×	×	×	✓
Soil status push notification	×	×	×	×	×	×	✓

Table 1 shows the comparison of the related studies conducted by different researchers. These aids the advocates in determining the gaps in the current research to enhance methods for resolving issues with IOT based Soil Management System. Most research rely on the Internet of Things, which incorporates hardware elements like sensors to gather data. Additionally, all the studies incorporate with features that have soil pH level Identification. Furthermore, mostly of the studies could Suggest crops suited for the soil to farmers and they are also common features for all studies which are crucial in measuring the current state of the soil.

However, the majority of studies do not concentrate on fertilizer recommendations based on the crops that farmers want to grow on their property. The ability to Suggest fertilizer base on the desired crop feature that must be considered by the researchers since the growth of crops could be affected by fertilizers and one of the main causes of low-quality goods if not attended. Within the expansive canvas of this study, a disquieting concern takes center stage: the relentless loss of soil organic matter, eroding the very fabric of fertility within rice-upland rotations. The capacity of these soils to bestow life-sustaining nutrients stands diminished, shackled by the weight of increased cropping practices. A dissonance reverberates through the agricultural landscape as imbalanced fertilization techniques emerge, casting a shadow upon the delicate harmony that once thrived [16].

Each study incorporates none of the elements mentioned above and also include the Capability to detect Moisture on Soil, base again on the feature must be considered by researchers since soil moisture have an impact on crop growth.

All things considered, the proponents feel that there is room for development that the different approaches of the related studies require improvement in terms of determining which soil and crops are most in need. Instead, the system would use Soil Data Analysis to improve the restricted performance of the soil pH and soil moisture

sensor. Farmers and planters have the chance to employ Ground Calibration for their crops and farmlands as a result of the current study.

1.1 Objectives of the Study

To develop a soil management application with the help of IOT that detects the acidity, alkalinity and moisture of the soil using Arduino sensors. Furthermore, to suggest crops and fertilizer, and collect data, and use it for data analysis to help the farmers.

1. Detect soil pH level using soil pH sensor.
2. Determine and suggest what fertilizers to use and crop to plant based on soil pH level.
3. Monitor soil moisture using soil moisture sensor.
4. Collect pH level and soil moisture for data analysis.
5. Soil Data analysis
6. Soil moisture and soil pH alert push notifications

1.2Purpose and Description

The project was proposed to help farmers know the condition of the soil.

Ground Calibrate following capabilities:

1. Mobile application with the help of IOT that detects PH level of the soil
2. Suggest plant on the detected soil
3. Suggest fertilizer on the chosen plant on the detected soil
4. Generates analysis based on data gathered on specific soil.
5. The soil pH level and soil moisture can be uploaded to the database.
6. Push notifications about the current status of the soil.

1.3 Scope and Limitation

The Ground calibrate application can be installed on mobile devices, and it will need an internet connection to be able to collect data and upload it to the database, the microprocessor to be used is

going to be Nodemcu v3. The device is going to need a dipswitch to unload the Nodemcu v3, it is also going to be powered by 5v output power bank, and the port coming from the Nodemcu v3 is going to be micro-USB. The soil that is going to be accommodated by the system will not be bigger than 5 meters in width and length, the soil that it can collect soil moisture and soil pH on can be any type of soil namely, clay, sand, rocky, muddy and others. The database that is going to be used is firebase and is going to make use of the real time database and cloud store which are the services provided by the firebase. The application size is going to be 28mb. The system is also going to run using Wi-Fi of mobile hotspot from mobile devices or Wi-Fi routers at home.

The system can only collect soil pH level and soil moisture, the crops that is going to be suggested by the app are only those crops that are commonly planted in Mindanao and not including flowers, and garden plants. the system can't run if there is no Wi-Fi connection. The Nodemcu v3 is not waterproof so it is going to need covers and casing. The Ground calibrate app retrieves push notifications every 1 second, if the internet connection is weak or slow it is going to take longer to send push notification, if the phone is not connected to the internet the Ground calibrate app can be opened but the soil pH and moisture will not show any result, it is also the same with the soil pH history and soil moisture history, the users will not be able to see these if there is no internet connection.

The Nodemcu v3 also can't restart automatically so it needs to be reset and unload every time it is going to be turned on using dipswitch. The firebase database also has limitations in how many reads and writes it can allow the users before it will start charging the firebase account so the Ground calibrate app users will need to refresh the soil pH and soil moisture manually to minimize app reads and writes from the database. The app can't be installed on low-end devices that are running on Android version lower than 8.1, and mobile phones that has lower than 3gb of ram.

1.4 Significance of the Study

The following individuals and organizations were the beneficiaries of this study:

1. Farmers. This study was designed to the Farmers/farming organizations for maximizing harvest and minimizing Bad harvest by the Ground calibrate feature suggestions for fertilizer and suggestions of plants farmers can make a big harvest.

2. Department of Agriculture. This study would be beneficial in promoting a technological approach in the field of agriculture as it focuses on maintaining their hard work to the fullest and will not result in nothing due to the death of crops but instead it will result of higher yields, enhanced productivity, and sustainable practices, this study aims to improve the situation of the agriculture where they can benefit and be efficient with their farming.

3. Future Researchers. This study may benefit study to improve the agricultural industry, where farmers encounter challenges with the fluctuations of soil acidity, drought or over dryness of the soil and over wetness of it, this transformative study is a helpful guide for the farmers for them to have an idea about the current status of their soil. It's helpful benefits will satisfy the needs of the farmers, helping them get better results in from their labor of feeding the country with their crops.

METHOD

2.1 Agile Software Development Method

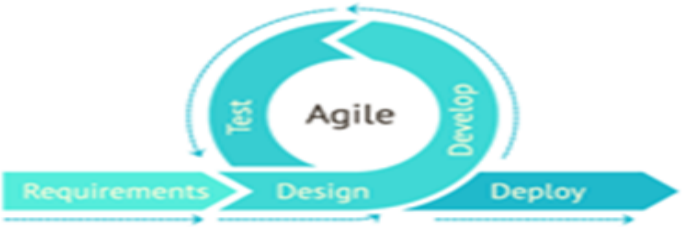

Figure 1. Agile Method.

The Agile Methodology will be employed by the study's proponents. Because the agile methodology uses an iterative or incremental approach, we believe it to be the ideal way for change and flexibility. Because it emphasizes customer participation and reduces total risk, this method is appropriate for the study because it encourages a prompt and flexible reaction to changes. Additionally, the product's quality is raised because the demands and anticipated outcomes align.

The proponents have used Agile methodology due to the usage of Arduino, during the development period many challenges were met by the developers due to the wirings and nature of microprocessors such as needing to reset every time the device is powered on, and needing to unload the Nodemcu v3 which resulted in needing to use dipswitches, the Arduino code integration with firebase also resulted in a few technical problems that resulted in a few changes in the development plan, these nature of changes in the development shows the effectiveness of using Agile methodology. Minimizing the wasting of resources, the ability to smoothly adapt to changes and improved control to the projects through increased flexibility are the benefits of using Agile methodology [17].

2.2 Conceptual Framework

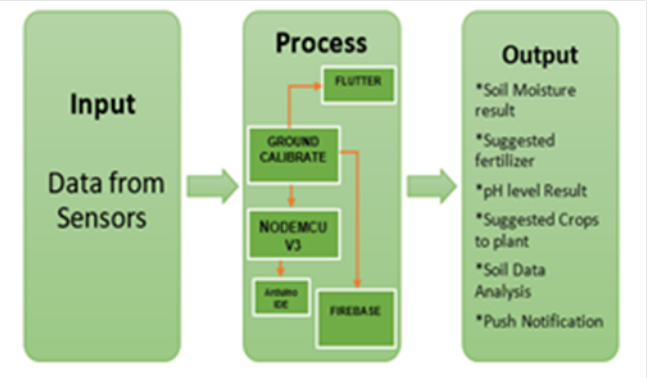

Figure 2. Input-Process-Output Model.

Figure 2 shows the input, process, and output of the system. The input needed will be the data that are collected from the sensors which are the soil moisture result which is a decimal number ranging from 1 - 235, and the pH level of the soil which is retrieved from the sensor in the form of hexadecimal values.

The process needed are Flutter, for developing the Ground Calibrate application and integrate it with firebase database. Use real time database to retrieve the value sent by the Nodemcu v3 through the stream, and cloud store to save the recorded soil pH level and moisture. Next is Arduino IDE for programming the Nodemcu v3 micro controller and integrate it with the sensors and the modules needed. Execute the proper wirings for it and power it with the required volts. The Arduino will be integrated with firebase and Wi-Fi package and the decimal number retrieved from the soil moisture sensor will be converted to percentage using the formula: (decimal number returned / 235) * 100, 1 being dry and 235 being completely submerged to water.

The output will be the soil moisture result converted to percentage, the soil pH level result converted to double, the suggested fertilizer based on the desired crop and pH level, the suggested crops to plant, and lastly, soil data analysis which is the analysis from the soil pH and soil moisture combined which will give the users an idea about the status of their soil and give recommendations.

2.3 Ground Algorithm

(See figure 3 below)

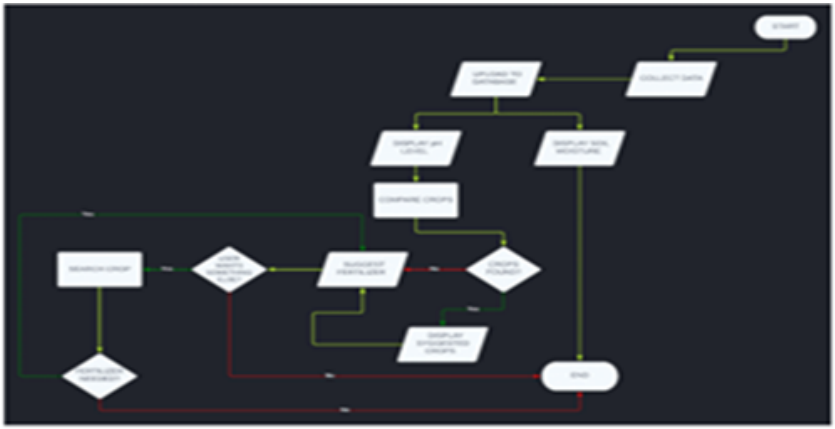

Figure 3. Ground Algorithm.

Ground Calibrate algorithm is utilized for collecting the pH level coming from the soil pH sensor, and soil moisture, then upload these collected data to the database, then display it to the phone next, the soil moisture collected will be analyzed to know whether the soil needs watering and inform the user. The pH level collected will then be analyzed to find the crops that are suitable for the soil pH level, if suitable crops are found then it will display the crops, after that the user has the ability to input other crops, then it will be searched if it is included in the list of crops supported by the app, and lastly, suggest a fertilizer to achieve the pH level suitable for the chosen crop.

2.4 System Architecture

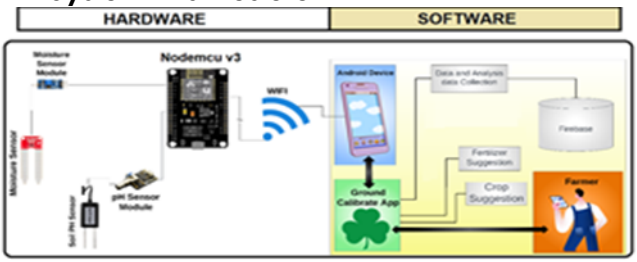

Figure 4. System Architecture.

Figure 4 Illustrates the System Architecture of The Ground Calibrate Soil management system and the required sensors, tools, equipment, and modules. The Arduino Soil pH and Soil Moisture Sensor that collects the Soil Moisture and pH with the help of their own respective modules, and to be passed to the Nodemcu v3 connected to the Wi-Fi then the data sent will be processed by the ground calibrate application which will provide the crop and fertilizer suggestions, and data collection for data analysis. The soil moisture data collected will be analyzed and be uploaded to the database.

RESULTS AND DISCUSSION

3.1 Compatibility Assessment

The purpose of the compatibility assessment is to determine what operating system is it going to be working on, which version, how much ram is the minimum it will work on, and whether it is going to be installed [18].

It evaluates the application's and the product's usability, dependability, and performance. A software product's ability to coexist is dependent on how well it operates while utilizing shared resources and environments without impairing the performance of other software products. The goal of compatibility assessment is to determine whether a software system, product, or component as a whole is coexisting and operating cooperatively with the hardware platforms, operating system, database, web browsers, networks, and other software [19].

In this study, a series of tests were performed to evaluate the effectiveness of the developed system. This includes testing the android operating system, RAM, and WI-FI distance testing.

The results of the conformity assessments performed are shown in Tables 2-4.

Table 2. Mobile Compatibility Test

Device	Android OS Version	Remarks
Samsung Duos	Andr oid 6.1	Not Installed
Oppo CPH1909	Andr oid 8.1	Passed
Huawei MatePad T	Andr oid 10.0	Passed
Oppo F7	Andr oid 10.0	Passed
Realme 5 pro	Andr oid 11.0	Passed
Xiomi poco m5	Andr oid 13.0	Passed
Redmi k40	Andr oid 13.0	Passed

Table 2 Illustrates the version of Android being tested for remarks and the researchers figured that Android version 6.1 is not compatible with the application as shown in the above table only the Android version 8.1 and up passed the installation.

3.2 Compatibility Assessment

The purpose of the compatibility assessment is to determine what operating system is it going to be working on, which version, how much ram is the minimum it will work on, and whether it is going to be installed [18]. It evaluates the application's and the product's usability, dependability, and performance. A software product's ability to coexist is dependent on how well it operates while utilizing shared resources and environments without impairing the performance of other software products.

The goal of compatibility assessment is to determine whether a software system, product, or component as a whole is coexisting and operating cooperatively with the hardware platforms, operating system, database, web browsers, networks, and other software [19].

In this study, a series of tests were performed to evaluate the effectiveness of the developed system. This includes testing the android operating system, RAM, and WI-FI distance testing. The results of the conformity assessments performed are shown in Tables 3-5.

Table 3. RAM testing

Device	RAM Capacity	Remarks and Performance
SAMSUNG DUOS	1GB RAM	Not Installed
OPPO CPH1909	3GB RAM	Working
HUAWEI MatePad T	3GB RAM	Working
OPPO F7	4GB RAM	Working
Xiomi poco m5	4GB RAM	Working
Realme 5 pro	4GB RAM	Working
Redmi k40	12GB RAM	Working

Table 3 shows the application was evaluated using Seven different Android phone models. The outcome demonstrates that installing the app is advised for phones with a minimum of 3GB or more of RAM. The proponents have conducted ram testing to identify how much ram the app will run efficiently and smoothly on that will give a proper result for the users. Users of high-end phones are less than users of low-end phones, therefore if an application is properly working devices that are high-end and costly, it doesn't mean that it is also going to work on devices that are mid to low-end [20].

Wi-Fi Distance testing

The proponents have conducted Wi-Fi distance testing to identify how much distance the device needs to achieve optimal performance and results. It is an important factor to test Wi-Fi signal strength in measuring the speed and reliability of devices that use wireless connection. An unreliable and slow connection of internet is the result of poor network signal strength [21].

Distance	Remarks
3 meters	Passed
4 meters	Passed
5 meters	Passed
6 meters	Passed
7 meters	Failed
8 meters	Failed

Table 4. Wi-Fi Distance Testing.

Table 4 shows the recommended distance from the WI-FI should not be greater than 7 meters from the Field while Testing and gathering data from the Device. It is suggested that the user has to take at least 6 meters towards the Field environment as shown in the table above.

3.3 Usability Assessment

The proponents conducted usability assessment to determine whether the users of the system will be satisfied and approve it, whether they will be catered by the expected functions and outcomes, and whether it will pass the test when it is being used in the farm [22]. Usability assessment or testing is a type of user research that assesses how well users interact with websites and mobile apps. It aids in the evaluation of a product's usability and intuitiveness by designers and product teams. By asking actual users, rather than programmers or designers, to carry out a set of usability activities on the product, usability testing helps you find issues with the product that might have overlooked otherwise. The ultimate purpose is to produce a product that assists users in achieving their goals while resolving their difficulties [23]. The findings of the usability test, as they relate to the application's features and modules, are displayed in Tables 6-7.

Functionality Testing

Table 5. Functionality Testing

Objective	Result
Scan pH	Passed
Detect Soil Moisture	Passed
Connect to Wi-Fi	Passed
Upload pH to Database	Passed
Upload Soil Moisture to Database	Passed

Table 5 predetermined the objective in the application's features and modules it shown above that the application passed to Scan the pH level of the soil, it detects soil moisture, the application could connect to Wi-Fi and upload the pH level and soil moisture gathered unto the database.

Table 6. Module Testing

Module Testing in Different Devices						
Functions / Modules	**Android Devices**					
Devices	**Huawei MatePad T**	**OPPO CPH1909**	**OPPO F7**	**Xiomi poco m5**	**Realme 5 pro**	**Redmi k40**
UI	Passed	Passed	Passed	Passed	Passed	Passed
Display Soil pH	Passed	Passed	Passed	Passed	Passed	Passed
Display Soil Moisture	Passed	Passed	Passed	Passed	Passed	Passed
Display History	Passed	Passed	Passed	Passed	Passed	Passed
Upload to Database	Passed	Passed	Passed	Passed	Passed	Passed
Suggest Fertilizer	Passed	Passed	Passed	Passed	Passed	Passed

Table 6 shows the results, it demonstrates that the application complies with the specified objectives and functionality of the proposed system. The process of testing individual software

modules or components is known as software testing. The proponents have conducted module testing to determine the effectiveness of each component of the app. Module testing is used to isolate a certain portion of code and validate its validity. During the initial phases of software development, the development team typically performs module testing [24]. Application's features, and Arduino sensors, are displayed in the table.

3.4 VALIDATION

When a test or measurement is deemed legitimate, researchers have determined that the instrument or apparatus measures the variables it was intended to, an expert's viewpoint is valid. Other researchers doing related studies may, with permission, use the device or equipment produced by the original researcher. The fact that an instrument is used repeatedly suggests strongly that it was made to measure the things it was intended to measure [25]. The researcher validates the IOT based Soil Management System to determine whether the system meets the objectives of this said study the proponents decided to use validation to determine whether our system meets the objectives of our study, or the declared functions that the system will produce [26].

Sample Data

Table 7. Sample Data

Parts of the Farm	pH	Moisture	Test Results
Part A	7	67%	Passed
Part B	7	67%	Passed
Part C	6	53%	Passed
Part D	6	53%	Passed
Plant pot a	5	23%	Passed
Plant pot b	5	31%	Passed
Plant pot c	7	43%	Passed
Plant pot d	4	61%	Passed

The table above shows the following parts of the farm and different types of soil being used in detection, parts A, B, C, D has been successfully detected by the Ground calibrate system of its soil pH and soil moisture, as well as several plant pots that can be seen in houses and in the farm. All of the soil that was tested, has shown crops, and fertilizer suggestions from the app. The table shows that the Ground calibrate device and application has successfully passed the testing of the soil, this demonstrates that the Ground calibrate system detects soil pH, soil moisture, suggests crops, and fertilizer properly. The soil moisture sensor returns value 1 - 235, 1 being dry and 235 being fully submerged to water, the soil moisture is calculated by: (value returned / 235) * 100 to get the moisture percentage.

Therefore, the aim of the compatibility assessment is to identify the operating system, version, minimum required RAM, and installation feasibility. Compatibility Assessment a non-functional testing that evaluates how well the product functions with various systems. It is one of the three crucial types of tests to assure the efficacy of a product. It examines usability as well as other crucial elements and Usability Assessment examines the available choices and decision-making procedures in relation to the product. Because all of these tests are successfully completed and pass, it means that the product has been thoroughly examined and is regarded as a success by the researchers.

It identifies areas for improvement and potential issues, the conducted usability assessment is to ascertain user satisfaction, approval, functionality fulfillment, and successful implementation in farm usage and the most crucial step is Validation, which is a process that determines whether the product functions as intended. The researcher validates the IoT-based Soil Management System to ensure it aligns with the study objectives and meets the intended functions. It ensures that the product accurately measures what it is supposed to measure.

3.5 Alpha Testing

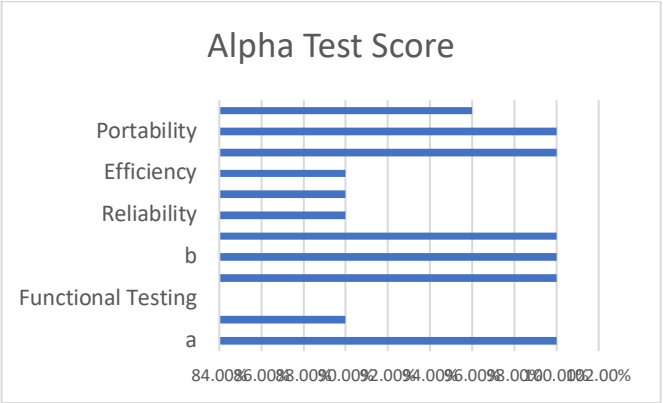

Figure 5. Alpha Testing Result

The proponents have conducted testing on different types of devices ranging from low-end, mid, to high-end level devices, with different android versions, different variations of RAM size, the application has entered the first phase of software testing, that is guided by the proponent's advisor. The illustration above shows the outcome of the alpha test. It was suggested by the proponent's advisor to improve the appearance of the device and improving the UI of the soil pH to show variation, overall, the alpha testing received an evaluation score of 92%.

3.5 Beta Testing

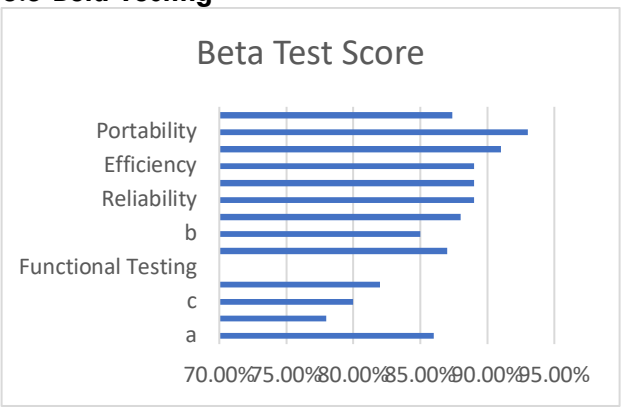

Figure 6. Beta Testing Result

The proponents conducted a beta test including participants of 10 people in the farm to evaluate the application's functionality, Connectivity, Usability, Compatibility, and Hardware design. These tests that were done helped the proponents to identify the things that needs to be polished and address their satisfaction, overall, the alpha testing received an evaluation score of 98%.

CONCLUSION AND RECOMMENDATIONS

The development and implementation of the Ground calibrate application and device, have shown that it is possible to detect the acidity and alkalinity of the soil and make recommendations of crops the farmers to help them identify what is the most suitable crops for their farm. The mobile application and the device were successfully released and tested. As a result, the following proponents of the project has achieved all of its goals:

1. Detect soil pH level using soil pH sensor
2. Determine and suggest what fertilizers to use and crop to plant based on soil pH level.
3. Monitor soil moisture using soil moisture sensor.
4. Collect pH level and soil moisture for data analysis.
5. Give Info through push notifications about the current status of the soil.

In this study, the use of Agile development method has been proven to be fitting and efficient as well because of the flexibility it provides that will allow sudden minor changes during the overall development process. The phases of Agile development method have guided the proponents to assure the quality and accuracy of the results.

The general objective is to develop an IoT-based soil management app that employs Arduino sensors to identify soil acidity, alkalinity, and moisture levels. Besides providing crop and fertilizer

suggestions, the application will gather essential data for analysis, enabling farmers to make well-informed choices, enhance their yields, and adopt more effective farming techniques, with specific features and the results have found to be effective and attain hence, the general objective which to develop an IOT base soil management system (Ground Calibrate) has been achieved.

Throughout the time of the development, the developers have discovered that the application can be installed in smartphones that has a minimum android version of 10 anything lower than that will result in the application not being able to install, and not lower than or equal to 1gb ram to achieve smooth performance, the application size is 27mb, but it is recommended that the smartphone has at least 200mb of free storage. Since the application can upload to the database it requires internet for that function, but the application can still be opened to check the history of soil moisture and soil ph. The ground calibrate device also needs a maximum of 10 meters distance away from the Wi-Fi or hotspot of the smartphone to avoid disconnection and a power bank with 5v output to power the device.

The following recommendations was suggested by the researchers for improvements of the Ground Calibrate System in the future. The proponents suggested adding additional soil pH and soil moisture sensors to increase the range that the device can monitor in the farm and/or field as the range of the Ground calibrate device. In the meantime, the range is limited to a small area in contrast to the size of a farm/field thus, the additional devices can be scattered throughout the farm/field so it can monitor the moisture with more accuracy.

REFERENCES

[1] Soil pH | Environment, land, and water | Queensland Government."https://www.qld.gov.au/environment/la /managem nt/soil/soil-properties/ph-levels (accessed Dec. 12, 2022).

[2] Soil Conservation Concerns | Farmers.gov." https://www.farmers.gov/conservation/concerns tool/soil (accessed Dec. 01, 2022).

[3] How to Monitor Soil pH and Moisture Level | DigiKey." https://www.digikey.com/en/articles/how-to-monitorsoil-ph-and-moisture-level (accessed Dec. 12, 2022).

[4] L. A. Msimbira and D. L. Smith, "The Roles of Plant Growth Promoting Microbes in Enhancing Plant Tolerance to Acidity and Alkalinity Stresses," Front Sustain Food Syst, vol. 4, p. 106, Jul. 2020, doi: 10.3389/FSUFS.2020.00106/BIBTEX.

[5]M. Armie, J. P. Ramirez, R. G. Visco, C. D. Predo, and M. A. Galang, "Assessment of Soil Condition Using Soil QualityIndex of Different Land Use Types in Liliw, Laguna, Philippines."

[6]"Chapter 5: Food Security — Special Report on Climate Change and Land." https://www.ipcc.ch/srccl/chapter/chapter-5/ (accessed Jan. 08, 2023).

[7]"11-17-Manzano-Mizoguchi".

[8]M. D. Bumaya, "Market analysis of soil laboratory services in Davao Region, Philippines A study on the characteristics of soil laboratories in Davao Region, Philippines and the perception of banana and rice farmers in the region on soil analysis services."

[9]"NoCot farmers urged to avail of free soil analysis at DA lab | Philippine News Agency." https://www.pna.gov.ph/articles/1178214 (accessed Dec. 12, 2022).

[10]"Soil pH sensor Commercialized." https://ag.purdue.edu/ssmc/frames/dec2003_purdue nl1.htm?fbclid=IwAR13SMXp6kRP0pWAsYy9gdV9Slu6f Z82enhsVQwuNHsYgWHhcV_dgk7Wc (accessed Nov. 08, 2022).

[11]M. S. Suchithra and M. L. Pai, "Improving the prediction accuracy of soil nutrient classification by optimizing extreme learning machine parameters," Information Processing in Agriculture, vol. 7, no. 1, pp. 72–82, Mar. 2020, doi: 10.1016/J.INPA.2019.05.003.

[12]M. Chandraprabha and R. K. Dhanaraj, "Soil Based Prediction for Crop Yield using Predictive Analytics," Proceedings - 2021 3rd International Conference on Advances in Computing, Communication Control and Networking, ICAC3N 2021, pp. 265–270, 2021, doi: 10.1109/ICAC3N53548.2021.9725758.

[13]S. Raut and V. Chitre, "Soil Monitoring and Testing Using IoT for Fertility Level and Crop Prediction," SSRN Electronic Journal, Apr. 2020, doi: 10.2139/SSRN.3561682.

[14]J. Valencia, J. B. Baleros, A. V. M. Bartolome, C. Orong, C. L. Rutaquio, and W. V. Ramos, "Monitoring and Control of Soil Acidity and Moisture by Using Microcontroller Unit for Capsicum frutescens," Ascendens Asia SingaporeBestlink College of the Philippines Journal of Multidisciplinary Research, vol. 2, no. 1, Apr. 2020, Accessed: Dec. 12, 2022. [Online]. Available: https://ojs.aaresearchindex.com/index.php/aasgbcpjm a/article/view/1393

[15]A. Oberoi, S. Basavaraju, and S. Lekshmi, "Effective Implementation of Automated Fertilization Unit Using Analog pH Sensor and Arduino," 2017 IEEE International Conference on Computational Intelligence and Computing Research, ICCIC 2017, Nov. 2018, doi: 10.1109/ICCIC.2017.8524170.

[16]M. Yousaf et al., "Effects of fertilization on crop production and nutrient-supplying capacity under rice-oilseed rape rotation system," Scientific Reports 2017 7:1, vol. 7, no. 1, pp. 1–9, Apr. 2017, doi: 10.1038/s41598-017-01412 0.

[17]"Benefits of Using Agile Project Management." https://www.villanovau.com/resources/project management/the-use-of-agile-project-management-is increasing/ (accessed Aug. 03, 2023).

[18]EPTC : 2017 IEEE 19th Electronics Packaging Technology Conference : 6-9 December 2017.

[19]"What is Compatibility Testing In Software | The Ultimate Guide." https://www.hurix.com/compatibility-testing definition-types-process/ (accessed Jul. 29, 2023).

[20]"Why Mobile App Testing on Low-end Devices is Important?"https://www.softwaretestinghelp.com/mbile-testing-low-end-devices/ (accessed Aug. 03, 2023).

[21]"WiFi Signal Strength — How to Boost It With NetSpot." https://www.netspotapp.com/wifi-signal-strength/ (accessed Aug. 03, 2023).

[22]N. Z. A. Fakri, A. Ismail, and A. M. Lokman, "UserRequirements and Usability Testing on a Mobile Application for Food Ordering Canteens," Malaysian Journal of Medicine and Health Sciences, vol. 18, pp. 34–39, Jul. 2022, doi: 10.47836/mjmhs18.s9.5.

[23]"What is Usability Testing? How to Evaluate the User Experience | Maze." https://maze.co/guides/usability testing/ (accessed Jul. 29, 2023).

[24]"Module Testing - GeeksforGeeks." https://www.geeksforgeeks.org/module-testing/ (accessed Aug. 03, 2023).

[25]"What is a validated test instrument or survey? – Ask Us!" https://ncu.libanswers.com/faq/168343 (accessed Jul. 29, 2023).