EAAICS: A TECHNOLOGICAL DRIVEN SYSTEM FOR IMPROVING CROP PRODUCTIVITY

Adebukola Onashoga[1], Afolabi AbdulAzeez[1], Femi T. Johnson[1], Afolorunsho Rele[2], Nwaocha Vivian[2]

[1] Federal University of Agriculture, Department of Computer Science, Abeokuta, Ogun state, Nigeria
[2] National Open University of Nigeria, Faculty of Information Management Systems, Abuja, Nigeria

Corresponding author: Femi T. Johnson, femijohnson123@hotmail.com

ABSTRACT: This paper proposes an Embedded Arduino Automatic Irrigation-Control System (EAAICS), which monitors and maintains the desired soil moisture content via automatic watering using embedded technology. The methodology employed in this paper is solely based on the integration of both hardware and software components to design and implement an App-controlled irrigation system, which solely depends on the soil moisture content. Input to the system was derived from soil samples with the aid of a soil moisture sensor and a microcontroller controlled the rate of flow of water from an electric water pump. A prototype was tested using a flower pot containing an ornamental plant, which was watered adequately through the mobile application and it grew to become a beautiful and blossom plant after forty days. The prototype showed that it would really help bring more yield from crop production if introduced into many farms regardless of the size. To perceive the ease of system's usefulness, it was later introduced to small and large-scale farmers to aid their farming activities and evaluated with the Technology Accepted Model (TAM). The results yielded a high acceptance rate by the respondents, which in turn signifies the importance of introducing embedded technology in automating irrigation system for better productivity.
KEYWORDS: Irrigation, Soil moisture, Arduino Technology, Embedded system Application, Controller

1. INTRODUCTION

The continuous increase in the demand of food requires a rapid improvement in the introduction and application of technology to aid agricultural practices. The volume of water utilized by agricultural based industries is high and thus would amount to much money when valued. The ones who manage this resource efficiently will be winning time and money [14]. The conventional rain induced agricultural system of irrigation has been in-efficient due to global warming and has resulted into the ever increase in the need for improved irrigation systems. Irrigation is mainly practised during periods of inadequate rainfall or dry seasons.
Practical experiences reflect that the artificial application of water to crops significantly increases yield to an appreciable value [13]. It was also further speculated that about 70% of the grain production in the world will be from irrigated lands and the available water resource for irrigation has to be put to optimal use through appropriate technology [4].
Other beneficial effects of irrigation includes the maintenance of landscapes, suppressing growth of weeds, protecting plants against frost and preventing soil consolidation [18]. Developed irrigation systems have also been used for dust suppression, disposal of sewage and in mining [10]. Traditional method adopted required the usage of backpack sprinklers and turnable watering cans which are operated manually [2]. This paper proposes the usage and implementation of real time Embedded Arduino Automatic Irrigation-Control System (EAAICS) as an improved technological driven system to minimize human effort in the irrigation of plants. Readings taken by the soil sensor are also used to automatically turn on/off the system. This paper is further organized as follows: Section 1 gives a brief introduction into irrigation and identified some of its beneficial effects. Section 2 presents a detailed review of related works on irrigation control and highlights methods of irrigation including an overview of embedded systems with the specification of adopted device used. In section 3, the methodology adopted in this research was clearly explained in details. Lastly, section 4 contains result analysis and evaluation. The conclusion of the research work is also presented in the later end of the paper

2. LITERATURE REVIEW

Ashwini in [2] proposed an automated system, which supplies water to the plant automatically when required. The sensors sensed the moisture content of the soil by sending current through the soil and measuring its output (resistance). The ability of water to conduct electricity was a basic principle in the system because water conducts electricity [19], so less resistance means that there is water present in the soil. Whenever there is more resistance, it means there is less water in the soil and irrigation needs to be performed on the farm land. Jaichandran [7] also proposed in an automatically controlled and remote accessed irrigation motor. Their developed prototype was claimed to assist farmers in controlling irrigation from remote locations. A successful implementation in [19] of a develop system tagged water flow sensor system for irrigation by Sanjukumar proved very effective in monitoring the flow of water. A preset value of moisture can be inputted and users are updated regularly about the value of all required parameters (temperature, soil moisture etc.) on LCD display. Future work for their system proposes the inclusion of other soil parameters such as soil pH, soil electrical conductivity etc.

As an attempt to automate the various activities on a farm land, [8] incorporated a new design consisting of an automated light, temperature, humidity and sprinkler system for animal enclosures to improve the overall health conditions of livestock. Animals were kept safe in their enclosures through a password protected digital lock, in order to facilitate the easy movement of animals a release door was also incorporated. The system efficiently conserved energy, water and reduces manual labor to a great extent. Results showed great improvement in the quality of livestock produced as the system was energy efficient and very convenient for the farmers.

The adoption of inteligent systems to aid agricultural activities was clearly emphasized by Femi and Joel [5] as a reliable and techno-efficient approach with future directions geared towards introducing highly techno-efficient intelligent systems requiring little or no human effort to improve crop yield. Arunlal stated in [1] that IoT is closely related to cloud computing in a way that IoT obtains powerful computing tools through cloud computing and cloud computing finds the best practicing channel based on Smart Agriculture. Associated hardware resources in agricultural information network are integrated into resource pool by using virtualization technology[15], achieving dynamic distribution of resource and balance of load, significantly improve efficiency of resource used.

2.1 Methods of Irrigation in Agriculture

Controlled application of water to plants at desired time intervals results into effective irrigation process. Several methods of irrigation exist with varied mode of adequate water application which include surface, ditch, terrace, drip, rotary and sprinkler[16] .

2.1.1 Overview and uses of Embedded Systems

The usage of embedded systems engulf all aspects of modern life and there are many examples of their use such as in home automation, medical and healthcare delivery, government, industries, agriculture etc. They require processing units to accomplish their intended tasks [9]. These tasks are majorly controlled by their in-built processors which may be grouped into two categories namely: ordinary microprocessors (μP) and microcontrollers (μC). Microprocesssors are fixed on ready-made computer boards [20] with embedded real time operating systems such as MicroC/OS-II, QNX or VxWorks for small, low-volume embedded and ruggedized systems [11].

A significant advantage is the low-cost components that may be used along with the same software development tools [12], used for general software development. Many systems in use today possess the characteristics of embedded systems.

2.2 Specification of Adopted Microcontroller and Sensor

There are several types of Arduino boards which allow codes to be loaded into their memory [6]. However, the adopted type for use in this paper is the Arduino Uno ATmega328 AVR Microcontroller as shown (Figure 1) with the underlisted features:

- Three 8-bits bi-directional I/O ports with internal pull-up resistors.
- 32K Bytes of flash memory.
- 1K Bytes EEPROM
- 2K Bytes of RAM
- 2 instruction words/vector.
- Programmable Serial USART

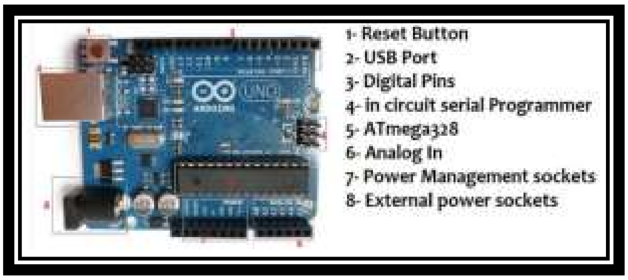


Figure 1. Arduino Uno

A YL-69 Moisture Sensor (Figure 2) consisting of two electrodes for reading moisture content by passing current across the electrodes through the soil was utilized. The resistance to the flow of current in the soil determines the level of the soil moisture. This sensor also comes with a small PCB board fitted with LM393 comparator chip and a digital potentiometer with specification as shown in Table1.

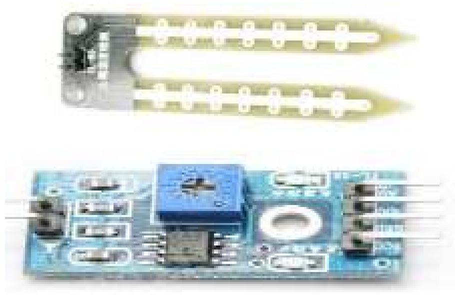


Figure 2: YL-69 Sensor and YL-69 PCB

In addition to the requirements for performing this research, software integration is necessary through a mobile application developed using the Google App Inventor. Figure 3 shows the interface of the intuitive way of programming by positioning instructions (codes) like pieces of puzzles with the Google App Development Inventor.

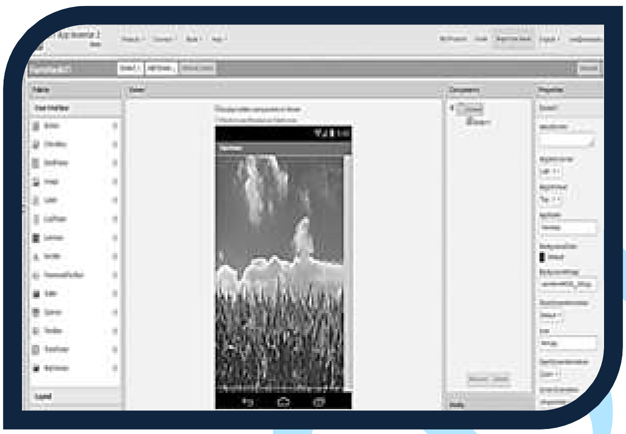


Figure 3. App Inventor Development Interface

Table 1. YL-69 specifications

Vee Power Supply	3.3v or 5V
Current	35mA
Signal Output Voltage	0-4.2V
Digital Outputs	0 or 1
Analog	Resistance(ohm)
Panel Dimension	3.0cm by 1.6cm
Probe Dimension	6.0cm by 3.0cm
GND	Connected to ground

3. METHODOLOGY AND MATERIALS

3.1 Soil Moisture Data Collection

Experimental soil samples collected through random sampling technique from the university farm were analysed for the required soil parameters. This technique enabled soil samples to be collected at five different locations on the farm in separate containers. Mathematical representation of the samples is presented as

$$Soil\ Samples\ (Sls) = \{Sl(A), Sl(B), Sl(C), Sl(D), Sl(E)\} \quad (1)$$

where

$Sl(A), Sl(B), Sl(C), Sl(D)\ and\ Sl(E)$ represent the experimental soil samples from different locations. In order to ensure uniformity in the mass of soil samples (MSls) collected, a weighing scale was deployed to accurately measure the different mass of soil samples *(A, B, C, D and E respectively*) as shown in equation (2) before determining the moisture content of the collected soil samples.

$$Mass\ of\ Soil\ Samples\ (MSls) = \{mSl(A), mSl(B), mSl(C), mSl(D), mSl(E)\} \quad (2)$$

Such that $mSl(A) = mSl(B) = mSl(C) = mSl(D) = mSl(E) = 200g$

$$MSl\ (\text{Total}) = \sum_{n=1}^{5} MSl(A) + MSl(B) + MSl(c) + MSl(D) + MSl(E) \quad (3)$$

The Total weight of the soil samples collected was calculated using equation (3). Calculation carried out on soil samples also depicts that there exist variations in the water holding capacity at different areas on the farm land. However, the percentage moisture content (Mc) of the soil samples (A, B, C, D and E) as represented in equation (4) is derived by equation 6 and 7.

$$Moisture\ Content(Mcs) = \{Mc(A), Mc(B), Mc(C), Mc(D), Mc(E)\} \quad (4)$$

$$Weight\ Difference\ (W.Diff) = Ini.W - Fin.W \quad (5)$$

$$Moisture\ Content(Mc)\% = \left(\frac{Ini.W - Fin.W}{Ini.W} \times 100\%\right) \quad (6)$$

$$Moisture\ Content(Mc)\% = \left(\frac{W.Diff}{Ini.W} \times 100\%\right) \quad (7)$$

Given that (Mcs) is the moisture content of the soil samples, *Ini. W* and *Fin.W* are the initial and final weight of soil samples respectively. Equation (5) calculates the differences in grams of the soil samples before and after the irrigation process. Information contained in table 2 summarizes the data collected for the research.

Table 2. Percentage moisture content from the collected soil samples

S/n	Soil Type	Ini.Weight (g)	Fin. Weight (g)	Weight Diff. (g)	Moisture Content (%)
1	Sample A	200.5	160.9	30.6	17.56
2	Sample B	200.5	170.7	20.8	13.66
3	Sample C	200.5	150.4	50.1	24.88
4	Sample D	200.5	150.0	50.5	26.83
5	Sample E	200.5	140.4	60.1	29.76

In a bid to determine water retaining capacity of the different soil samples, a few quantity was added to the soil samples in different pots and the soil values were re-measured with readings taken as depicted in Table 3.

Table 3. Soil samples Moisture content and pH readings after manual application of water

S/n	Soil Type	Moisture Content (%)	Soil PH
1	Sample A	66.56	6.74
2	Sample B	62.43	6.86
3	Sample C	64.78	6.55
4	Sample D	72.10	7.24
5	Sample E	75.45	7.18

3.2 Software and Hardware Design

Integration of both software and hardware is a necessary methodological requirement for this research. This includes MIT App Inventor and Embedded system for designing the mobile application and controlling the system respectively. Figure 4 shows a block diagram of the developed system. Communication of data between the application software and developed system was possible through bluetooth connections with readings taken from five different soil samples at the university farm.

3.2.1 Control Unit

ATMega328P microcontroller on Arduino platform serves as the control unit of the system. Arduino Uno in its manufacturers specification has six (6) analog and fourteen (14) digital input pins. The digital pins can be used as either inputs or outputs and also 6 of the 14 pins can be utilized as PWM. Embedded with the control unit is a sixteen (16) MHz resonator system board with ports for connecting a Univeral Serial Bus (USB) cable and a power jack for electricity supply. In the design of the system, analog pins were selected as the input pins and digital pins were selected as the output pins. The microcontroller which also hosts the program code controls the operation of the motor, which the water sprinklers are attached, in response to messages received from the connected smart phone with the aid of the installed mobile application

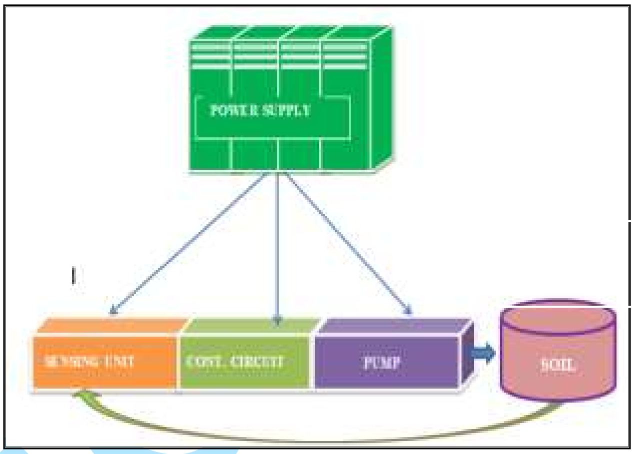


Figure 4. EAAIC System Block Diagram

3.2.2 Sensing Unit

YL-69 soil moisture sensor was interfaced to the Arduino through a digital PCB drive. A LM393 comparator interfaced with the PCB drive was used to compare the voltages across the sensor probes and the set Vcc voltage. Analogue configuration was selected because of its improved stability over the digital configuration. In addition, a PCB drive pin A0 was connected to the Arduino analog pin A0. An ultrasonic sensor senses the height of the water in the tank through its echo and trigger pins which enables it measure distances. The system therefore automates an existing water pump to fill the tank and also activates the pre-existing irrigation method.

The Ultrasonic sensor is placed on the cover of the tank to measure the level of water in the tank in order to stop the electric pump from supplying water when the optimum mark is reached. The soil moisture sensor also detects the amount of water in the soil for the microcontroller to decide when to pump water from the overhead to the sprinkler or to wet the crop field.

Actions being performed are displayed on a LCD monitor based on the instructions received from the mobile application. Similarly, the readings obtained by the microcontroller from the soil moisture sensor and the ultrasonic are also depicted on the monitor which displays “Dry soil”, ”Full tank”, or “Empty Tank” as programmed in the microcontroller.

3.3 System Framework and Design

Figure 5 depicts the framework of the embedded irrigation system. At the initial stage, these components are connected as shown in the circuit diagram. A program is written for the microcontroller to interpret the different states of the soil as prompted by the soil sensor. The Arduino integrated development environment (IDE) was used for the software design. The idea is based on C++ and thus can be extended using C++ libraries.

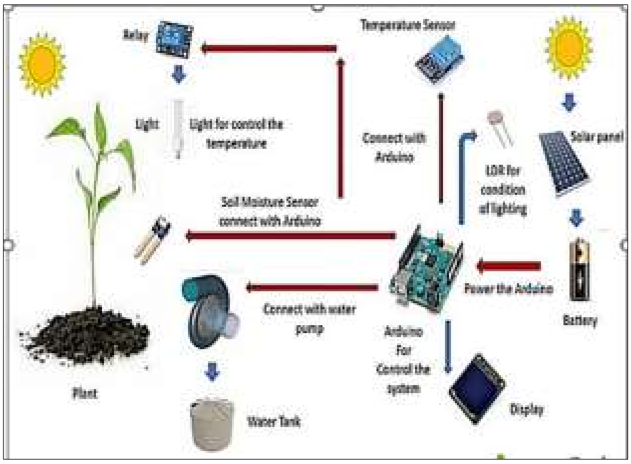


Figure 5: The EAAICS Framework

3.4 System Coding and Implementation

Implementation process involves the development of mobile application with an installed MIT App inventor. System coding was initiated by dragging and dropping blocks relating to the software coding instructions. Intuitive buttons and palettes contained in the user interface of the designed application are:

a. List picker: Picks the bluetooth host to connect with.
b. Status Label: Indicates if bluetooth connection was successfully established.
c. Buttons: To wet the soil or fill the tank.
d. Bluetooth widget: To make the app request for bluetooth on opening.
e. Notifier: Notifies user when tank is full on the application.

In addition, a programmed microcontroller with the aid of the Arduino IDE conveyed instructions and written codes through a USB to Serial port.

The soil moisture pins are connected to an analog pin and ground of the Arduino. Echo and trigger pins of the ultrasonic sensor are also connected to the digital pins of Arduino because it sends digital signal for the Arduino to read. Also, there exist a connection between the electric pump and relay connected to the Arduino board which triggers the power source on when the pump button is pressed on the mobile app.

Figure 6. The MIT Application coding interface

4. RESULTS AND DISCUSSION

Evidently, from this research, it has been observed that there exist variations in the moisture content of soil samples collected at different locations on the same piece of farm land as shown in Figure 8. Thus, it is mandatory that these variations be put into consideration when deciding on the type of crop and the amount of water to be supplied during irrigation process.

This research also buttresses the fact that the volume of water used during irrigation is dependent on seasonal changes. An examplary case is Nigeria, during dry season it is usually observed that atmospheric temperature rises, soil losses more water through evaporation and moisture content is greatly reduced compared to wet or rainny season when soil moisture is increased. Figure 7 depicts a comparision chart between the volume of water discharged in millilitres into different soil samples to reach a pre-defined value expressed in percentage with varying degrees of mosture content for a period of ninety seconds.

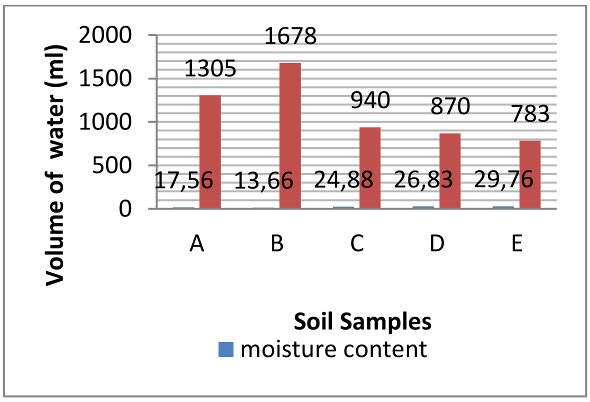


Figure 7. Graph of discharged water volume

In addition, the volume and accuracy of water applied during manual irrigation was rated against automatic irrigation performed by the embedded system. The embedded system controlled automatic irrigation out-performed the manual type with a significant reduction in the volume of water discharged. An approximate value of 570ml of water was saved due to the sensitivity of the moisture sensor to precisely determine the pre-defined moisture readings, effective curbing of water spillage to undesirable locations and leakages from water pipe. This significant improvement is better appreciated when irrigation is performed on a very large area of land. The improvement noted above will also help in reducing farmers cost of suppling water for irrigation process as only the right quantity will be used during the process. Crop yields also blossom bountifully as crops do not need to be die due to insufficient water, imbalanced moisture content or the soil be overlogged with water which may adversely affect the crop yield. The relationship which exists between the initial moisture content of collected soil samples before and after the application of water is depicted in Figure 8. Soil pH of soil samples derived in this research are also depicted in Figure 9.

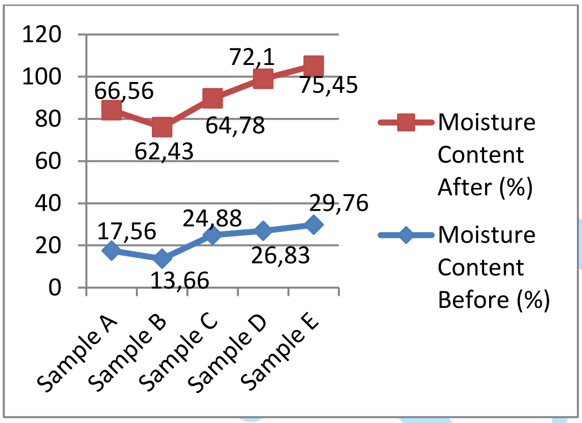


Figure 8. Variations and Relationship between soil moisture content

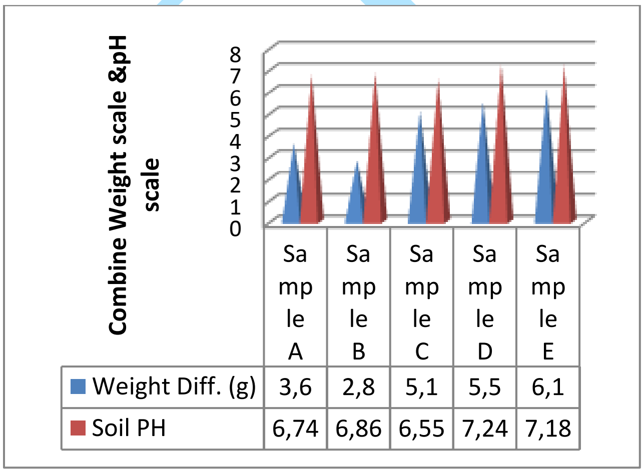


Figure 9. Combined weight Difference and soil pH values

4.1 Evaluation: The System's Technology Acceptance Model (TAM)

A practical evaluation of the system was done using Technology Acceptance Model (TAM) developed by Davis [3]. This model describes the level of acceptance and usage of newly developed information systems by individuals. Many resarchers have adopted TAM and have emperically proven its appropriateness and validity for testing the usage of information sytems [17].

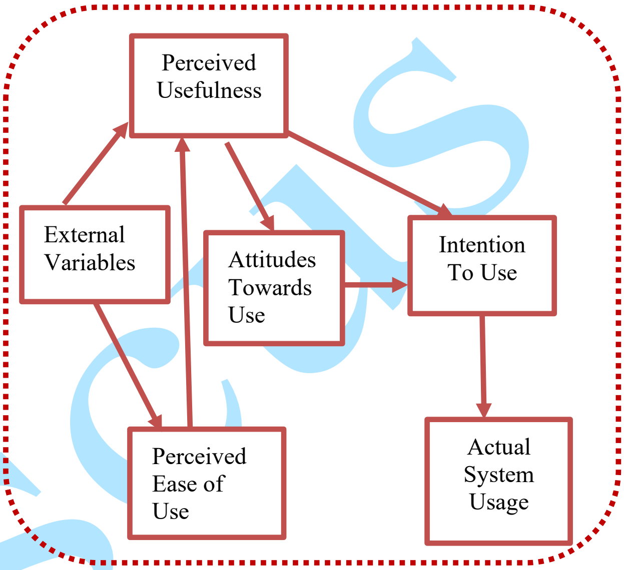
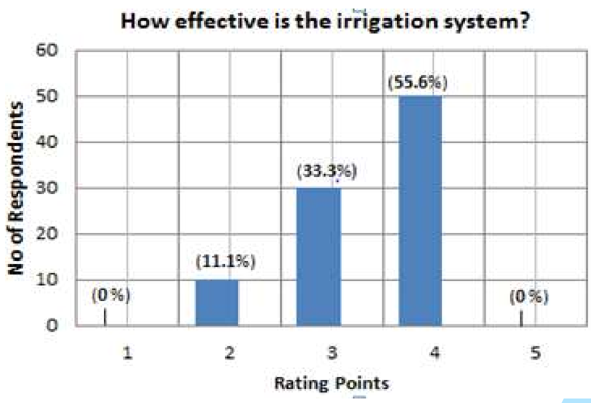


Figure 10. Technology Acceptance Model Chart

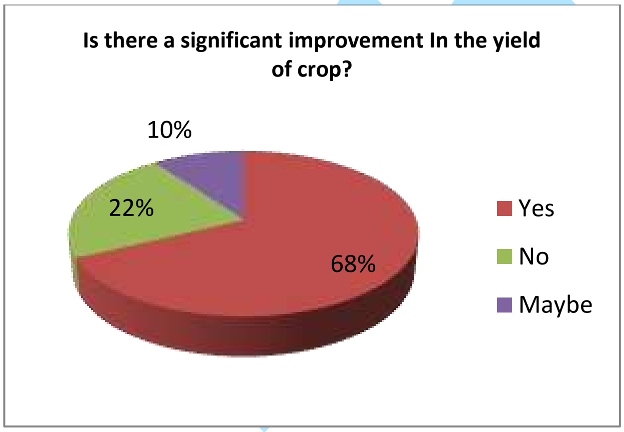
TAM theorizes that an individual's behavioral intention to adopt a new system is determined by two beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). Perceived Usefulness is a probability defined by the users (farmers) towards the adoption of a system to enhance their productivity. Associatively, is the the degree to which the users (farmers) expects the system to be used with minimal energy or free of effort termed as Perceived Ease of Use. This will enable the farmers spare and channel efforts towards accomplishing other tasks. Other factors included in the model are Attitude towards Use (AU) which provides a feedback towards the desirability evaluation of the system and the Intention to Use (IU) as shown in Figure 10.

A total of ninety (90) administered questionnaires to farmers were collected and analyzed based on the TAM. The bar chart below summarizes the responses regarding the effectiveness of the automatic irrigation method on a rating scale (1-5). Ten, thirty and fifty (10, 30 and 50) farmers rated the system as Fair, Good and Very Good respectively.

However, a total of 80 farmers with good responses have a higher probability towards the adoption of the method. A significant improvement in the yield of crop depicted in the pie chart was also noted among farmers, although 10% were indifferent in their responses, 22% responded negatively possibly due to their inability to take adequate measures or ascertain the level of their yield but the highest percentage of 68% was recorded among educated farmers who took proper readings of data and necessary precautions in the usage of the new system. The Perceived Ease of Use of the system among the farmers analyzed as depicted in Figure 11c indicated that more energy is being conserved through the use of the system for other farming activities thus increasing productivity and efficiency of the farmers.

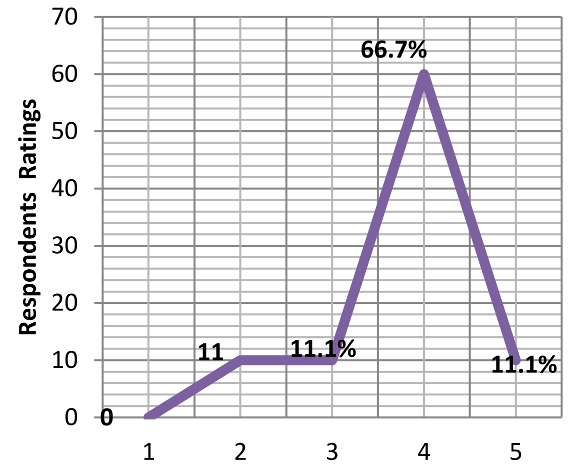


a. System Effectiveness rating



b. Crop Improvement

Furthermore, a parametric comparison of the system with similar systems shows significant improvement with ratings depicted in Figure 12. Table 4 presents the cost value (in naira) of some major components of the system at the time of development.



c. Series Analysis and Representation of Perceived Ease of Use

Figure 11. Result Analysis Based on Technology Acceptance Model

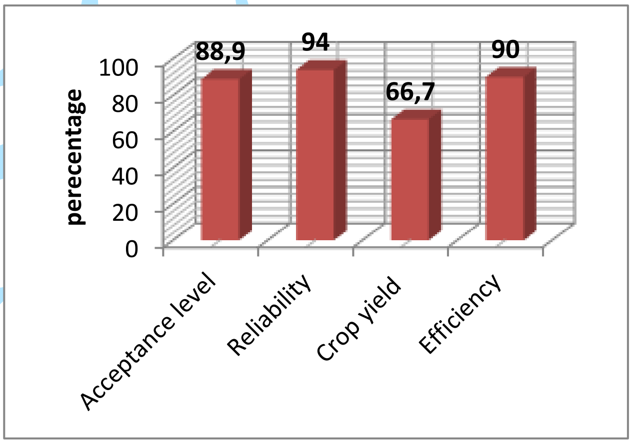


Figure 12. Specified Improved Comparison parametric ratings of the developed system

Table 4. Irrigation system major components cost

S/n	Components	Price (Naira)
1.	Arduino Uno ATmega328 AVR Microcontroller	62000
2.	A YL-69 Moisture Sensor	20000
3.	YL-69 PCB	20000
4.	Water level Determinant (Ultrasonic sensor)	20000
5.	LCD monitor embedded in a mobile phone	25000
6.	Water Supply Pump	25000
7.	DC Power Supply Unit	15000

5. CONCLUSIONS

Irrigation of plants is usually a very time-consuming activity, which requires large amount of human effort, resources and activities to be done in a reasonable amount of time. Nowadays, many systems have been developed to reduce the number of workers or the time required to water plants but with such systems, the control is very limited and many resources are still wasted. In this paper, a more efficient method is proposed using Arduino microcontroller controlled by a mobile application software to automate the entire process in a newly developed system. This system acts as a better alternative to other systems because it was designed having studied the features of existing systems, improving on their limitations and drawbacks.

Evaluation of the system showed that though being a novel development, it was largely accepted by 88.9% of the present farmers who tested and claimed that the system was effective enough to bring about a good percentage of yield to their production. Crops (precisely vegetables) yield increased maximally by a whooping percentage of 66.7% with vegetables becoming greener and fresher thereby attracting potential buyers and increasing sales for user farmer. The system was also perceived to be an added advantage to agriculture as all other farm activities could be incorporated in similar manner. An approximated value of 90% rating showed that the system is very useful and efficient in saving manual energy for other related farming activities.

In addition, the efficiency of the developed system may be improved by incorporating temperature and humidity sensors to monitor the overall weather conditions for more blossom crop yields. Integrating a GSM technology to send SMS or get the attention of the farmer through a customized tone regarding the status of the pump whenever it switches ON/OFF will be an added advantage to farmers as they are notified of the working status of the pumping machine. Moreso, the limitation observed regarding soil calibration can be averted by adopting a better and cost effective method.

Consequently, the idea of this embedded system for irrigation can be extended to other farm activities such as cattle management, fire detection and climate control as it will greatly minimize human intervention in the farming activities.

REFERENCES

[1] **Arunlal K. S. & Rajkiran S. N.** - *Smart Agriculture: IoT Based Precise and Productive Farming Approach*. International Journal of Advanced Research, Ideas and Innovations in Technology, Vol 4, Issue 6, 127-131, 2018.

[2] **Ashwini C., Diparna Adhikary, Amisha Mishra & Shruti Dugga** - *Automatic Irrigation System using Arduino. International Research Journal of Engineering and Technology* (IRJET), P-ISSN: 2395-0072, vol.5, Issue 10, 1436-1439, 2018.

[3] **Davis F. D., Bagozzi R. P. & Warshaw P. R.** - *User acceptance of computer technology: A Comparison of Two Theoretical Models*, Management science, issue 35, vol.8,.982-1003, 1989 doi: 10.1287/mnsc.35.8.982

[4] **Food and Agricultural Organization Report** - The State of Food Insecurity in the World 2015, Meeting the 2015 international hunger targets: taking stock of uneven progress' White paper from Food and Agriculture Organization Publications, Rome. Available online at http://www.fao.org/home/en/

[5] **Femi T. Johnson, Joel Akerele** – *Artificial intelligence for weed Detection-A Techno-Efficent Approach*, Internatonal ICTACT Journal of Images and Video Processing, Vol.11, Issue 2, 2299-2305, 2020.DOI: 10.21917/ijivp.2020.0326

[6] **Gutierrez J., Villa-medina J. F., NietoGaribay A. & Porta-Gandara** - *Automated Irrigation System Using a wireless Sensor Network and GPRS Module.* Journal of Instrumentation and Measurement, IEEE Transactions, Volume 6,Issue 1, 166-176,2014, doi:10.1109/TIM.2013.2276487

[7] **Jaichandran R., Irudhayaraj A. A., Surabhi R. K. & Sinha** - *Prototype for Automatic Controlling and Remote Accessing of Irrigation Motor*, International Journal of Innovative Research in Computer and Communication Engineering, vol.1, 4, 800-807, 2013.

[8] **Kanjilal D., Singh D., Reddy R. & Mathew** - J-*Smart Farm: Extending Automation to the Farm level,* International Journal of Scientific and Technology Research, vol. 3, issue 7, 109-113, 2014.

[9] **Karthick C., & Prabhakaran D.** - *Embedded System Based Remotely Operated Smart Irrigation System Using PIC18f455 Microcontroller,* International Journal for Research in Applied Science and Engineering (IJRASET), Vol. 5, Issue xi, 2199-2203, 2017

[10] **Luthra S. K, Kaledhaikar M. J., Singh O. P. & Tyagi N. K.** - *Design and development of an auto irrigation System*, Elsevier Journal of Agricultural Water Management, 33, 169-180, 2017.

[11] **Massimo Banzi** - *Getting started with Arduino*'.Second Edition, O'Reilly Media, Inc. 2nd Edition, pp.130, 2011

[12] **Muñoz-Carpena R., & Dukes M**. - *Automatic Irrigation Based on Soil Moisture for Vegetable Crops*.EDIS, 2005, volume 8., 2019. https://journals.flvc.org/edis/article/view/114983

[13] **Onashoga S. A., Ojesanmi O., Johnson F., Ayo E.** - *A Fuzzy-based Decision Support System for Soil Selection in Olericulture*, Journal of Agricultural Informatics, 9 (3); 65-7, 2018.

[14] **Pavithra D. S., &Srinath M**. - *GSM based Automatic Irrigation control system for efficient use of resources and crop planning by using an Android mobile*. IOSR Journal of Mechanical and Civil Engineering, p-ISSN: 2320-334X, vol.11, issue 4, 49-55, 2014.

[15] **Qiuming K., Yandong Z. and Chenxiang B. -** *Automatic monitor and control system of water saving irrigation*. Transactions of the Chinese Society of Agricultural Engineering, vol.6, 136-139, 2017.

[16] **Rajendranath UNVP & Berlin Hency** - *Implementation of an Automated Irrigation System.* IEEE Sponsored 2nd International Conference on Innovations in Information, Embedded and Communications systems, 2, 1-6, 2015.

[17] **Ramayah T., Ma'ruf J. J., Jantan M. & Osman M.** - *Technology Acceptance Model: is it applicable to users and non-users of internet banking*. The Proceedings of the International Seminar, Indonesia-Malaysia, the role of harmonization of Economics and business discipline in global competitiveness, Banda Aceh, Indonesia, 14-15, 2002.

[18] **Sadee B. A., Foulkes M. E. & Hill S. J.** - *A Study of Arsenic Speciation in Soil, Irrigation water and Plant tissue: A case study of the Broad Bean Plant, Vicia faba*, Food chemistry, vol.210,362-370, 2016. https://doi.org/10.1016/j.foodchem.2016.04.066

[19] **Sanjukumar R. K.** - *Advance Technique for Soil Moisture Content Based Automatic Motor Pumping for Agriculture Land Purpose*. International Journal of VLSI and Embedded Systems-IJVES, **ISSN:** 2249 – 6556, vol. 4. 559-603, 2013.

[20] **Venkata Naha G** - Microcontroller Based Automatic Plant Irrigation System. International Journal of Advancement in Research and Technology, Vol.2, Issue 4, pp.194-198, 2013.