Sensor-based Irrigation System (Case Study for Agogo Farmers)

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ABSTRACT
This paper proposed sensor-based irrigation system for farmers at Agogo, a municipal capital of Ashanti Akim North of Ghana. The system seeks to monitors and maintains the desired soil moisture content using automatic watering. Microcontroller ATMEGA328P on the Arduino Uno platform is used to implement the control unit of the system. The irrigation system uses soil moisture sensors to measure the exact moisture level of the soil. The measured value is used to control irrigation of the farm. The threshold value enables the system to use appropriate quantity of water which avoids over and under irrigation. IOT is used to keep the farmers updated about the status of watering pump. Information from the sensors is regularly updated on an application through which a farmer can check whether the water pump is ON or OFF at any given time.

Keywords
Irrigation System

1. INTRODUCTION
Agriculture is the backbone of Ghana. It is the main source of food for the country and also a source of raw material for industries. Crop farmers in Ghana mainly rely on rainfall as a source of water for crop production. As a result, farmers are not able to farm during dry season leading to national hunger. Agogo, a municipal capital town in the Ashanti region of Ghana, is a notable farming community but rely solely on rainfall for farming. This puts farmers idle during dry season resulting in shortage of food. Very few farmers farm during dry season but rely on wells and dams for irrigation and use manual irrigation method. This irrigation is manually done hence farmers are not able to undertake large scale farming. Shortage of food in Agogo is caused by various factors among which are poverty, lack of expert farmers, outdated technique used. A new and scarier factor that is almost impossible to control by humans is the climate change which is faced globally. There has been reduction in annual rainfall in Ghana, leading to a decline in food production in the country [1]. This is due to the fact that most farmers rely on rainfall for farming. Studies shows that countries having an economy based on agriculture highly rely on rainfall and wells for irrigation. They also specified that the climate change will affect the rainfall and that irrigation systems were manual requiring someone to put it on or off [2]. The effect of climate change is much felt in rainfall variability because of the country over reliance on rainfall for agriculture [3]. In order to meet the food demand, there is need to divorce from rain-fed agriculture and put most of the arable land under irrigation [4].

2. LITERATURE REVIEW
The need for crop plant watering in farming cannot be overlooked both during dry and wet seasons. As a result, many researchers have done a lot of research on this topic. A study conducted by Vimal and others recognized that the most difficult task in agriculture is watering the fields. They identified different types of watering system as drip system, nozzles type, tube method and sprinkler system but focuses on the drip system [5]. Shreyash et al noted that using more water for irrigation than it's needed for crops results in the wastage of water and causes the problem in the growth of crops [6]. In irrigation system Arduino technology is main employed to control watering and roofing of the greenhouse [7]. The Arduino uses data from sensors for its operation [8]. Soil moisture is the most important parameter in designing irrigation system [9]. Arduino irrigation system is found to be feasible and cost effective for optimizing water resources for agriculture production and allows cultivation in places with water scarcity thereby improving sustainability [10]. Gomez et al conducted a systematic review of the available literature about smart irrigation systems with a focus on systems using artificial intelligence techniques in urban and rural agriculture [11]. They further opine that smart farming emphasizes the use of various ICTs to manage physical farms. New technologies such as the Internet of Things and cloud computing are expected to use this development to bring more robotics and artificial intelligence into agriculture. In a conclusive statement by Samat et al in a paper entitled "Solar Power Smart Irrigation System (SPSIS)" opines that SPSIS makes irrigation of crops much easier for farmers, lessens the User's excessive effort while irrigation, and provides proper management in irrigation scheduling [12]. Lorvanleuang et al in their studies entitled "Automatic Irrigation System Using Android" noted that an automated irrigation system water crop uniformly by analyzing the soil parameters, and optimizes the usage of water [13]. Vinoth et al provided a correctional means for any deviation from the measured reference value from the sensors [14]. Kansara et al enumerated several reasons for using sensor-based automated irrigation system for watering crop farm [15]. Adding to how useful smart irrigation to agricultural development, Amairaj et al opines that a sensor-based automated irrigation system provides a promising solution to manage agricultural activity [16]. The aim of this project is to develop a simplified sensor-based irrigation system for agogo farmers.

3. METHODOLOGY
3.1: Activity diagram of the current irrigation system used by Agogo farmers
Figure 1 shows activity diagram of the current irrigation system used for irrigation by Agogo farmers

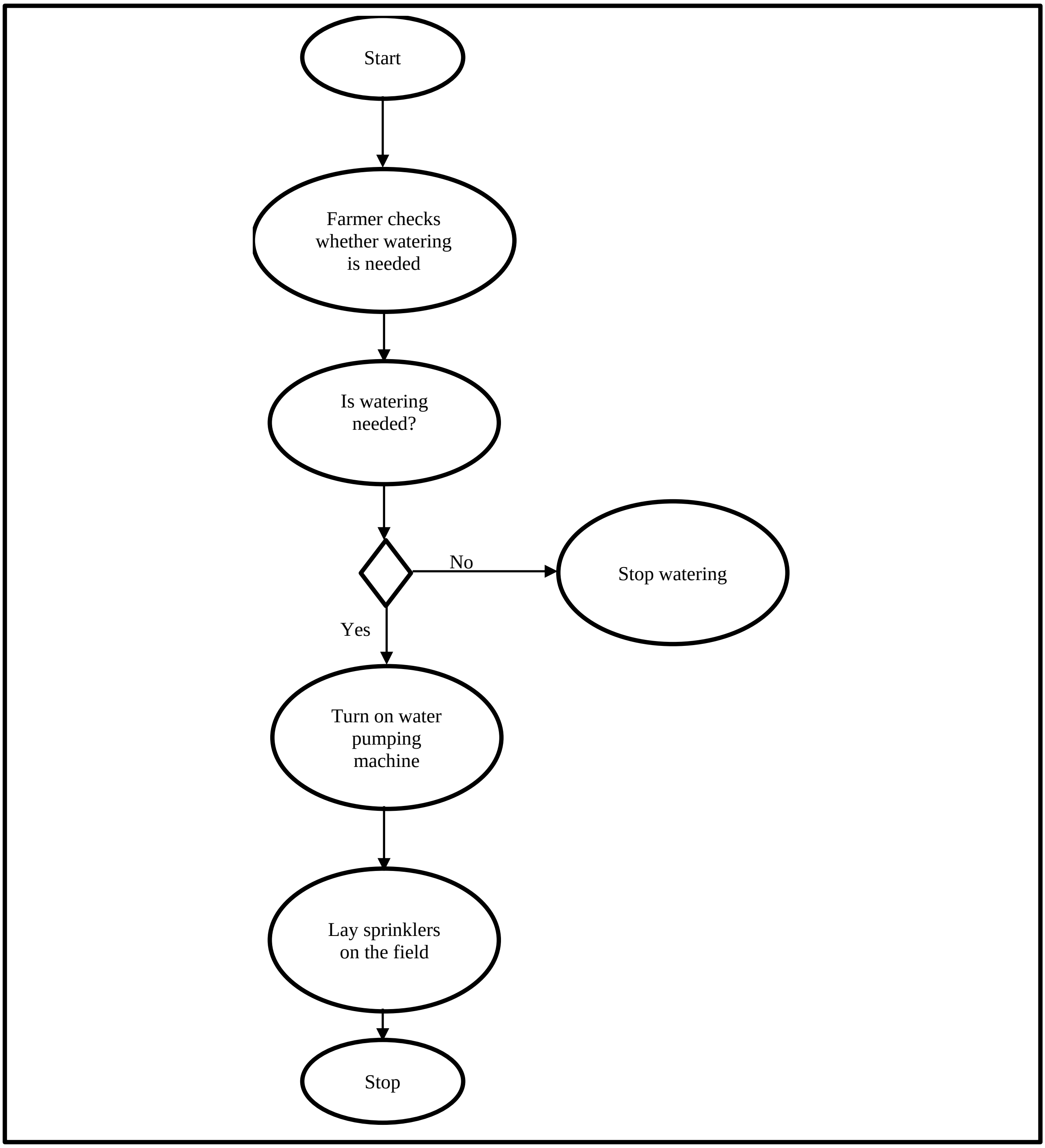

Figure 1 Shows activity diagram of the current irrigation system used for irrigation by Agogo farmers

3.2 Use case diagram of the proposed irrigation system

Figure 2 shows use case diagram of the proposed irrigation system for Agogo farmers

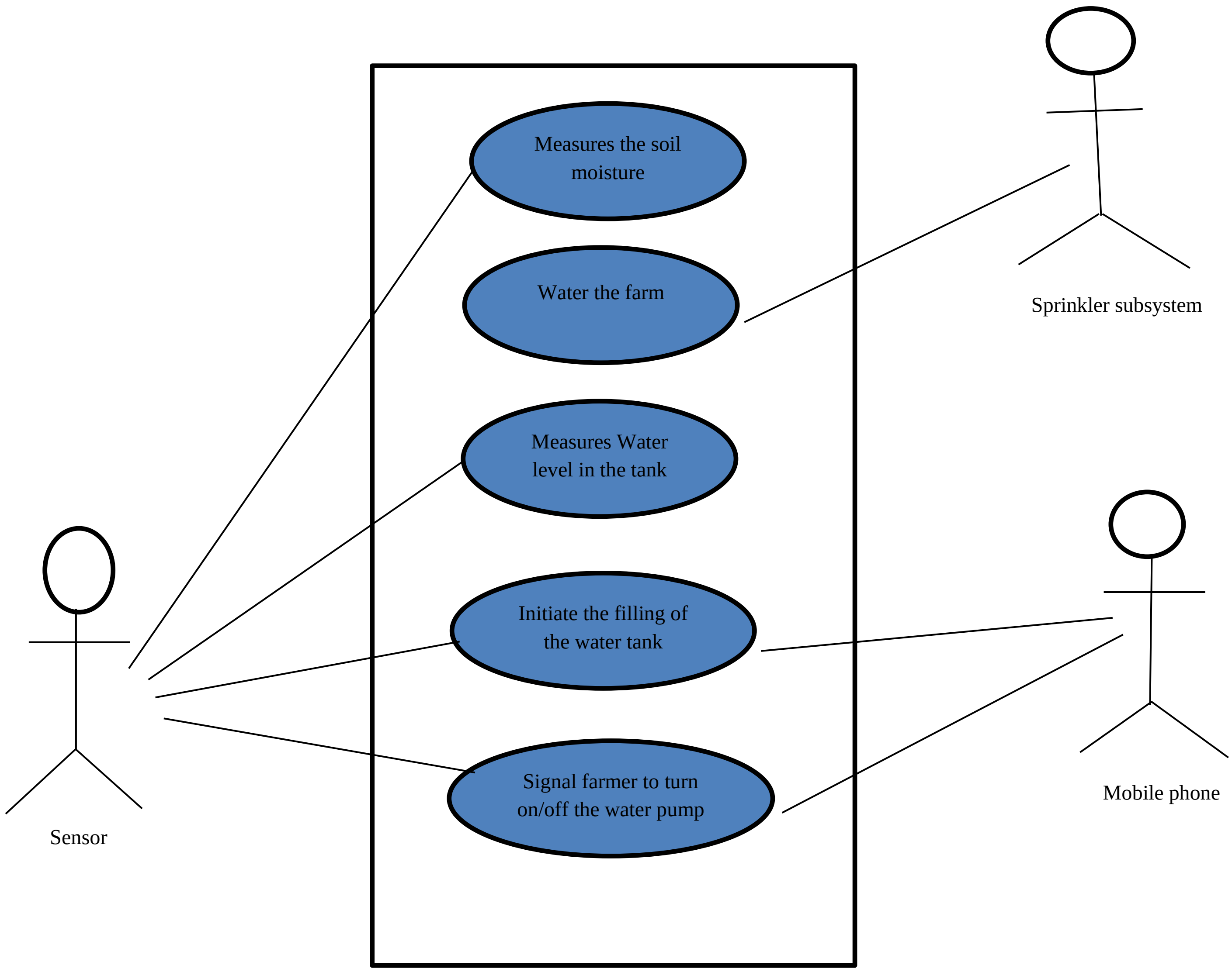

Figure 2: Use case diagram of the proposed irrigation system for Agogo farmers

3.3 Weaknesses in the current irrigation system

The following have been found as negative contributing factors toward the current system used by Agogo farmers: There is guessing of the moisture content by farmer when checking whether the crops need watering or not. This is because farmer use their hands and eye to estimate the soil moisture due to the failure to use moisture measuring device. As a result, watering is based on discretion of farmers. Additionally, the farmer has to turn on the pumping motor manually requiring that the farmer should be in the farm before watering can be done.

4. IMPLEMENTATION

4.1 Block Diagram of the System

Figure 3 below shows the block diagram of the system.

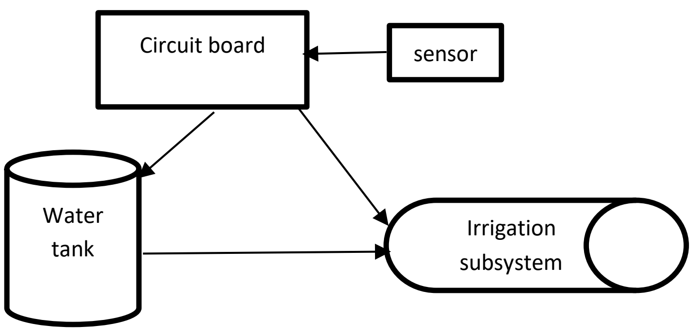

Fig 3: Block diagram of the system

4.1.1 Circuit board

The circuit board (CB) is Arduino ATmega 328. It is the main controller of the irrigation system. The CB is connected to computer installed with a software to enable the farmer to control the entire system. The CB receives input values from the sensor the flow of water into the irrigation pump. The software used was the Arduino IDE which supports C++.The built prototype measures the soil moisture and water level. The normal values were predefined based on the soil type and plant type. When the values are less than normal, a signal is sent to trigger the irrigation sprinkler to turn on. Also, when the water requirement is satisfied, the watering system goes off. This system has helped in reducing water wastage.

4.1.2 Sensor

Sensor is a device which provides a usable output in response to a specified measurand. Sensor is a device that detects and responds to some type of input from the physical environment. Input could be light, heat, motion, moisture, force, pressure, displacement, and others. The following sensors were used in this project:

Soil Moisture Sensor

The soil moisture sensor is used to measure the volumetric water content of soil. It is used to monitor soil moisture content to control irrigation in greenhouse. A moisture sensor is used to sense the level of moisture content present in irrigation field. It has a level detection module in which a reference value can be set [17]. Soil moisture sensor plays major role of this system. In this system, soil moisture sensor is inserted into anywhere in the soil of the farm to measure the moisture content of the soil and sends the measured value to the controller. If the soil moisture level as measured by the sensor goes below 28% as advised by crop expert, the irrigation sprinkler is turned on and turn off when the sensor gets to 45%.

Water flow sensor

Water flow sensor is characterized by a water pressure connected to the pipe of the submersible water pump to measure the water flow. The water flow sensor generates an electric pulse with every revolution through its integrated magnetic hall effect sensor that is sealed off from the water and allows the sensor to stay safe and dry [18].

4.1.3 Water tank

Water tank is a reservoir of water. It stores water for the irrigation. The water tank is connected to the pump which pumps water into the tank when the level of water in the tank get to a certain threshold and stops pumping the water into the tank when the level of water in the pump get to a set threshold. In this project, the threshold for initiate pumping of water into the tank is set to 20% of the volume of the tank and the threshold to stop pumping water into the tank is 98% of the volume of the tank

4.1.4 Irrigation sprinkler subsystem

A part from the traditional irrigation method, there are several modern irrigation methods such as sprinkler, drip, hybrid, pot and propane powered irrigation, with each have its strengths and weaknesses. In this project, sprinkler irrigation was used. This subsystem waters the plants in the farm. It takes its source of water from the water tank. Sprinkler irrigation method can be installed in three ways such as permanent, semi-permanent; temporary in which water is supplied to the field thorough pipes on the top sprinkler is attached with that to spray water. To maintain humidity this method adopted in regions like high temperature, water scarcity, uneven ground level and sandy soil. The efficiency of this irrigation is higher than most of the other methods of irrigation. The difference between permanent and temporal installation is how easy it is to change the position of the sprinkler. The temporal setup is easy to shift from one location to the other whereas the permanent setup cannot be moved due to how the pipelines are installed. In this project, the temporal method of installation was used.

4.2 Set-up of the System

The prototype of sensor-based irrigation system is shown in figure 4 and the pepper farm field is shown in figure 5.

Figure 4: prototype sensor-based irrigation system

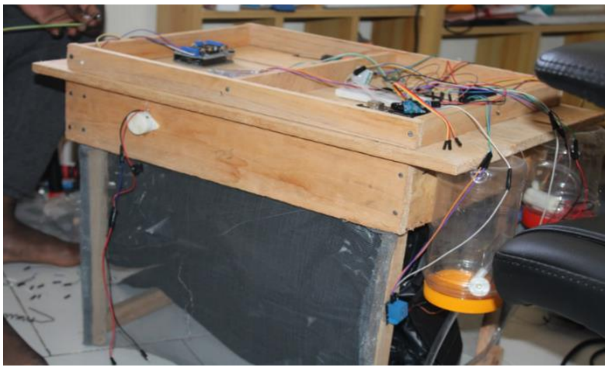

Figure 4: Prototype of the Sensor-based Irrigation System

Figure 5: Farm Field of Pepper

In figure 4, the main controlling board, Arduino is a central device through which all other components are connected. Moisture sensor is inserted in the soils of the pepper farm in figure 5 to measure the soil moisture. If the measured soils moisture goes below 28%, the Arduino triggers irrigation in the irrigation sprinkler subsystem to water the pepper farm; and stops irrigation when the moisture content gets to 45%. The water level sensor measures the water level of the tank. This sensor is planted in the tank. If the water level moisture measures 20% of the volume of the tank, the Arduino sends a message to the farmers' mobile form and triggers the pumping machine to start pumping water into the tank. The Arduino stops the pumping machine when the water level of the tank gets to 98% of the volume of the tank. The farmer can equally use the mobile phone connected to the Arduino system using internet to start and stop irrigation, and start and stop filling of the water tank remotely

5. CONCLUSION

The researchers built a prototyped sensor-based irrigation system for Agogo farmers that ensure efficient use of water and reduce human intervention. The system used two sensors; namely moisture sensor to measure the soil moisture to trigger irrigation, and waterflow sensor measures the water level in the tank determine whether or not to turn on the watering pump. Arduino serve as the main control of the system. The system was used to water crops in cage as shown in figure 5. the system can be expanded to irrigate large and commercial farm in

Ghana for farmers. This system enables irrigation of farm to be carried out with little or no human influence.

6. REFERENCES

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