JEEE-U
Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

Small-scale Automated Drip Circulation System

Sistem Sirkulasi Tetes Otomatis Skala Kecil

Yaw Obeng Okofo Dartey[1], Eno Boamah Osei Antwi[2], Maryam Munagah Bassit1[3], Elizabeth Ayaw Oduro-Koranteng[4]
[1]KNUST- College of Engineering Innovation Centre, Kumasi, Ghana
[1,2,3,4]Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[1]darteyobeng@gmail.com
[2]boamaheno22@gmail.com
[3]maryam.munagah01@gmail.com
[4]odurokorantengelizabeth@gmail.com

Abstract**—**Hunger and Poverty are one of the major problems faced in Sub-Saharan Africa. To get rid of this problem in line with the aim of the sustainable development goals, there is the need to increase current production levels of food. This can be achieved by mechanizing farming systems and introducing technology to farming systems. This paper seeks to introduce an automation system that uses automated drip irrigation with a circulation system to efficiently use energy and avoid the amount of water wasted during farming activities to attempt to increase food production levels.

Keywords— *small-scale farming; drip circulation; solar power generation; automatic watering.*

I. Introduction

The Sustainable Development Goals were introduced by the United Nations in the year 2015 as a mandate to end hunger and poverty, protect the earth, and ensure that by 2030 everybody enjoys peace and prosperity. The availability and accessibility of water, energy and food is essential in attaining these goals.

The water, energy, and food security nexus mean that water, energy, and food security are connected and dependent on one another according to the Food and Agriculture Organisation Agency of the United Nations. Africa's major challenge since time immemorial is hunger which is as a result of poverty. In order to bring about development to the continent, this challenge must be expunged. Hunger in this context can be understood as a condition in which a person cannot afford sufficient food to meet basic nutritional needs for a sustained period. Most Africans find themselves in this category as food security in Africa is very low. In a 2019 Africa Regional Overview of Food and Security and Nutrition by the Food and Agriculture Organisation, it was reported that Food insecurity has been rising in Africa in recent years and the continent is not on track to eliminate hunger by 2030.

Africa has a total population of 1.34 billion, however, the United Nations Conference on Trade and Development's recent figures shows that 73 million people are food insecure. This implies that it is only a few countries in Africa that are food insecure. Most of these countries are Sub-Saharan African countries. 25.06% of the 814 million undernourished people in the world live in sub-Saharan Africa(Nosipho Hlophe-Ginindza and Mpandeli, 2021) The United Nations predicts that by 2050, 86% of the world's population living in extreme poverty will be concentrated in sub-Saharan Africa(Nosipho Hlophe-Ginindza and Mpandeli, 2021) In Ghana, for instance, studies have shown that about 5% of Ghana's population are food insecure and about 2 million people are vulnerable to becoming food insecure.

Agriculture is one of the most essential economic sectors in Ghana, employing more than 50% of the population as and accounting for close to 50% of gross domestic product as well as export earnings and is dominated by small-scale farming(Darfour and Rosentrater, 2016). The number of small-scale farmers in Ghana should be enough to alleviate the problem of food insecurity in Ghana. Ghanaian small-scale farmers grow a myriad of crops in the different climatic zones in the regions in the country. Ghanaian farmers grow 51% of cereal needs, 60% of fish requirements, 50% of meat, and less than 30% of the raw materials needed for agro-based industries(Darfour and Rosentrater, 2016).

[Figure 1 about here.]

Ghana can undoubtedly be considered as an agriculture-dependent nation, although technology is almost non-existent in farming activities and practices.(Darfour and Rosentrater, 2016) The country is however burdened with food insecurity. To ensure food security in the future, current food production

10.21070/jeeeu.v5i2.1576

levels will need to be increased by nothing less than 70%(Nosipho Hlophe-Ginindza and Mpandeli, 2021) There is therefore a very strong need to mechanize small-scale farming and introduce technology to the farming industry in the country. Farms around the world are accountable for 70% of all water that is used in a year. Out of which 40% is lost to the environment due to poor water management by farmers(Technologies, no date).

The solution talked about in this paper reduces the amount of water wasted during farming because it uses rain reservoirs with the help of gravity. The involvement of hydroponics allows water to be recycled every two weeks. Water is pumped into a poly tank using capillary action aided by a solar-powered pump to be used in the event of scarcity of water for production to occur all year long and not affected by climatic changes. Earlier studies have shown a wide gap between the energy required and what is available to meet the objectives of agricultural mechanization. This system, therefore, uses solar energy which is readily available to power the system.

This paper proposes an automated drip irrigation system for small-scale farms that runs on solar energy and can be modified. Chapter II reviews similar systems designed by researchers, III explains the materials and methodology used in designing the proposed system and IV talks about the operation of the system and V discusses the possible use cases and concludes.

II. RELATED WORKS

Prakash et al(Ani and Gopalakirishnan, 2020) presented work on the design and concept of a prototype model that involves smart wireless fertilizer dispensary systems that use drip irrigation aided by Zigbee and GSM technology. This paper mainly focuses on optimum fertilizer distribution among crops using the nutritional requirement for each crop. The higher advantage this system has is the fact that when the system is operating in automatic mode, it mixes the right amounts of nutrients needed by just remotely selecting the crops. It also has a rain detector that restricts the opening of the valves when it is raining. However, this system does not detect soil moisture hence, it is unable to tell if the crop has too much or too little. Zaher et al(Bhattacharjee, Prakash and Islam, 2018) highlighted the use of potential energy for irrigation using drip tape enhancing efficient water distribution ensuring the minimum usage of energy. Unlike other papers, this paper is keen on the use of renewable energy in the sense that potential energy is mainly used for irrigation using the drip tape which ensures even distribution of water. A water sensor is programmed to control the operation of the pump preventing the crops from drowning. However, this system would have been more efficient if it was a circulation system.

Ani et al(Ani and Gopalakirishnan, 2020) presented a system that recorded the value of the sensor values and manipulated the nutrient values when required. This system presents an automated system that provides the amount of water and fertilizer to plants. The results are organized monthly into a scheme for both water and fertilizer. However, the system is not able to detect the nutrient level and would continue to run on the same amount until the values are updated by the user. Chontanaswat et al(Tangwongkit, Tangwongkit and Chontanaswat, 2014) designed and tested a suitable set of drip irrigation powered by a solar cell in a dry rainfed and no electricity area. The system designed was easy to install and move about and hence they could be moved to other farms. The drawback of this system is that the water would have to be refilled continuously making the system cost and labour-intensive. Parimala et al(Rani, 2021) introduced an automated water system and fertigation process using remote sensors. This designed system controls fertilizer waste by using automatic water and fertigation systems using remote sensors. Here farmers are allowed to monitor their farms and control the whole process remotely. They can also monitor soil parameters using a phone app. Considering the demographic of other countries, most farmers may not understand the mobile app making this system a bit complex.

[Table 4 about here.]

Andaluz et al(Andaluz *et al.*, 2016) presented a paper that discusses the control drip with a developed interface between the human and machine which monitors the moisture, pH, temperature, and electrical conductivity of the soil using sensors. Part of the paper highlighted the distribution of the tomato's nutritional requirements based on the physical variables measured. This paper was restricted to only tomatoes hence, it is unknown if this system is feasible for other crops. Again, obtaining results would be difficult. Sudana et al(Sudana, Eman and Suyoto, 2019) explained the application of non-circulating hydroponic systems with IoT to paprika plants. This system is expected to reduce the level of damage to paprika plants which is an improvement on regular irrigation systems. Here hydroponic drip management is implemented using Arduino Uno Microcontroller that uses sensors to measure the soil moisture, temperature, and pH. This system can be managed using mobile devices which are expected to be able to provide the efficient use of nutritious water. The drawback of this system is that it is limited to paprika plants. Another drawback is the fact that the system is a non-circulation system. Here water is not used efficiently.

Shonkra et al(Shonkora and Salau, 2020) proposed a system that makes use of sensors to observe the soil moisture and temperature data obtained from the microcontroller. This is an automated system implemented using a PIC16F877A microcontroller connected to an array of sensors and

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

actuators. The system is configured not to work when it is raining and during the day since it is not advisable for irrigation to occur during the day. The authors proposed an automated drip irrigation system with weather forecasting. The system consists of a transmitter and receiver module that are wirelessly connected. The transmitter consists of a microcontroller and weather forecasting equipment which sends data to the receiver module. The pump operates based on the data obtained. Thus, water is utilized efficiently and effectively. However, this system may not allow the plants to receive the right moisture requirements since the data is not based on soil parameters. In (Bottazzi and Altobelli, 2020) authors monitored the performance of the various rice varieties when subjected to drip irrigation. After the first year, the results showed that the drip irrigation technique could maintain high production levels for most of the varieties. However, it was concluded that this irrigation technique does not work for all the varieties since the varieties belonging to the Lango B group could not adapt to the conditions of the experimental site.

In (Jain *et al.*, 2020) the authors discussed an IOT enabled automatic drip irrigation system that uses a web application interface with a microcontroller responsible for controlling the soil sensor, temperature, and humidity. Web applications were introduced to monitor and control the plants. This system ensures that water is used efficiently for irrigation. It also allows farmers to observe and cater crop yield and production on the whole. Narciso et al(Caya *et al.*, 2019) proposed the creation of a drip irrigation system that can adapt to variable flow input. It defines the creation of a drip irrigation system with a predefined water threshold. The main objectives of this research were to create a device that uses drip irrigation to water plants and to restrict the drip irrigation system to produce the required amounts needed by plants. However, this system was restricted to small areas and used AC power. This does not make the system energy efficient. Other renewable sources such as solar power could have been used.

III. MATERIALS AND METHODOLOGY

The Automated Drip Circulation System (ADCS) is designed with small-scale farmers in mind, to ease the burden of watering plants frequently and also to maintain optimal nutrients in the water needed to water the plant. The ADCS is designed to work with low torque motors due to the drip irrigation system implementation and use less energy in operation, this allowed us to harness the energy-saving prowess of Solar Photo Voltaic power with a solar panel and battery storage for watering the farm at night and monitoring the water in the reservoir. The entire system can be divided into three components as seen in

Figure **2**. There is the Water Reservoir component which comprises, the System Control Component and the Farm.

A. System Control Component

This can be described as the brain of the ADSC and houses the user indication elements. A photovoltaic module or solar panel that harnesses the energy from sunlight using its photocells is the source of electricity for this system. There is a battery to ensure that the system runs 24hours the day; even at night when the panels are no longer collecting energy. Connected directly between the Solar Panel and the battery is a Charge Controller that regulates the rate of electric current being added to the battery, prevents any occurrences of overcharging, and reduces the chances of overvoltage. The main controller is connected directly to the charge controller for the power supply. The water pump in the reservoir is also powered through the charge controller.

[Figure 2 about here.]

The main controller controls all inputs and outputs of the ADSC. An Arduino Uno Microcontroller is used because of its processing power, durability, and low cost. With the 5V pin on the Arduino, LED indicator lights can be powered and controlled to signal to the farmer at any given time what is happening to the system. Indicator Light Emitting Diode (LED) 0 is always on when the controller has power, it is the System On indication light. Indicator LED 1 comes on when the when the system is on. Indicator LED 2 comes on when the water reservoir detects a low water level and alerts the farmer. The light remains on until the water level is increased. RGB Indicator LED 3 is the only RGB indicator light in our system, this is to reduce complexities in communication with the farmer and regulate the number of indicator lights. This indicator changes colour depending on the reading of the pH sensor. When the LED shows amber or yellow, it means the pH level of the water reservoir is low, it shows green when the pH level of the water reservoir is at a reasonable range and health for the crop and shows red when the pH level is high.

The optional buzzer is installed to alert the farmer when the water levels are low, when the pH reading is low or when the pH reading is too high. This is useful to inform the farmer from a distance without him or her coming close to the system, this ensures prompt response. The farmer can know what is wrong with the system by reading the Indicator LED values.

[Figure 3 about here.]

The HC-SR04 and pH sensors in the water reservoir are connected as inputs to the controller which runs the algorithm in

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

Figure 5 and outputs the results as indicator lights for the farmer to easily understand happening at a given point in time.

B. Water Reservoir Component

The water reservoir connected directly to the farm is an intelligent system that waters the farm, collects the recirculated water, reads the needed vitals of the water in it and sends the information to the system control component to be communicated to the farmer in real-time. A HC-SR04 Ultrasonic Sensor is proposed for this use because of its reliability and its high accuracy range of non-contact sonar detection of system components, additionally its cost and compatibility with the controller of choice made it a perfect fit to be used(Hidayat *et al.*, 2019). The pH sensor gives us the levels of acidity or alkalinity of the water in the reservoir as this regulates the availability of the nutrients within the soil the reservoir feeds and this goes a long way to influence the health of the plants. A low horsepower water pump is submerged into the water reservoir and instructed by the system control component on when to pump water from the reservoir into the farm. These electronic components must be installed in a way to prevent water from damaging them or rusting due to the moisture in the reservoir. The farmer manually refills the reservoir.

In a typical smallholder farm in Ghana, it is ordinary to see a barrel or reservoir that holds water from either the rain or the towns water supply. The ADSC will not be connected directly to such systems because of their typical large size and the fact that it is often difficult to control measures such as the soil pH consistently and with a minimum margin of error, hence the reason to use another smaller retrofitted reservoir to directly water the farm. This reservoir is as mentioned in the previous paragraph is designed to safely house the electronics and also has an inlet to collect the excess water from the plant-soil as part of the circulation system to ensure that minimum water is wasted and increase the efficiency of watering.

[Figure 4 about here.]

C. Farm Setup

The ADSC can serve farms that grow shallow-rooted crops or crops that can be placed in a pot. Correct Row Planting must be ensured to help organize the watering probes that are inserted into each pot. As seen in

Figure 4 the setup should allow for excess water to be harvested and sent back into the reservoir for future use.

The total number of probes used in a system is a factor of the area of the planting setup in use. The bigger the setup, the more probes have to be used and a higher horsepower pump has to be used to ensure that adequate water reaches all planting pots. The pump of choice or size is determined by the water horsepower(whp) which is a factor of the pumping rate of the system in gallons per minute(gpm) and the total dynamic head (TDH) measured in feet. (Fipps, 1995) gives more details on the proper mathematical calculations needed to choose the perfect pump and ensure efficient energy use.

$$whp = \frac{gpm\ x\ TDH}{3{,}960} \qquad (1)$$

TDH is seen as the total load on the system in feet and is calculated by static head + friction loss + operating pressure + elevation change. Equation (1) further explains the calculations.

ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

IV. Operation

[Figure 5 about here.]

The figure above shows a flow of electrical signals through the ADSC system and how each of the components of the Water Reservoir component, System Control component and the Solar power system work together to make farming easier for the user.

1. Indicator LED 0 turns on to show that the system is working.
2. The current system time is collected, the system then checks if the current time is between 4 AM to 6 AM GMT. If this is true then the pump is activated (moving the water from the water reservoir to the watering probes in the farm).
3. If the statement is false it moves to check if the time is between the hours of 5 PM to 7 PM GMT. If this statement is false; the code goes back to input the current time. If the statement is true, it activates the pump. After the pump is activated Indicator LED 1 is turned on.
4. The Water Reservoir Sensor readings are input. If the HC-SR04 reads the water level is low then the indicator LED 2 comes on and the Buzzer sounds, this continues till the sensor reads true. If the decision is false, the code goes back to check the water level again.
5. The pH sensor is read, if the sensor feedback shows a low pH level or true the RGB indicator LED 3 shows the colour amber or yellow and the buzzer is sounded. If the low pH decision is false, the code checks if the reading is a good pH value.
6. If this is true the RGB Indicator LED 3 shows the colour Green and no Buzzer sounds. If false the code checks to see if the pH sensor reading is High pH.
7. If it reads a high pH(true), the RGB indicator LED 3 shows red, and the Buzzer is sounded to alert the farmer. If false the system goes back to read the pH sensor value.

The entire system then moves to be completed and an infinity loop runs to make sure the system works 24hours in a day.

V. Discussion and Conclusion

This system proposed is a solar-powered circulating drip irrigation system with a reservoir that indicates to users the water level and the pH levels of the water supplied. The pH level is an indication of the number of nutrients in the water that is manually supplied. This system is power efficient since the water circulation does not rely heavily on the power generated. From the orientation in figure 3, the plants are seen placed on a platform higher than the reservoir making the water flow back using gravitational energy. Water is also used efficiently since the water is circulating throughout the system. Other systems have the water sent to the farm without coming back to the source and this incurs waste as the water is dripped onto the plants. This system can be used in areas with water scarcity. The system is also simple and easy to understand when it comes to indicators. Other systems have mobile apps and web applications which may prove difficult for our demographic which is small-scale farmers. Ghanaian farmers cultivate less than one hectare of land making this system an easier option since it can work on different land sizes. Future works would have this system on a large scale for farmers that have bigger farms. They would also be able to afford this system since the materials used in implementation are cheap and easy to come by.

Considering the fact that Ghana’s population depends heavily on rice, maize, cassava, plantain, etc. Cultivating these crops using drip irrigation would increase crop yield and also improve the amount of water saved. This would allow crops to be available all year and would reduce the agricultural sector’s dependency on rainfall. It also reduces labour costs in irrigation and the supply of nutrients simultaneously. Farmers would only be indicated when the water level and pH are too low or too high and would only have to make refills when needed.

One drawback of the system is that it is unable to give the farmer data when it comes to soil moisture because there was no provision for it. Using soil moisture sensors would not be accurate since it would give data for some parts of the soil. Future works would involve finding innovative ways to measure and produce the soil moisture values simply for the farmer. Even though this system reduces labour costs it does not do so entirely since the reservoir needs to be filled as and when the water level drops. Developing an automatic refill system that fills up the reservoir with the nutrients in their right proportions would be the best improvement for this system.

This system's main focus is increasing the amount of water saved using an automated circulating drip irrigation system. Indicators inform farmers as and when the water and pH levels are low. This ensures that there is the continuous supply of water infused with nutrients with the optimum pH needed by plants.

VI. References

[1]. Andaluz, V. H. *et al.* (2016) ‘Automatic control of drip irrigation on hydroponic agriculture: Daniela tomato

10.21070/jeeeu.v5i2.1576

production', in *2016 IEEE International Conference on Automatica, ICA-ACCA 2016*. doi: 10.1109/ICA-ACCA.2016.7778389.

[2]. Ani, A. and Gopalakirishnan, P. (2020) 'Automated Hydroponic Drip Irrigation Using Big Data', in *Proceedings of the 2nd International Conference on Inventive Research in Computing Applications, ICIRCA 2020*. doi: 10.1109/ICIRCA48905.2020.9182908.

[3]. Bhattacharjee, D., Prakash, O. and Islam, H. (2018) 'Smart fertilizer dispensary system for automated drip irrigation', *2018 3rd IEEE International Conference on Recent Trends in Electronics, Information and Communication Technology, RTEICT 2018 - Proceedings*, pp. 1458–1462. doi: 10.1109/RTEICT42901.2018.9012416.

[4]. Bottazzi, P. and Altobelli, F. (2020) 'Performance of different rice varieties under drip irrigation', pp. 333–337.

[5]. Caya, M. V. C. *et al.* (2019) 'Integration of Water Control with a Drip Irrigation System for Agricultural Application', *2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management, HNICEM 2019*. doi: 10.1109/HNICEM48295.2019.9072773.

[6]. Darfour, B. and Rosentrater, K. A. (2016) 'Agriculture and food security in Ghana', *2016 American Society of Agricultural and Biological Engineers Annual International Meeting, ASABE 2016*. doi: 10.13031/aim.20162460507.

[7]. DIvyapriya, S. *et al.* (2020) 'IoT enabled drip irrigation system with weather forecasting', *Proceedings of the 4th International Conference on IoT in Social, Mobile, Analytics and Cloud, ISMAC 2020*, pp. 86–89. doi: 10.1109/I-SMAC49090.2020.9243349.

[8]. Fipps, G. (1995) 'Calculating Horsepower Requirements and Sizing Irrigation Supply Pipelines', *Texas Agriculture Extension Services*, pp. 1–10.

[9]. Hidayat, M. R. *et al.* (2019) 'Soft Water Tank Level Monitoring System Using Ultrasonic HC-SR04 Sensor Based on ATMega 328 Microcontroller', *Proceeding of 2019 5th International Conference on Wireless and Telematics, ICWT 2019*, pp. 2019–2022. doi: 10.1109/ICWT47785.2019.8978229.

[10]. Jain, R. K. *et al.* (2020) 'IOT Enabled Smart Drip Irrigation System Using Web/Android Applications', *2020 11th International Conference on Computing, Communication and Networking Technologies, ICCCNT 2020*. doi: 10.1109/ICCCNT49239.2020.9225345.

[11]. Nosipho Hlophe-Ginindza, S. and Mpandeli, N. S. (2021) 'The Role of Small-Scale Farmers in Ensuring Food Security in Africa', *Food Security in Africa*, (June). doi: 10.5772/intechopen.91694.

[12]. Rani, M. J. (2021) 'IoT based Intelligent Fertigation through Drip Irrigation', (Icicv), pp. 0–4.

[13]. Shonkora, S. S. and Salau, A. O. (2020) 'Modeling and Implementation of an Automatic Drip Irrigation System', *2020 International Conference on Data Analytics for Business and Industry: Way Towards a Sustainable Economy, ICDABI 2020*. doi: 10.1109/ICDABI51230.2020.9325665.

[14]. Sudana, D., Eman, D. and Suyoto (2019) 'Iot based: Hydroponic using drip non-circulation system for paprika', *Proceeding - 2019 International Conference of Artificial Intelligence and Information Technology, ICAIIT 2019*, pp. 124–128. doi: 10.1109/ICAIIT.2019.8834581.

[15]. Tangwongkit, B., Tangwongkit, R. and Chontanaswat, P. (2014) 'Drip irrigation powered by solar cell for dry rainfed and no electricity area', *Proceedings of the 2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development, ICUE 2014*, (March), pp. 19–21.

[16]. Technologies, H. T. (no date) *Water Usage In The Agricultural Industry | High Tide Technologies*. Available at: https://htt.io/water-usage-in-the-agricultural-industry/ (Accessed: 22 July 2021).

[17]. Xu, W. (2021) 'Home Smart Planting System Based on Internet of Things'.

[18]. Zaher, A. *et al.* (no date) 'Automated Smart Solar Irrigation System'.

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

DAFTAR TABEL

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021

10.21070/jeeeu.v5i2.1576

TABLE 2 SIMILAR EXISTING SMART FARMING APPLICATIONS REVIEW RESULTS.

	(Caya *et al.*, 2019)	(Jain *et al.*, 2020)	(DIvyapriya *et al.*, 2020)	(Shonkora and Salau, 2020)	(Ani and Gopalakirishnan, 2020)	(Zaher *et al.*, no date)	(Rani, 2021)	(Xu, 2021)	(Bhattacharjee, Prakash and Islam, 2018)	(Sudana, Eman and Suyoto, 2019)
Water circulation system										
Reservoir		✓				✓				✓
Solar energy			✓		✓	✓				
Drip irrigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
System indicators	✓	✓				✓				
Electric water pump		✓	✓	✓		✓	✓		✓	
Power Efficiency		✓				✓				

JEEE-U
Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021
10.21070/jeeeu.v5i2.1576

DAFTAR GAMBAR

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021

10.21070/jeeeu.v5i2.1576

Figure 1. A typical small-scale Ghanaian farm.

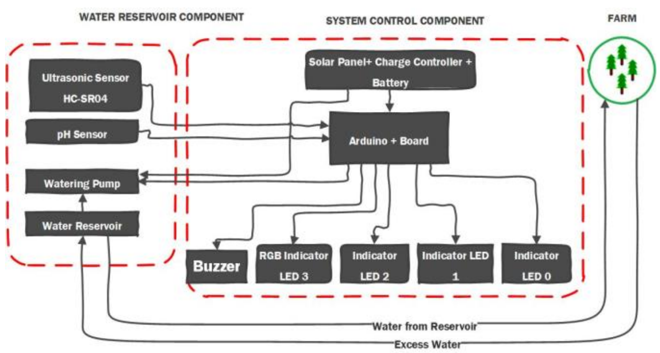

Figure 2. Conceptual design of system operation.

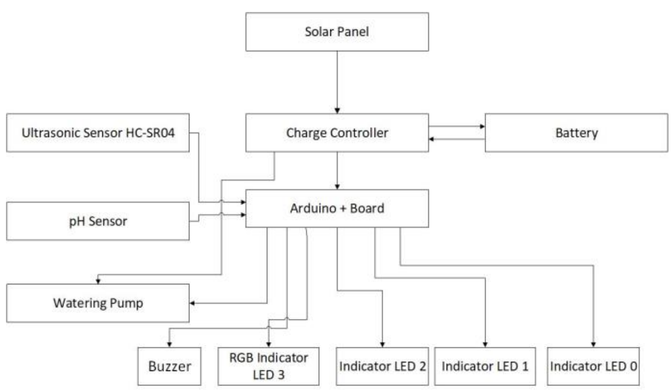

Figure 3. Design of signal flow of the proposed system.

Journal of Electrical and Electronic Engineering-UMSIDA
ISSN 2460-9250 (print), ISSN 2540-8658 (online)
Vol. 5, No. 2, October 2021

10.21070/jeeeu.v5i2.1576

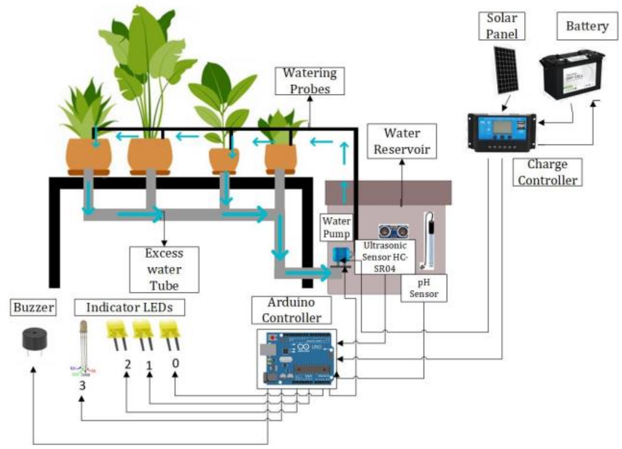

Figure 4. Architecture of the Automated Drip Circulation System with Solar Power.

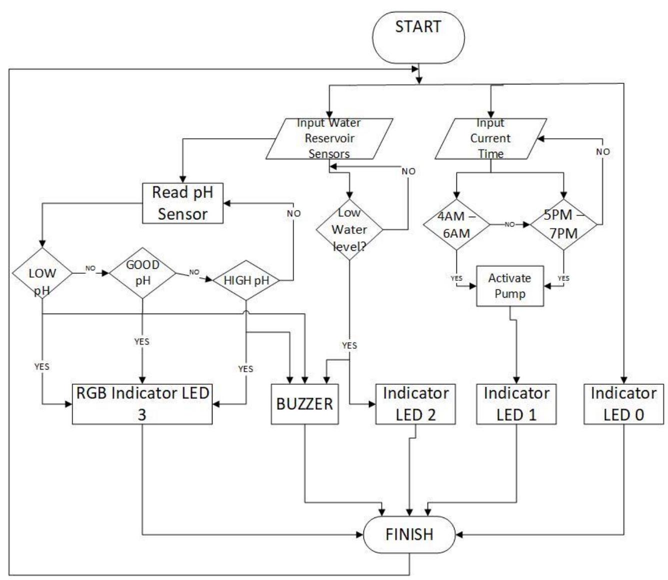

Figure 5. System Flowchart.