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A Survey on Remote Monitoring and Controlling of Drip Irrigation Methodologies

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Abstract— **Using wireless sensor network in farming from independent power source distribution, monitoring valves and switches operation, and remote area control will efficiently produce excellent quality farm products in all season. Then in order to control farm power distribution and irrigation system, a communication methodology of the wireless sensor network is required for collecting environment data and sending control command to turn on/off irrigation system and manipulate power distribution. The major problem faced in many agricultural areas is the lack of mechanization in agricultural activities. In India agricultural activities is carried out by manual labor, using conventional tools such as plough, sickle etc. This kind of smart farming system reduces the manual work and automates the agricultural activities. In this paper we have surveyed various existing systems which use technologies like WSN, Pervasive Computing and Internet of Things. Factors like soil moisture, humidity, temperature and pH values have been considered to give an optimized and automated system for irrigation purpose.**

Index Terms— **Embedded Systems, Drip Irrigation, Internet of Things, Sensor Network, Web-Service**

I. Introduction

Agriculture plays a crucial role in world-wide economy. It is the main source of livelihood for people. So it is necessary to make efficient utilization of resources according to the environmental conditions to meet the basic requirements of the crops. With the help of modern technology, it is possible to collect and analyze information about the environmental factors in a precise manner. This information can help the farmers to take appropriate decisions which can help in the reduction of nutrient leaching and also save resources. Technological advancements within the area of agriculture will confirm to increase in productivity and reduced manual work. The important trouble confronted in many agricultural areas is that lack of mechanization in agricultural activities. In agricultural ecosystem, clever tracking of soil parameters like humidity, pH, and irrigation manipulate systems etc. can be measured using WSN with precision. Sensors are used for amassing facts about the environmental attributes while actuators are hired to react on the feedback to have manipulations over the conditions. The context acquisition through sensors provides a precious contribution in modeling conditions of domains which have form of time variation attributes.

A self regulating drip irrigation system optimizes water and fertilizer use for agricultural crops. Water is provided directly to the roots of the plants which is a perfect way to water.1It makes efficient use of water by slowly dripping it to the roots of the plants through narrow tubes and valves.2 In these systems, pumps and valves may be manually or automatically operated by a controller.

A wireless sensor network (WSN) is a wireless network having geographically distributed autonomous devices using sensors to monitor physical or environmental condition. A WSN finds substantial applications in agricultural field. Sensors are mainly used for collecting information of weather, crop and soil. The nodes are operated by battery power and used to monitor and control the soil parameters from remote locations.3To extend battery life, a WSN node periodically wakes up and sends data by powering on the radio and then powering it off to save energy.

The Internet of Things (IoT) is system of integral computing devices, mechanical and digital machines that are provided with unique identifiers and which can transfer data over a network without requiring human-to-human or human-to-computer interaction. The IOT can achieve functions like intelligent control, intelligent recognition, data acquisition, location tracing, tracking and monitoring.4 This survey will elaborate the available techniques for the remote monitoring and controlling of drip irrigation systems. Section 2 gives the survey on the already existing methodologies for irrigation system based on WSN and IOT. Section 3 presents the sensor related information. Section 4 concludes the survey on automatic drip irrigation system.

II. Existing Methodologies

A. *Automatic Drip Irrigation System Using Fuzzy Logic and Mobile Technology*

In [1] a canny trickle drip irrigation system framework improves water and manure use for rural products utilizing wireless sensors and fluffy logic. WSN comprises of numerous sensor nodes, center and control unit. Sensor gathers ongoing information, for example, temperature, soil dampness. This information is exchange to the center point

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utilizing the wireless technology. The center point forms the information utilizing fuzzy logic and chooses the time span for keeping the valves open. As needs be, the drip irrigation system framework is actualized for a specific measure of time. These frameworks have photovoltaic cells and correspondence link which permits the framework to be checked, controlled, and booked through text messages. The framework can rapidly and precisely compute water request measure of yields, which can give an scientific basis to water-sparing water system, and also a strategy to enhance the measure of compost utilized. This system can save a lot of water and is easy to implement. The system architecture is very simple, therefore making it beneficiary for all types of agriculturists.

B. Drip Irrigation System using Wireless Sensor Networks

In [2] a closed loop model is proposed. This model incorporates pressure, temperature and soil moisture sensors to monitor the irrigation operations. It basically deals with the case where a system malfunction occurs, as when the pipe emitters can be blocked due to environmental condition such as sludge, sand which can cause plant stress or the pipes can be broken by accident which might cause water waste and plants damage. To deal with this type of situations the proposed system comprises sensors and actuators such as soil moisture sensor, temperature sensor, pressure sensor, solenoid valve and sink node. It has two types of traffic gathered from wireless sensor network. First one can be classified as normal traffic which is assembled from temperature and soil moisture sensors. The second is the priority traffic as it needs a critical intervention. Priority traffic is assembled from pressure sensors. In this manner, it accomplishes a high QoS execution through a satisfactory need based routing protocol

C. Using wireless sensor network and Embedded Linux board

In [3] framework makes utilization of Raspberry Pi as the inserted Linux board alongside wireless sensor network (WSN) technology to introduce automation in the irrigation of farms. A web interface is also provided to the user in order to control and supervise the irrigation system framework in a remote manner. The embedded Linux board makes use of the ZigBee protocol to communicate with the sensor nodes distributed over the farm area. It also acts like a coordinator node to gather the soil dampness and temperature parameters through sensors. The sensor nodes are additionally furnished with ZigBee RF radio wire for transmitting to and receiving from the coordinator node. The gathered information is put away in the database and analyzed by the Raspberry Pi and accordingly the crops are watered. Appropriate algorithms are used for this mechanism. The Ethernet interface of the Raspberry Pi enables in running a simple data web server. Thus, with the help of a web browser, user is ready to monitor the irrigation system framework of farms to enable reduction in water consumption and ultimately increasing the crop yields.

D. Regulation of Water in Agriculture Field Using Internet of Things

In [4] emphasizes on the use of IOT in agriculture to overcome the problems like lack of exact information and communication which leads to the loss in production. The overall system is designed such as it is able to supply water from storage areas like well. When the land is dry it is also able to remove excess water from the land when in excess. The main components used are a solar cell, two sensors and GSM network work mainly to make this mechanism work, the working is purely based on inter-linkage. For power source ultimate hybrid solar cell is used. Hard suction hose is used to suck the water which is present in excess. Soil hygrometer is a simple water sensor can be utilized to identify soil dampness level, when the soil moisture deficiency module yields an high level i.e. an abnormal state, and vice versa output low. The proposed methodology is to work in both seasons. In summer season the hygrometer plays a major role. It detects the moisture level of soil and if the level is below the threshold level, it will send a warning message to a user's mobile phone through GSM. During Rainy season VRS-20 SDI-12 RADAR LEVEL SENSOR plays a major role and if the water level reaches the level which has been fixed, then a warning message will be sent to the user whether to remove the excess water or not.

E. Monitoring of Soil Parameters for Effective Irrigation using Wireless Sensor Networks

In [5], WSN technology is used to measure soil parameters like humidity, pH, and irrigation control system. This system propose, to develop a WSN based Dynamic and Automated Irrigation System design and instrumentation. This process maintains soil type and programming for continuous detecting and control of rural water system framework. The proficiency of water system frameworks can be raised up via atomated remote detecting and nonstop examination of soil parameters. Minimal effort remote checking framework for farming ecosystems is developed in this system. A number of intelligent wireless sensor nodes are connected to an Internet-enabled computer system installed on site to store and disseminate relevant soil information and to provide remote access to the monitoring system. To achieve a high accuracy of the wireless monitoring system soil moisture sensors are used. Irrigation system works according to humidity. If humidity increases then time interrupt the functional timer unit thereby halting the process and the original time set for the irrigation will be modified. Mobile agents performing data acquisition, data analysis, data aggregation and decision making directly on the nodes, are able to respond in a timely manner to changes in the soil parameters and to precisely schedule irrigation events, which results in a reduction of freshwater consumption and cost.

F. Using WSN and GPRS Networks

In [6] system was proposed with a perspective to accomplish the remote observing and support of greenhouses on the premise of wireless sensor network (WSN) and GPRS innovations. Continuous monitoring of different parameters like air temperature, air humidity, soil temperature, soil dampness, intensity or power of light and concentration of CO_2 is done. In order to meet the requirements of the monitoring of greenhouse environment in an effective manner, focus is made for low power consumption, user-friendly and interactive interface as well as flexible networking. Six types of sensors are used to acquire the data of each of the parameters. The gathered data is then sent to the remote platform via GPRS. The communication protocol used is ANT, which is an ultra-low power standard for wireless networking. The ANT protocol is based on the ZigBee protocol. With this protocol regular wake-up, sleep and time-sharing functions are utilized in order to overcome unnecessary energy losses. This system was formulated with a view to provide a cost-efficient and power-efficient solution to greenhouse monitoring.

G. Smart Drip Irrigation System using Raspberry pi and Arduino

In [7] automation is introduced to make an efficient use of electricity and water in order to reduce wastage of these resources. A smart system for drip irrigation is proposed which makes use of the devices like Arduino microcontrollers and Raspberry Pi. Also, XBee is used in order to control the entire system in a wireless manner. First of all, an email is sent to a predefined account with subject line as run the irrigation system for Y minutes. Raspberry Pi is utilized to poll the emails in the account. The corresponding GPIO pin of Raspberry Pi is turned high to indicate the reception of mail. To achieve this, a program is written in Python programming language. The controlling of the relay and the ultrasound distance sensor is done by the open source microcontroller, Arduino. The ultrasound distance sensor is used to keep track of the water level in the tank so that the water level does not rise above the threshold or drop below it. Accordingly, signals are sent to the solenoid valve to open or close via Arduino and Pi using the ZigBee protocol. This system, thus, regulates the watering process without much manual intervention and also enables its control by sending the email with appropriate subject line depending upon the weather conditions.

H. Using Sensors for Agricultural Task Automation

In [8] the main focus is on sensing physical parameters like soil moisture level, nutrient content and pH levels. A movable overhead crane system is used for irrigation purpose. Electronic components, mechanical machineries and sensors are used to bring in automation in farming. Three motors along with optocouplers are attached to the system. These motors are attached to an impeller. The IR sensor, which acts as the feedback, maintains and regulates the speed of the monitor. A GSM module is used as a communication module between two systems. Use of a pipeline system and sensors checks the level of green manure, seeds, water and compost. This data is collected in a real time environment and used to bring in automation and make remote control possible

I. Using IOT Technology

In [9] the proposed system uses IOT for remote control and monitoring in Greenhouse. It is cost effective, flexible and efficient. Even in this paper the basic working remains same, sensors are used to collect data and this data is collected in the greenhouse and sent to the ZigBee coordinator. This data is then sent to the web server node. The main focus is on collecting data based on environmental conditions and taking actions based on the data sheet or the threshold values. Temperature, humidity, wind, light, pressure and CO2 are some of the parameters that are being considered. The screen/curtains, fan and sprinklers are being controlled based on the collected data. The GUI of the system is very user friendly with options to make it automatic or manual and gives remote user friendly options to control the control equipments. The paper shows that the collected data are accurate and data transfer is secure.

J. Wireless Sensor and Actuator System for Smart Irrigation on the Cloud

In [10] a cloud-based solution is developed for a smart irrigation system organized as a Wireless Sensor and Actuator Network (WSAN).Number of devices are connected to internet and the interconnection of smart objects embedded with sensors enables them to interact with the environment that forming a WSN . These network nodes perform acquisition, collection and analysis of data like temperature and soil moisture. Collected data can be used to automate the irrigation process in agriculture while decreasing water consumption, resulting in monetary and environmental benefits. Cloud Computing are used to store large amount of data generated by the WSN. This paper proposes and evaluates on a real deployment a cloud-based Wireless Sensor and Actuator Network (WSAN) communication system. Proposed system can control a set of sensors and actuators, respectively, to assess plants water needs. In this system first data is acquired and then analyze and compare. The development of a system for smart irrigation can greatly benefit from the knowledge of the soil and water. This information was useful for the development of the crops. Besides the soil moisture monitoring, to assess the plants water needs for its proper and healthy development. This system is also useful for different soil types. Collaboration of soil and excess use of water are avoided using this system. Using this system quality of crops as well as production growth of crops also improves.

K. ZigBee-Based Irrigation System for Home Gardens

In [11] a wireless irrigation system has been implemented. It is used to screen the temperature and soil dampness for home garden. Web Server-Master-Slaves design is utilized as a part of this framework. The framework is made out of expert station and slave nodes. The master station and slave nodes are likewise furnished with a wireless microcontroller. Microcontrollers are advantageous as far as low power utilization, built-in resources, size, toughness and affordability. Each of the slave nodes is furnished with a temperature sensor and a soil dampness sensor. The slave microcontroller peruses and outlines the gathered information. ZigBee ad-hoc network is utilized to forward these frame to the expert station. The expert node is in charge of social event the detected information and afterward directing the relating water-valve of the slave nodes on the premise of installed water system calculations. A home web-server is incorporated with master and slave modules. This enables remote accessibility and monitoring of the irrigation system for farming process. Remote operation is made possible using a high-end personal computer which acts as the server. Wireless interface is required to communicate with the master module via personal computer. This system can be modified and integrated with the already existing home automation system, thus making it a more feasible solution.

L. Using Web Based Service

In [12] the water flow will be allowed in the pipe and its flow range will be decided on the premise of the moisture level present in the soil. The grove moisture sensors are sent in the farming field. These sensors are in charge of recovering the measure of moisture substance in the soil. In light of the moisture content, the suitable water stream will be permitted. The water stream sensors are in charge of detecting the stream range and choosing the working pressure. This implies relying on the moisture content present in the soil, the water stream should be permitted in a commanding or restricted way. Notwithstanding this, web service is likewise given to the client. The sensor information is put away in the database and the same is made available to the user via a web portal. If the retrieved data is greater than the default measure then the database is simply updated and the user can view the sensor details through the web page, else the user will be intimated via SMS about the functionality status of the respective motors.

M. Using Smart Phone and Wireless Sensor Networks for Smart Farm

In [13] the proposed system is making an irrigation automatic and also giving an option to control it manually via smart phones from anywhere in the world. It is a portable system and it gauges soil moisture, temperature and dampness. The water system framework and the water levels near the roots of the vegetables are remotely monitored and controlled. The results suggest that in the proposed system, the accuracy of remote control is 96 percent and that of data collection is 98 percent. There is a serial communication between every node placed at various points in the concerned area. The sensed data is sent to the coordinator node. The sensor node sends this data either directly or via another node depending on whether it is in the range of the coordinator node or not. The coordinator node collects and sends the data to the web server node and sends commands to the sensor nodes to control the environment based on threshold values. This data transmission takes place via XBEE which transmits signals as the characters through small chip. Data can either be transferred point to point or point to multipoint. The web server shows data collected from the coordinator node to the user when the user requests for the data using smart phone. This collected data is not enough to make intelligent decisions or to make it completely automatic. An error is also found in the amount of water being supplied.

N. Using master-slave architecture

In [14] a fully automated and wireless irrigation control system that avoids subjective decisions about irrigation volumes and timing has been developed. All fields in the farm are accessible via TCP/IP protocol. Master-Slaves architecture is used in this system. The irrigation control and monitoring program is implemented in the host computer in the farm, which monitors the states of all crops and controls the valves using a threshold and timers. Different soils types requiring different volumes of water for a same crop, using moisture and conductivity sensors check whether famers use only required volume of water or not. This paper proposes a smart irrigation at farms scale covering field crops as well as plantations. Each farm has one data collection node and the data is stored in host computer. There are Master and slave node. Slave nodes are connected to XBee network. Master nodes have two sensors and a solenoid valve.Master Node controls the irrigation of the field with a same crop using slave nodes.TCP/IP protocol are used for monitoring the farm.This system is feasible for large scale implementation.

O. Using Wireless Sensor Network

In [15] wireless sensor network technology has been utilized. Wireless Sensor Network has been broadly utilized as a part of numerous regions for observation and checking in farming and living space observing furthermore it enhances work execution. In this paper, we talk about and review wireless sensor network applications for natural checking.WSN technology has vision to increase the growth of low cost, low power and multifunctional sensors which are in small size and communicate in short range. Execution of task and data processing is done by using microcontroller. Temperature, light, sound and pressure are collected by sensors and then transfer to server.WSN mainly used in Medical, military, industrial, agricultural and environmental monitoring. This paper mainly focuses on environmental monitoring system. These systems have low power consumption, ease and are a simple approach to control real-time observation for unprotected agriculture. It can be applied to indoor living monitoring, greenhouse monitoring, climate monitoring and forest monitoring. This system improves the performance, robustness, and provides efficiency in the monitoring system.

P. Connecting Agriculture to the Internet of Things through Sensor Networks

In [16] reports the design of the sensor network enabling the connection of agriculture to IOT. This connection helps in linking the agronomists, crops, and farms irrespective of their geographical diversity, thus, improving the productivity of crops. To achieve reliability, cost and application-specific features, a customized sensor node is designed. The sensor data is communicated to the server which, in turn, stores the data into the database. The decision support system (DSS) is utilized which contains various agricultural models. It also analyzes the database and provides the relevant guidance to the user. The guidance is provided in aspects of management, irrigation and disastrous climate warnings, which are intimated to user via SMS. A web server interface can provide the ability to view data, run queries on the historical data and create alerts. Thus, the Internet of Things can help in changing the way we organize and consume information by the connection of the real-world objects.

Q. Using a Hybrid Wired/Wireless Networking Infrastructure

In [17] a solution is given for the optimal management of all the greenhouses in the farm. The data must be first acquired from the greenhouse and then it must be transferred to a control unit in a control room which is away from the greenhouse. So basically data is transferred between the greenhouses and their respective control rooms. For this data transfer, wired communication is done using field bus. But in these contexts, wireless communications are more flexible, as they can be easily extended and modified. But introducing a completely wireless network does not solve the problem as it has its disadvantages. Thus, a hybrid of wired and wireless technology is being introduced in this paper. Flexibility is required inside the greenhouse. So it is wirelessly connected inside the greenhouse. Flexibility is introduced in terms of cost, scalability, mobility and installation. The connection between the greenhouse and the control area, that is, outside the greenhouse is done using a wireless network. This network is ZigBee-based which guarantees long battery life and low maintenance. It works as the control backbone in the system. The entire location of the greenhouse is rarely changed, thus making wired communication a good option. So this makes the system scalable inside the greenhouse and avoids the deployment and localization tasks of sensors outside the greenhouse. As the system is a combination of wired and wireless network all devices are managed as a part of a single network. It has been tested to work in different environments.

R. The Application of Wireless Sensor Network in the Irrigation Area Automatic System

In [18] automation is introduced in irrigation systems using a multiple to single wireless sensor network. Multiple sensor nodes are deployed to collect data. The sink node collects real time data from the surrounding. Data related to water level, rainfall and gate position is collected via these sensors. The main transformation is from wired to wireless network. It reduces costs and efforts required in installation and maintenance. It also improves the reliability of the system and increases scalability. The system basically consists of sensor nodes, sink nodes and information center. The sink node collects data from the sensors deployed and uploads it to the information center on a real time basis using GPRS network. The position of the sensor node and sink node is relatively fixed. This system uses broadcast communication protocol encouraging lower power consumption and redundant reliable request. The use of wireless sensor network has gained a lot of applications.

S. Using a Distributed Wireless Sensor Network

In [19] a framework, a wireless sensor network, and programming for real-time in-field detecting and control of a site-specific exactness irrigation system is designed and implemented. It has developed the machine conversion from a conventional irrigation system to an electronically controllable system for individual control of irrigation sprinklers. It provides extensive details for the wireless communication interface of sensors from in-field sensor stations and for a programmable logic controller from a control station to the computer at a base station. A plug-and-play communication module is offered by the Bluetooth wireless technology used in this paper which also saves significant time and expense by using commercially available sensors and controllers equipped with serial communication ports.

T. Using Pervasive Wireless Sensor Networks:

In [20] focus is on the use of pervasive computing for agriculture welfare. By creating a pervasive, self-configuring network of cost effective, simple devices can learn about their environment and seek to control it for beneficial purposes. It has focused on sensor networks as a means for providing a new level of information about the state of pastures. The initial experiments have revolved around the use of solar-powered moisture nodes and low-resolution camera nodes for pasture assessment. To make the platform ideal for long-term outdoor deployments: a Nordic radio with a range of over 1 km that operates on the 433MHz or 915-MHz band, an integral solar battery charging circuit, and an extensive range of sensors and sensor interfaces are incorporated..

III. Sensor Specifications

This DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability.

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. TheLM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling.

The soil moisture sensor can be used to test the moisture of soil. When the soil is having water shortage, the module output is at high level else the output is at low level.

Table 1. Sensor Specifications [21]

Sensor Name	**Measurement Range**	**Humidity Accuracy**	**Temperature Accuracy**	**Package**
DHT11	20-90%RH 0-50 °C	±5%RH	±2°C	4 Pin Single Row
LM35	-55 to 150 °C	-	±5°C	SOIC
Soil Moisture Sensor	5-90%RH	±3%RH	-	2 probed device

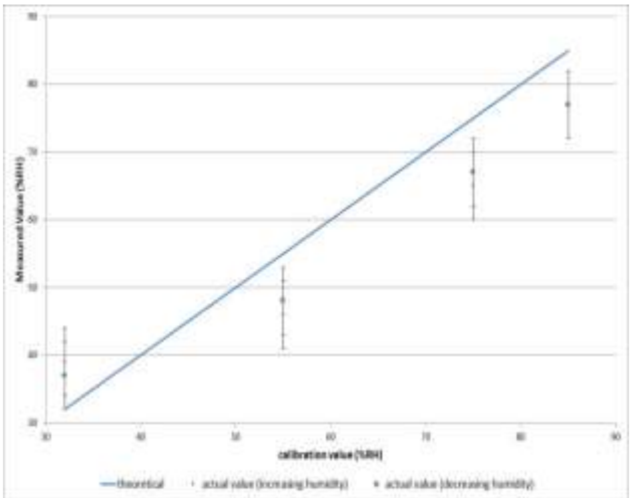

Fig. 1. Characteristics of DHT11 Sensor [22]

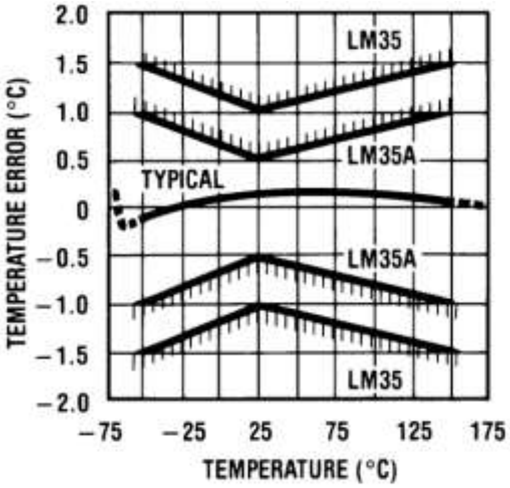

Fig. 2. Characteristics of LM35 Sensors [23]

There are several sensors that are utilized for agricultural attributes acquisition. These are presented in the following table.

Table 2. Sensors used in Agricultural Domain [24]

S. no.	Sensors	Soil							References
		Temperature	Moisture	Dielectric permittivity	Rain/ water flow	Water level	Conductivity	Salinity	
1	Hydra probe II soil sensor	✓	✓	✓	✓	✓	✓	✓	www.stevenswater.com
2	Pogo portable soil sensor	✓	✓	✓	✓	-	✓	-	www.stevenswater.com
3	MP406 Soil moisture sensor	✓	✓	✓	-	-	-	-	www.ictinternational.com.au
4	ECH2O soil moisture sensor	✓	✓	✓	-	✓	✓	-	www.ictinternational.com.au
5	EC sensor (EC250)	✓	✓	-	✓	-	✓	✓	www.stevenswater.com/catalog/products/water_quality_sensors/manual
6	ECRN-50 low-REC rain gauge	-	-	-	✓	-	-	-	http://www.decagon.com
7	ECRN-100 high-REC rain gauge	-	-	-	✓	-	-	-	http://www.decagon.com
8	Tipping buket rain gage	-	-	-	✓	-	-	-	www.stevenswater.com
9	107-L temperature Sensor (BetaTherm 100K6A1B Thermistor)	✓	-	-	-	-	-	-	http://www.campbellsci.com/107-l

IV. CONCLUSION

This paper reviews various automated wireless drip irrigation systems using IOT and embedded Linux board. Raspberry Pi is an embedded Linux board which collects the sensor information from sensor node continuously, stores it in a database and provides the web interface to the user. Efficient watering of crops can be done by analyzing the soil parameters. User can easily monitor and control the system with the help of web interface and automation. Thus, it would ultimately minimize the human intervention. The ZigBee protocol can be used here for wireless communication. This can enable effortless creation of network along with the combination of a microcontroller, XBee and sensors. The main aim is to provide low power and inexpensive solution for the drip irrigation system. Web-service can also be provided to the user to access system status using any internet-accessible device. From the above survey different drip irrigation techniques using WSN and IOT have been elaborated. In future work, we are trying to make the existing system more robust, cost effective and improving the life span of sensors.

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