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REVIEW OF SMART FARM SYSTEMS FOR IRRIGATION AND FLOOD CONTROL

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Abstract:

Smart Farm Systems for Irrigation and Flood Control is a system that will be customized to upgrade existing drip irrigation systems, surface irrigation systems, and sprinkler irrigation systems to overcome their existing limitations. At present, Flooding and water scarcity have been major challenges bedeviling Nigerian farmers which is capable of impeding national food security. Farming during dry season is also a challenge in the northern part of Nigeria. To overcome these challenges, a smart irrigation and flood monitoring system will be designed to automatically solve the above mentioned problems. The research objectives are: to design and develop an irrigation and drainage based wireless sensor network (WSN) using Arduino technology with an intelligent algorithm, and to incorporate remote reporting device for the validation of the research work. These are the research gaps and research contribution; Raspberry Pi technology is expensive but the proposed system will use arduino technology that is less expensive, in the event of over flooding, there is no checkmating mechanism but the proposed system will be programmed to involve flood drainage mechanism, there are existence of wired network but the proposed system will be wireless, Many reviewed systems run on GSM with issues of network fluctuation and could not consider the soil temperature but the proposed system will be smart and from the research conducted, we observed that a system was running on non-programmable op–amp and is not sensitive enough to detect the actual volume of water needed for the soil but the proposed system will use arduino technology that is reprogrammable and smart.

Key Words: Smart Farm Systems, Arduino Technology, Wireless Sensor Network and Irrigation and Flood Control

I. Introduction

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall (Ufoaroh *et al,* 2016). The intelligent use of water for crops requires understanding of evapotranspiration processes and use of efficient irrigation methods (Darshana *et al,* 2015). The need for additional food for the world's population has spurred rapid development of irrigated land throughout the world. New irrigation systems, design and selection techniques are continually being developed and examined in an effort to obtain high practical, attainable and efficiency in water applications. The main objective of irrigation is to provide plants with sufficient water and prevent stress that may reduce the yield. The frequency and quantity of water depends upon local climatic conditions, crop and stage of growth, and soil moisture plant characteristics. Need for irrigation can be determined in several ways that do not require knowledge of evapotranspiration (ET) rates. One way is to observe crop indicators such as change of color or leaf angle, but this information may appear too late to avoid reduction in the crop yield or quality sustainable irrigation (Darshana *et al*, 2015). At the same time these production systems are becoming more intensive, in an effort to optimize the return on expensive and scarce resources such as water and nutrients.

It is not only sufficient for water to be supplied to a field for optimum yield; the need to ensure that the level of water required by the crop does not exceed a threshold level is paramount. Many farmers have helplessly watched their crops destroyed by flooding which arises as a result of river overflowing their banks owing to heavy rainfall. According to Abdulkareem, 2021, about 75 per cent of Nigerian farmers were estimated to have been affected by the ravaging effects of drought and flooding in 2020 as shown by a survey conducted by SBMIntel, an Africa focused research firm, in seven states of the country namely Nasarawa, Osun, Benue, Oyo, Kastina, and Lagos. In fact, in Kebbi state alone, above 500 000 hectares of farmland were destroyed by flooding, with the cost being upward of 5 billion naira (Abdulkareem, 2021). These extreme climatic events witnessed by many states of the country triggered the negative effects being noticed on the prices of staple foods.

This work shall therefore develop a robust smart system to enhance both irrigation and flood monitoring and control, leveraging on Wireless Sensor Networks (WSNs) to boost agricultural production. This automated irrigation system is customizable and can also be used to upgrade existing drip irrigation systems, surface irrigation systems, and sprinkler irrigation systems to overcome their existing limitations. In the system's implementation, Arduino based instrumentation, integrated with temperature, soil moisture and water level sensors shall be adopted to monitor the agricultural environment, while reporting the status wirelessly through the Radio Frequency (RF) modules to the base station. The base station shall evaluate the received data and either activates or deactivates the irrigation or drainage pump using specified threshold values. The remote reporting of the state of the farm shall be done by deploying a 900MHz transmitter interfaced with the system's controller. This work shall be validated by using an experimental test bed, which shall be used for field experiments, data collection and evaluation. The results of this work shall highlight the potentials of WSN technology in monitoring and control of both irrigation and flooding within the farm and in turn boost the productivity.

II. Evolution of Irrigation systems

Table 1: Summary of the evolution of irrigation systems

S/N	DATE	DESCRIPTION
i.	**1600BC**	Irrigation began at about the same time in Egypt and Mesopotamia (present day Iraq and Iran) using the water of the flooding Nile or Tigris/Euphrates rivers. The flood waters, which occurred July through December, were diverted to fields for 40 to 60 days. The water was then drained back into the river at the right moment in the growing cycle (Ahmed *et al,* 2016).
ii	**1700BC**	**Shaduf:** A large pole balanced on a crossbeam, a rope and bucket on one end and a heavy counter weight at the other. By pulling the rope, it lowered the bucket into a canal or river. The operator would then raise the full bucket of water by pushing down on the counter weight. The pole could be swung around and the bucket emptied in a field or different canal. This development enabled irrigation when a river wasn't in flood which meant higher ground could be used for farming.
iii	**550-331 BC**	Qanat: The development of this technique allowed the use of ground water to become the primary source for crop irrigation. A Qanat was built by first digging a vertical well into sloping ground. Once the well was completed a tunnel was dug nearly horizontal to the lower end of the well. The natural slope would allow well water to travel by gravity down the tunnel and emerge some distance down slope from the well. Construction of Qanat was labor intensive

		and vertical openings were placed every 20-30 meters to allow the tunnel diggers to breathe and to remove the debris from the tunnel. Once the tunnel was completed, the area had a constant source of water. Qanats are still in use today and at least 20,000 still operate from China to Morocco.
iv	**500BC**	**Sakia:** The first use of what is now called a pump. This device was an endless series of pots on a rope which ran over two pulleys. The oxen-powered device powered a cogged wheel allowing the pots to enter the water supply, fill and then be raised and emptied.

III. Modern irrigation

Modern irrigation can be classified into surface irrigation, sprinkler irrigation, and drip irrigation.

i. Surface irrigation: Surface irrigation stands for a large group of irrigation methods in which water is distributed by gravity over the surface of the field. The three most common methods are basin irrigation, border irrigation and furrow irrigation. Water is typically introduced at the highest point or along the edge of a field, which allows covering the field by overland flow. Historically, surface irrigation has been the most common method of irrigating agricultural land. The defining feature of surface irrigation methods is that the soil is used as the transport medium as opposed to pipeline. Surface irrigation methods contain two basic categories ponding (surface water pooled in a puddle) and moving water (Hill *et al.,* 2018). The moving water methods require some runoff or ponding to guarantee adequate infiltration at the lower end of the field. The soil type controls the length of the run and the depth of infiltrated over time. The better the quality of the soil is the less is the unnecessary runoff and the better the infiltration into the soil and therefore the use for the crops (Hill *et al.,* 2018). Figure 1 shows a typical example of surface irrigation.

Figure 1: Surface Irrigation (Ahmed *et al*., 2016)

Due to flooding, it is important not to irrigate the crops during the day but in the early morning or at night in order to avoid water loss due to evaporation. Each surface system has its own unique advantages and disadvantages depending on some factors such as; initial development costs, size and shape of individual fields, soil characteristics, nature and availability of the water supply, climate, cropping pattern, social preferences and structures, and historical experience. Critical factors to be considered before embarking on the construction of surface irrigation include:

a. Soil Type: The soil, which is used to convey the water over the field, has properties that are highly varied both spatially and temporally. This creates an engineering problem in which at least two of the primary design variables (discharge and time of application) must be estimated not only at the field layout stage but also judged by the irrigator prior to the initiation of every surface irrigation event. Thus, while it is possible for the new generation of surface irrigation methods to be attractive alternatives to sprinkler and trickle systems, their associated design and management practices are much more difficult to define and implement (UCCE, 2005).

b. Costs: Leveling the fields and building the water ditches and reservoirs might be expensive, but once this is done, costs are low and the self-help capacity is very high. Thus, the expected life of the system, fixed costs, and annual operation costs (energy, water depreciation, land preparation, maintenance, labor, taxes, etc.) should be included in the analysis when selecting an irrigation system (UCCE, 2005).The water allocation is done by gravity, therefore no energy is required although it is labor intensive.

c. Operation and Maintenance: Operation of surface irrigation requires being there to "tend" the water, that is to move the water to successive application points as it reaches the end of the run (Hill *et al.*,2018). Good operation of any irrigation system includes matching the irrigation duration with the rate of application and the intake rate of the soil to maximize the fraction of water stored in the root zone. Ditches should be cleaned out at least annually and more often if needed. A shovel can be used to clean smaller ditches. A mechanical ditcher and tractor is very helpful on larger ditches. Often ditch cleaning is an early spring "rite" to be completed prior to the first delivery of water. Many irrigation and canal companies require that shareholders maintain their own head gates and keep them in good operating condition. Periodic re-levelling of surface irrigated fields may be needed to compensate for soil settlement or consolidation over time (Hill *et al.*, 2018).

i. **Applicability:** This system depends on three factors: type of soil, water quality and climate, plant and labors. If the soil is very permeable, it is difficult to transport the water over the surface and the entire field may not be irrigated. But surface irrigation is not negatively influenced by winds or sediments and debris as are sprinkler systems. Moreover, salinity is less of a problem under surface irrigation because of less risk of clogging pipes and salts can be leached from the soil profile. Surface irrigation is not a high-automated system which makes it simpler, but it requires therefore also more labors.

The surface irrigation is further classified into basin irrigation, border irrigation, furrow irrigation, sprinkler irrigation, and drip irrigation.

a. ***Basin Irrigation***

Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. If a field is level in all directions, is encompassed by a dyke to prevent runoff, and provides an undirected flow of water onto the field, it is herein called a basin. Generally, basin irrigation is favored by moderate to slow intake soils and deep-rooted, closely spaced crops. Crops, which do not tolerate flooding and soils subject to crusting can be basin irrigated by furrowing. Basin irrigation is an effective method of leaching salts from the soil profile into the deeper groundwater. Basin irrigation systems can be automated with relatively simple and inexpensive flow controls at the basin inlet. However, basin irrigation has a number of limitations in association with agriculture in the less developed countries: Accurate land levelling is prerequisite to high uniformities and efficiencies, but this is difficult to accomplish in small areas; the perimeter dikes must be well maintained to eliminate breaching and waste; and it is difficult and often infeasible to incorporate the use of modem farm machinery in small basins, thereby limiting small-scale basin irrigation to hand and animal powered cultivation (UCCE, 2003).

b. ***Border Irrigation System***

In many circumstances, border irrigation can be viewed as an expansion of basin irrigation to include long rectangular or contoured field shapes, longitudinal but no lateral slope, and free draining or blocked conditions at the lower end. In border irrigation, a field is divided into strips separated by border ridges running down the slope of the field. The width of the stripes is usually from 20 to 100 feet (6 to 30 meters). The area between the ridges is flooded during irrigation. Border irrigation is used for tree crops and for crops as alfalfa (Medicago sativa) and small grains (UCCE, 2003).

c. ***Furrow Irrigation***

An alternative to flooding the entire field surface is to construct small channels along the primary direction of water movement. Water introduced in these furrows infiltrates through the wetted perimeter and moves vertically and laterally thereafter to refill the soil. Furrows can be used in conjunction with basins and borders to overcome topographical variation and crusting (UCCE, 2003). Furrows are well adapted to row crops and orchards or vineyards (Agbetuyi *et al*, 2020). Furrow systems require more labor than border or basin systems. Some disadvantages are salinity hazards between the furrows, limited machinery mobility across the lateral field direction and an increased erosion potential. On the other hand, topographical conditions can be more severe and variable, and the smaller wetted area can reduce evaporation loss (UCCE, 2003).

The three most important hardware items for efficient furrow irrigation are (Agbetuyi *et al*, 2020):

a) A tail water return flow system, which incorporates a reservoir
b) Short furrows for an acceptable advanced ratio
c) A large variable water supply stream

ii. **Sprinkler Irrigation:** Sprinkler irrigation is a method of providing rainfall-like irrigation to the crops. Water is distributed through a system of pipes usually by pumping. Spray heads at the outlets distribute the water over the entire soil surface. Sprinklers provide efficient coverage for small to large areas and are suitable for all types of crops. Furthermore, they can be adapted to nearly all irrigable soils since sprinklers are available with a variety of discharge capacities (FAO, 2015). However, sprinkler systems can easily clog with the presence of sediment or debris and large systems incur high capital costs.

Figure 2: Examples of Sprinkler (Ahmed *et al*., 2016)

Impact and gear-drive sprinklers are two general types of sprinklers used in lawns, gardens and pastures. They produce moving streams of water and spray nozzles that discharge water on the whole wetted pattern at all times. Impact or gear-drive sprinklers can accommodate only full or part circle application patterns. Since each sprinkler covers a large area (typically 12 m head-to-head spacing), they are used on pastures and larger lawn areas.

Figure 3: Sprinkler Head (Ahmed *et al*., 2016)

Figure 4: Sprinkler System (Ahmed *et al*., 2016)

Several sprinkler heads are connected to a lateral pipe, which is supplied by a mainline. These sprinklers may be used in a solid set configuration where sufficient nozzles are installed to cover all parts of the desired area drawing water from a surface or buried mainline and laterals. Or they can be used in a set-move configuration where lateral lines are operated and then moved at intervals of 12 or 24 hours. Solid set systems cost more to install, but have lower labor requirements and may be automated. The equipment and installation cost per acre of set-move systems is less expensive, but their operation requires more labor, as they cannot be completely automated. The following systems employ the operation of Sprinkler Irrigation:

i. ***Centre Pivot***

This self-propelled sprinkler system rotates around the pivot point and has the lowest labor requirements of the systems considered here. It is constructed using pipes attached to moveable towers. The amount of water applied is controlled by the speed of rotation. Centre pivots can be adjusted to any crop height and are particularly suited for lighter soils. With a computerized control system, the operator is able to program many features for the irrigation process. Furthermore, it is possible to install a corner attachment system (also called "end-gun") that allows irrigation of corner areas missed out by conventional Centre pivot systems

ii. ***Linear Move***

The linear move (also called lateral move) irrigation system is built the same way as a center pivot; that is moving towers and pipes interconnecting the towers. The main difference is that all the towers move at the same speed and in the same direction. Water is pumped into one of the ends or into the center. Due to the high capital investment, linear moves are used on high-value crops such as potatoes, vegetables and turf.

Figure 5: Demonstration of Linear move (Ahmed *et al*., 2016)

iii. ***Travelling Big Gun***

Hose reel irrigation systems, also called traveling gun systems, consist of a single powerful, portable sprinkler head that sprays water in a circular pattern. These movable sprinklers are installed on “traveling” carts, with a water hose attached. The carts can be positioned wherever necessary, as long as they remain connected to a water source. These sprinklers are best used on: irregular-shaped areas; difficult-to-reach areas and fields that cannot be otherwise irrigated because of ditches, power lines, trees, buildings, etc.

Figure 6: Demonstration of Travelling Big Gun (Ahmed *et al*., 2016)

iv. ***Side Roll***

The side roll (also called wheel roll) system consists of a lateral, usually a quarter mile long, mounted on 4 to 10 foot (1 to 3 meters) wheels in diameter and the pipe serving as an axle. When the desired amount of water has been applied to an area, a gasoline engine at the center is used to move the side roll to the next. The sprinklers are generally mounted on weighted, swiveling connectors so that no matter where the side roll is stopped, the sprinklers will always be on top. This type of system is not recommended for gradients greater than 5 per cent and should be used mainly on flat ground. Side roll systems are adapted only to low growing crops, have medium labour requirements and moderate initial investment.

Figure 7: Demonstration of Side Roll (Ahmed *et al*., 2016)

iii. **Drip irrigation:** With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Compared to other types of irrigation (sprinkler irrigation or surface irrigation), only the immediate root zone of each plant is wetted. Therefore this can be a very efficient method of irrigation. Drip irrigation is sometimes called trickle irrigation (FAO, 2015). Drip irrigation can be a very technical irrigation system for food or plant production fields. But compared to other technical systems (e.g. sprinkler irrigation) it is a low technique solution. Furthermore it is possible to combine this system with a water treatment plant (e.g. non-planted filter or constructed wetlands (horizontal flow or vertical flow) and use the treated water as irrigation water).

Figure 8: Examples of Drip nozzles (Ahmed *et al*., 2016)

Drip irrigation requires little water compared to other irrigation methods. About 40- 80 liters per day are needed per 100-200 plants (Walker, 2017). The small amount of water reduces weed growth and limits the leaching of plant nutrients down in the soil. Inorganic fertilizer or urine tea can be applied efficiently to the plants through the drip system (Walker, 2017).

Drainage System

Drainage is the natural or artificial removal of a surface's water and sub-surface water from an area with excess of water. The internal drainage of most agricultural soils is good enough to prevent severe waterlogging (anaerobic conditions that harm root growth), but many soils need artificial drainage to improve production or to manage water supplies.

Types of drainage system include:

i. **Surface drainage system:** The system was designed to remove excess (ponding) water from the surface of the land by using surface drainage. This was accomplished by shallow open field drains. In order to facilitate the flow of excess water towards these open drains, the field is usually given an artificial slope by means of land shaping or grading as shown in Figure 9.

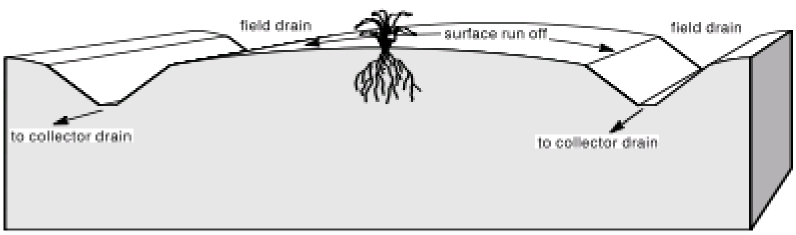

Figure 9: Surface drainage to remove excess water from the land surface(Mohammad *et al.* 2020)

ii. **Field drains for subsurface drainage:** This system was designed to remove excess water from the root zone. By subsurface drainage, watertable was being controlled, and excess water is removed from the underground by gravity through open or pipe drains installed at depths varying from 1 to 3 m. This system is shown in figure 10

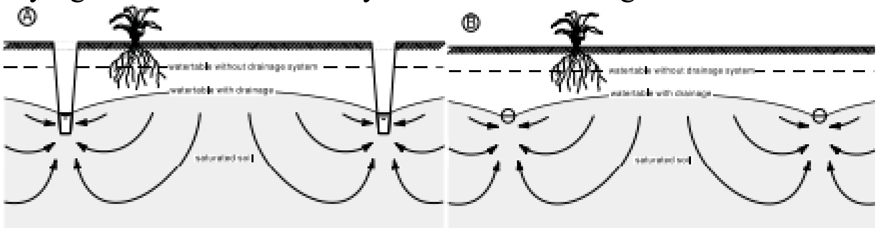

Figure 10: Field drains for subsurface drainage may be open (A) or pipe (B) (Mohammad *et al.* 2020)

iii. **Tubewell drainage:** Tubewell drainage is a special type of subsurface drainage where excess water is removed by pumping from a series of wells drilled into the ground to a depth of several tens of metres. The pumped water is then discharged into open surface drains. Figure 11 depicts this system.

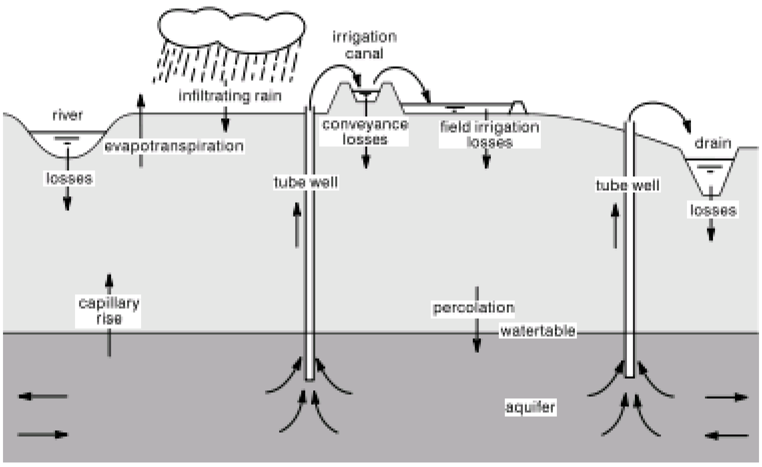

Figure 11: Tubewell drainage (Mohammad *et al.* 2020)

iv. **Field drainage system:** A field drainage system is used to avoid ponding water and/or to control the watertable in the field. The main drainage system is used to convey the water away from the farm area. It controls water ponding and/or waterlogging in the field. It can be a surface drainage system (to remove ponding water from the surface of the land), a subsurface drainage system (to control the watertable in the soil) or a combination of these two. And the outlet is the point of safe disposal of the drainage water. It is represented in the figure below.

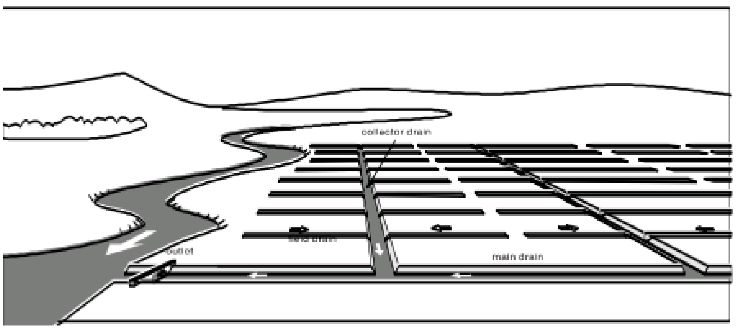

Figure 12: Schematic lay-out of a field drainage system (Mohammad *et al.* 2020)

v. **Single subsurface drainage system:** The most commonly installed subsurface drainage system is a singular system with piped field drains discharging into open collector drains (Figure 13). The main function of the field drains is to control the watertable level. The corrugated plastic field drains (Ø 60 mm) are installed at a depth of 1.0 to 1.3 m. In fine or reduced soil layers, voluminous organic (coconut fibres) envelopes were used in the past, but they have been replaced by synthetic pre-wrapped envelopes. Depending on the drain depth and soil texture, installation is done by either trencher or trenchless drainage machines. The discharge from the subsurface field drains and the surface runoff is removed by gravity through a system of open collector drains.

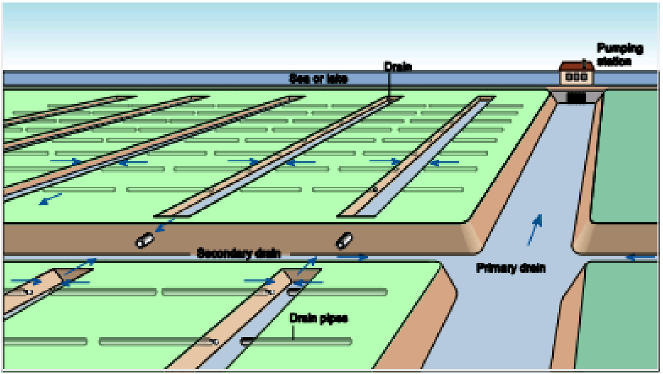

Figure 12: singular system with piped field drains

IV Review of related works

The following are some previous studies and projects regarding automation of irrigation.

In **Android based Automated Irrigation System using Raspberry Pi** (Apurva *et al.,*2017) its aim was to design irrigation by drip that would be economical and efficient as water management has a crucial importance. The system was to control the water supply to each plant automatically depending on values of temperature and soil moisture sensors. The mechanism was done such that soil moisture sensor electrodes are inserted in front of each soil. It consisted of distributed wireless sensor network of soil moisture, and temperature sensors placed in the crop field. The system used Raspberry Pi as the brain of the system thereby making the system smart. The use of Raspberry Pi as the brain of the system makes it expensive and it also has no mechanism for flood drainage in the event of over flooding. These shortfalls are well taken care of in the proposed system by using arduino Uno as the brain of the system which is much cheaper. Also, it provides a mechanism for drainage in the event of flooding.

In **Arduino Based Automatic Plant Watering System** (Devika *et al.,*2014) the system was aimed at supplying water to plants when the need arises with little or no human interference. The system consisted of a number of moisture sensor placed at different positions in the field. The moisture sensors measure the level of moisture in the soil and send the signal to the Arduino if watering is required. The motor/water pump supplied water to the plants until the desired moisture level is reached. However, this system is only suitable for low to medium field because of the wire network interconnectivity necessary for its efficient operation. This short coming is overcome in the proposed system by making it wireless thereby suitable for large farm area.

A Real time implementation of a GSM based Automated Irrigation Control System using drip Irrigation Methodology (Veena *et al.,2013*) was aimed at developing a system that would water a field by the command of the farmer at a remote distance from the field. It communicates using two mobiles. The connections between the two mobiles are done using GSM while the GSM module and microcontroller are connected using MAX232. When the moisture sensor senses that the moisture content of the soil has become low, it gives a signal to the microcontroller. The microcontroller then gives a signal to the called mobile (which is kept in the auto answering mode). The called mobile activates the buzzer. Therefore when calling mobile calls, that buzzer is heard indicating the valve needs to be open. By pressing the button in the called function, the signal is given back to the microcontroller. The microcontroller gives signal to the valves which causes it to get open and water flows to the root of the plant drop by drop. When the moisture content becomes sufficient, the sensor senses this and gives back the signal to the microcontroller and the buzzer becomes off. Then by pressing the button in the calling function again, the valve is made off. The power supply needed by the controlling system is +5V. The major shortfall of this work is the inclusion of human interface who might be at the location outside network coverage area. This could have adverse effects on the plants which would greatly hamper the overall productivity of the plants. However, in the proposed system, human interference is completely removed as the microcontroller does all the control thereby making the system entirely smart.

In **Automated irrigation system using solar power in Bangladesh** (Uddim *et al.,*2017) the gadget was designed to keep the farmer abreast with the information about the level of water in the field (mostly rice field). The system senses the level of water in the field and relays the information to the farmer through his mobile phone. The decision to water the field or not solely resides with the farmer base on the information received from the system. If the need for irrigation arises, he manually turns ON the pump. The blessing of this machine is that it depends on the sun energy to get hold of electricity. The dangers of this system are that it centered on one sort of sensor, the water stage sensor. No provision is made for temperature sensor which leads to loss of water by evaporation when irrigated at the wrong time. Besides, the operator may be far from the field at the time of he receives the message. The more he delayed the irrigation, the more the plants are adversely affected thereby leading to reduction in farm produce. These shortfalls are well taken care of by the provision of temperature sensor which ensures that the irrigation is done at the right time. Also, the problems associated with the human interface are completely done away with by making the system smart.

In **Sensor-based Automatic Irrigation System** (Mohamed *et al.,*2015) the work is aimed at designing a system that could water a field with little human interference. It also depends on the measurement of soil humidity and temperature. The system works by sending a signal from farm controller to user phone and it phone must be in automatic reply in case that soil needs water. A signal from phone is sent to farm controller again to switch on or off the system. The only disadvantage of this study is that it works with Wi-Fi. Often, agricultural land is far from the city, and the network might not be good in those areas. Also, this system needs to access the farmer via his phone who might be out of network coverage area. But in the proposed system, the Wi-Fi is only needed to keep the farmer abreast with the happenings in the farm. The actual irrigation does not depend on him in any form.

In **Design And Implementation Of An Automatic Irrigation System Based On Monitoring Soil Moisture** (Agbetuyi *et al.,*2020) the work aimed at drastically reducing the amount of water wastage during manual irrigation. The system was designed to continuously sense the moisture level of the soil. The system responded appropriately by watering the soil with the exact required amount of water and then shuts down the water supply when the required level of soil moisture is achieved. The reference level of soil moisture content was made to be adjustable for the three most common soil samples (sandy, loamy and clayey soils. Also the amount of irrigation, i.e. the volume of water delivered to the soil, will be adjustable by the system operator (mild, nominal and high levels). However, the work was designed to activate the water pump as soon as the moisture sensor sends signal to the microcontroller without considering the temperature of the soil thereby leading to water lost through evaporation. This shortfall is considered in this proposed system by using a thermistor which determines the right time for the irrigation of the field.

In **Arduino Based Smart Irrigation System** (Madhu *et al.,*2018) the project probes into the design of the mindless irrigation system based on Arduino and IoT technology**.** It was designed in an effort to enhance an automatic irrigation strategy that controls the pumping motorized via turning the machine On or Off due to depending on the moisture quantity of the soil. The decision taken by the microcontroller was based on the output of the moisture sensor. When the sensor senses the dryness of the soil, it communicates the controller which sends signal to activate the water pump for the irrigation of the farm land. The major draw back of this system is its inability to suspend the operation of the irrigation pump when the temperature is high though the soil is dry. This therefore leads to water wastage by evaporation during irrigation.

In **Soil Moisture Based Irrigation Test in a Remotely Monitored Automated System** (Matenge, 2017). The work aimed at determining the most efficient soil moisture monitoring method in an intelligent remotely monitored system and to automatically water the field when the need arises. The system is controlled by Microcontroller and programmed using LabVIEW Software. It made use of soil moisture sensors and actuators, which collected data and sent it to microcontroller for interpretation. The microcontroller then sent the data to Personal computer or an android mobile phone for real time monitoring and controlling activities by the farmer. This allows the user/farmer to control farming activities from anywhere automatically without manual labour intervention.
But in the event of network failure which is often inevitable especially in a developing world, the plants will be denied of the necessary action of the farmer until the network issue is resolved. Besides, it still requires the input of labour. In this proposed work, the shortfall is well taken care of by completely transmitting all commands wirelessly without human intervention.

In **Automatic Plant Irrigation System** (Thilagavathi *et al*.,2016) it is aimed at creating an automated irrigation mechanism which turns the pumping motor ON and OFF by detecting the dampness/moisture content of the earth. To achieve this aim, the Op-amp is configured here as a comparator. The comparator monitors the sensors and when sensors sense the dry condition, then the system will switch on the motor; the motor is switched off when the sensors are in wet. The comparator does the above job when it receives the signals from the sensors. The circuit design of the system is shown in Figure 13. The major draw back of this system was the use of op-amp as the controller. This made the system to be rigid, that is, difficulty in adjusting it to suit changes in some parameters like soil type, etc because the op–amp is not reprogrammable. Also, its response to signal is slow. The use of microcontroller in the propose design makes it reprogrammable(flexible), scalable, and of high speed.

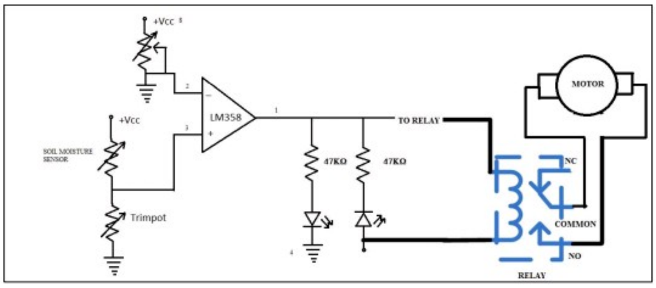

Figure 13: Automatic Plant Irrigation System (Thilagavathi *et al*.,2016)

In **Smart Irrigation System Based on Internet of Things** (Nurulisma *et al.,*2019) was aimed at developing a system that could be controlled both manually and automatically. The Smart Irrigation System is integrated into the mobile application system to enable the user to easily monitor and control the irrigation of the farm field. On the mobile application system, there is an interface to view data collected directly from the sensors via the help of the Firebase, which is the cloud that creates a bridge between hardware and the cloud database. This system made use of Internet of a Thing to communicate with the owner of the field of all the activities of the system. It has the system of remotely controllable water pump using buttons from BLYNK app for automatic irrigation if the soil moisture content sensed from the communication based soil moisture sensor falls below a certain threshold level. It supports both the automatic and manual controls which allow transition between the modes of automatic or manual. That is, the owner can initiate the irrigation from his location if the need arises. The water pump turns on for 10 seconds and stops to check the soil moisture content level if the soil has gotten the right amount of moisture. If not, the pump is turned on for another 10s. This process continues until the soil is sufficiently irrigated. As wonderful as the system appears to be, it still leads to a lot of water wastage in the sense that if the soil only needs, say, 12s of irrigation, the pump operates for 10s, stops, and operates for another 10s leading to 8s pumping of unneeded water. Hence, the system can not be said to be fully smart. The figure below shows the hardware connection of the system.

This serious shortfall was taken care of in this proposed system. The system irrigates the land with the appropriate quantity of water thereby preventing wastage of water.

V. Summary of the related Literature

Table 2: Summary of the related Literature

S/N	Name of research work	Authors/year of publication	methodology	Research gaps
1.	Android based Automated Irrigation System using Raspberry Pi	Apurva T, Nina G, Navani J.P, Tiwari R and Aniimika G. (2017)	Raspberry Pi technology	I. The use of Raspberry Pi technology is expensive ii.it also has no mechanism for

				flood drainage in the event of over flooding.
2.	**Arduino Based Automatic Plant Watering System**	Devika S.V, Khamuruddeen S.K, Jayanth T and Khalesha S(2014)	Arduino technolgy	i.The system is running on wired network. ii. the system is only suitable for low to medium field
3.	A Real time implementation of a GSM based Automated Irrigation Control System using drip Irrigation Methodology	Veena D.K, Anyush A, Chandan K, Raunak B and Rochak B(2013).	*GSM module, programmable integrated circuits technology and* drip Irrigation Methodology	i.GSM network fluctuation. ii.Not completely smart because of human interface.
4.	Automated irrigation system using solar power in Bangladesh	Uddim J, Reza S.M.T, Newaz Q, Islam T and Kim J. (2017)	GSM module, solar technology and temperature sensor	i.GSM network fluctuation. ii.Not completely smart because of human interface. iii. the system is limited to a location
5.	Sensor-based Automatic Irrigation System	Mohamed A.A, Gebremedhn M.G and Tsigabu T.B. (2015)	GSM and WIFI modules, programmable integrated circuits technology humidity and temperature sensors.	i.GSM network fluctuation. ii.Not completely smart because of human interface.
6.	Design And Implementation Of An Automatic Irrigation System Based On Monitoring Soil Moisture	Agbetuyi A.F, Orovwode H.E, Awelewa A.A, Wara S.T and Oyediran T. (2020)	Microcontroller based technology	I. The system did not consider the temperature of the soil thereby leading to water lost through evaporation
7.	Arduino Based Smart Irrigation System	Madhu V.K, Kavipriya R,	Arduino and IOT technology	I. This system is unable to suspend

		DivyaPriya D and Ambika M.(2018)		the operation of the irrigation pump when the temperature is high thereby leading to water wastage by evaporation during irrigation.
8.	Soil Moisture Based Irrigation Test in a Remotely Monitored Automated System	Matenge G.R.(2017)	Microcontroller based technology, GSM modules	.GSM network fluctuation. ii. Not completely smart because of human interface.
9.	Automatic Plant Irrigation System	Thilagavatsh S, Aishwarya R and Priyadharshini K (2016)	Op-amp technology	I. The system is rigid because the op–amp is not reprogrammable. Ii. Also, its response to signal is slow.
10.	**Smart Irrigation System Based on Internet of Things**	Nurulisma I, Shegillshah R, Wong C.T and Than K.X. (2019)	GSM module, IOT technology	i.the system is not sensitive because it cannot detect when the volume of water is enough for the soil but continues until the number of seconds programmed for spraying water elapsed.

VI. Research gaps and Research Contribution

These are the research gaps presented from the reviewed related literature with the research contribution of the proposed system;

i. The use of Raspberry Pi technology is expensive but the proposed system will use arduino technology that is less expensive.

ii. Many existing systems have no mechanism for flood drainage in the event of over flooding, the proposed system was programmed to involve effective flood drainage mechanism

iii. Many previous systems are running on wired network but the proposed system will be wireless.

iv. Many of the reviewed systems run with GSM modules that have issue of network fluctuation but the proposed system will run on smart communication to all the units.

v. Many existing systems encountered during the research could not consider the temperature of the soil thereby leading to water lost through evaporation but the proposed system will solve this problem by the use of temperature sensor that ensures that the soil temperature is at suitable range before watering.

vi. From the research conducted, we observed that a system was running on the op–amp that is not reprogrammable but the proposed system will use arduino technology that is reprogrammable.

vii. We also observed that a system is not sensitive because it cannot detect when the volume of water is enough for the soil but continues until the number of seconds programmed for spraying water elapsed but with the smartness of the proposed system, the problem will be eradicated.

VII. Conclusion

At the end of the Smart Farm Systems for Irrigation and Flood Control review, we were able to deduct that Raspberry Pi technology is presently the most efficient technology for this project though very expensive, there must be checkmating mechanisms for flood drainage system. Many reviewed systems run on GSM with issues of network fluctuation therefore there is need for efficient network. We also observed that many systems were running on non-programmable op–amp and are not sensitive enough to detect the actual volume of water needed for the soil, we are recommending as in our proposed system that re-programmable and smart technologies should be used to solve the observed problem. Many existing systems encountered during the research could not consider the temperature of the soil thereby leading to water lost through evaporation, we recommend the use of temperature sensor that ensures that the soil temperature is at suitable range before watering. Finally, We observed that some systems are not sensitive because it cannot detect when the volume of water is enough for the soil but continues to spray water, this problem can be eradicated by the use of smart re-programmable technologies.

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