Internet of Things (IoT): An Approach towards Agriculture

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Abstract— Internet of Things (IoT) is an environment that is consisting of physically connected objects that are accessible through the internet. The 'thing' in IoT could be any object which are build-in-sensors that have been assigned as an IP address and have the ability to collect and transfer the data over a network without any manual assistance. IoT has many number of applications that are smart agriculture, smart healthcare, smart water management, smart city, smart home, energy engagement, farming, poultry, smart retail, and also for industrial purpose. Agriculture plays an important role in India which depends on weather conditions and the natural resources. Hence, the agriculture environment can be monitor by a remote location from the user. The plant growth can be measured by using the sensor which is placed in the soil. The sensor will collect the input as measurements and transfer it to the controller through internet from where the farmers will get the intimation of plants growth. The intimation can be an application.

Keywords— ***IOT, Humidity, Soil Moisture, Temperature, and Arduino Microcontroller***

I. INTRODUCTION

IoT is a combination of both software and hardware technologies along with embedded devices which enable to provide facilities and services to everyone, anytime, anywhere that are required by any network. The connectivity helps us to capture large amount of data from different places, ensuring in improving safety and security and increasing the efficiency.

IoT is transformational services that can assist the companies to improve performance through IoT analytics and IoT Security to convey better outcome. IoT provide benefits in businesses such as oil and gas, transportation, infrastructure, utilities, insurance, manufacturing, and retail sectors, aided by the torrent of interactional and transactional data at their disposal. IoT is expected to propose higher connectivity of services, devices and, systems that goes beyond machine-to-machine (M2M) interactions and covers a wide range of applications, domains and protocols. The interconnection of these embedded devices (including smart objects), is expected to lead in automation in almost all fields, while also enabling advanced applications like a smart grid, and expanding to areas such as smart cities.

Agriculture is one of the important parts for developing the country's economy. Agriculture is the basic thing for food and raw material for the living on the earth. The agriculture plays an important role in providing large scale employment. Agriculture continues to play an important role for the growth of economies. Three fourths of the Indian population workforce is related with agriculture.

The IoT based agricultural convergence technology is a technology to create a high values such as increase of agricultural products in the whole process of agricultural production and improvement of production efficiency.

The main aim of our study is to analyze various techniques that can be used in monitoring the agriculture using IoT. And what are different sensors have been used till now, how the data is secured, the applications and challenges in IoT agriculture.

By using IoT, we can expect to increase in production with low cost by monitoring the efficiency of the temperature, humidity monitoring and soil, fertilizers efficiency, rainfall monitoring, theft detection in agriculture areas and monitoring storage capacity of water tanks. With latest technologies there is combination of traditional methods such as Wireless Sensor Networks and Internet of Things can lead to agricultural modernization. The Wireless Sensor Network which collects the data from various types of sensors and using wireless protocol sends it to the main server. There are different factors that affect the productivity to great extent. Factors include attack of pests and insects and when the crops grown up it is attacked by wild animals, the attack of pests and insects can be controlled by spraying the proper pesticides and insecticides. The crop yield is declining because of unpredictable water scarcity, improper use of water and monsoon rainfalls. The figure 1 shows the overview of agriculture.

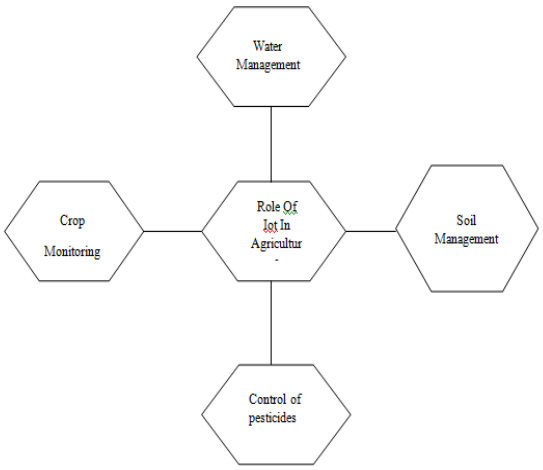

Fig1: Overview of IoT in agriculture

Further the paper is prepared as follows: section II gives details about the recent related work, section III illustrates the advantages of IoT agriculture, in the section IV discussed about challenges on IoT agriculture, and paper is concluded in section V.

II. RELATED WORK

The paper focused on field monitoring using IoT devices which would provide the present humidity, soil moisture and temperature of the field to the farmers. An individual would be able to retrieve the information to manage the field based on the data collected from field. By using an arduino microcontroller board along with humidity, soil and temperature sensors is used to retrieve the data from the field on the fly from a remote field. The data once received are analysed. This work invoked to increase the productivity of crop and to take a preventive measure for loss of crop. Flied monitoring based on IoT which helps farmers in monitoring the fields effectively using the fast and reliable system. This helps the farmers to take effective measure for the protection and better yield of the crop. Monitoring vegetation fields from distant locations not only helps in better utilization of the manpower but also quality of the crop. [1]

This paper focused on providing a remote sensing of agriculture parameters and control system to the greenhouse agriculture. The plan is to control temperature, light, soil moisture and CO2. Based on the soil moisture the controlling action is accomplished for the greenhouse windows/doors based on crops once a quarter complete round the year. The objective is to provide organic farming and to increase the yield. The result shows the remote control of temperature, soil moisture, light and CO2 for the greenhouse. [2]

This paper aims making use of modern technology i.e. IoT and smart agriculture using automation. Monitoring environmental factors is the major task to improve the yield of the efficient crops. The feature of this paper includes monitoring humidity and temperature in agricultural field through sensors using CC3200 single chip. Camera is installed with CC3200 to capture images and send that pictures through MMS to farmers mobile using internet. This agriculture monitoring system serves as an efficient and reliable system and corrective action would be taken. Wireless monitoring of field reduces the human workload and it also allows user to see simultaneous changes in crop yield. It is low in cost and consumes less power. The system can be used in green house and temperature dependant plants. [3]

This paper proposed an Unmanned Aerial Vehicle (UAV) is used to locate and assist ground IoT devices to form themselves in cluster formation then provides a reliable uplink communication backbone for data transmission. Use of multi frequency, multi power transmission, and mobile sink make it possible to reduce power utilization of IoT devices as much as possible. The proposed UAV assisted dynamic clustering and routing technique URP to harness IoT in agriculture, we name it AG-IoT. In this proposed URP, heterogeneous IoT devices are installed in farm field and they form themselves in clusters format according to the instructions of UAV. The best node among all is then elected as CH. The process of node localization, clustering, and CH formation is conducted dynamically at runtime. [4]

They surveyed some typical applications of Agriculture IoT Sensor Monitoring Network technologies using Cloud computing as the backbone. This survey is used to understand the various technologies and to build smart agriculture. Simple IoT agriculture model is proposed with a wireless network. IOT can be applied in various domains of agriculture. First one is the Energy and Water: for Agriculture, Water and energy are the most important inputs and their costs can increase or low the agricultural business. Due to leaky irrigation systems, inefficient field application methods and the planting of water intensive crops in the wrong growing location water wastage is done. For its operation Pumps, boosters, lighting etc need electrical energy. Water use can be made smarter for agriculture by monitoring and change water volume, location timing and duration of flow can be done with IoT. [5]

This paper deals with remote monitoring system based on IoT protocol used by various researchers to increase agriculture production and optimal utilization of resources along with the proposed system which is useful in monitoring data. The proposed system is mainly developed to help the farmers. The use of IoT over the different technology one helps for deploying it in any type of environment for monitoring, making it flexible and robust. [6]

This paper provides that agriculture plays important role in India which depends on natural resources and the weather conditions. Here, the user can monitor the agriculture environment from a remote location. The growth of the plant can be measured by various sensors which is placed in the soil. The sensors will collect the input as measurements and transfer it to the controller through Wi-Fi from where the farmers will get the information of plants growth. The information may be an application or a text message. [7]

This paper shows the quality and different types of characteristic asset has debased throughout the years because of monetary issues related with expanded cost of information and diminishing ranch salary always declining land, labour, resources, and environmental issue, for example, soil and water contamination putting the suitability without bounds horticulture operation at chance. The solution for this is to embrace the savvy agribusiness framework in light of IOT with help farming administration and development of products including less utilization of compost, pesticide and water. [8]

This paper aims to improve productivity, global market, and efficiency and to reduce human workload, time and cost there can be reduce by introducing new technology named Internet of Things. IoT is the network of devices to transfer the information without human involvement. Hence, to gain high productivity, IoT works in the form of synergy with agriculture to obtain smart farming. This focuses on role of IoT in agriculture that leads to smart framing. [9]

This paper involves in indicating that IoT is still in its infancy in the agriculture and food domains. Applications are often fragmentary, lack seamless integration and especially in an experimental stage of development they are many advanced solutions. Important challenges to overcome this situation include (a) integration of existing IoT solutions by open IoT platforms, architectures and standards, (b) improving the usage of interoperable IoT technologies beyond early adopters especially by the simplification of existing solutions and make it more affordable for end users, and (c) further improvement of IoT technologies to ensure a broad usability in the diversity of the agri-food domain. [10]

This presents the IoT-based agricultural production system for stabilizing supply and demand of agricultural products while developing the environment sensors and prediction system for the growth and production of large amount of crops by retrieving its environmental information. Currently, the demand by consumption of agricultural products could be predicted quantitatively, however, the variation of harvest and production by the change of farm's cultivated area, weather change, disease and insect damage etc. could not be predicted, so that the supply and demand of agricultural products has not been controlled properly. [11]

This paper shows the review depended on applying a cloud construct application in light of agriculture. This depends on agro-cloud that upgrades agricultural generation and accessibility of information identified with research extends in the fizzled, the effect of doing this will spare the cost and time makes the correspondence simpler and speedier. This paper would advance a ton of research in the region of use of IoT in agriculture. [12]

This paper proposed a new IoT technology with cloud computing and Li-Fi. Wi-Fi is great for general wireless coverage within buildings, whereas Li-Fi is wireless data coverage with high density in confined area. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. First this project includes remote controlled process to perform tasks like spraying, weeding, bird and animal scaring, keeping vigilance, moisture sensing, etc. Secondly it includes smart warehouse management which includes temperature maintenance, humidity maintenance and theft detection in the warehouse. Thirdly, intelligent decision making based on accurate real time field data for smart irrigation with smart control. Controlling of all these operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing cameras, sensors, Li-Fi or ZigBee modules. [13]

In this paper two key gaps facing the agriculture sector has been identified. They include the inability to meet domestic food requirements and the inability to export at quality levels required for market success. They envisage that these problems can be solved by using internet of things (IoT) and data analytics (DA). In this paper, the application of IoT technologies and DA in agriculture is discussed. The benefits and challenges of deploying the IoT and DA are presented. Finally, methods that can be adopted towards solving the problems facing Nigeria's agriculture sector are proposed. [14]

This paper describes an approach to combine loT and image processing in order to determine the environmental factor or man-made factor (pesticides/fertilizers) which is specifically hindering the growth of the plant. Using an loT sensing network which takes the readings of the crucial environmental factors and the image of the leaf lattice, it is processed under MATLAB software by the help of histogram analysis. [15]

TABLE 1: OVERVIEW ON THE SMART AGRICULTURE TECHNOLOGY

References	Devices/Technologies	Benefits
Field Monitoring Using IoT in Agriculture [1]	Temperature, Soil Moisture, Humidity sensors and Arduino Microcontroller	Filed monitoring using IoT is fast and reliable system which helps the farmers in monitoring the fields effectively.
Remote Sensing and Controlling of Greenhouse Agriculture Parameters based on IoT [2]	Greenhouse parameters such as temperature, light CO2, and soil moisture	The objective is to provide organic farming and to increase the yield which helps the farmers.
IoT Based Monitoring System in Smart Agriculture [3]	IoT, Temperature, NWP, CC3200.	To increase the yield of the crops in farming.
Agriculture Internet of Things: AG-IOT [4]	Dynamic routing, WSN, Smart agriculture, Clustering, IoT.	In order to reduce power utilization of IoT devices as much as possible.
Smart Agriculture System based on IoT and its Social Impact [8]	Temperature, Humidity, Pressure, Moisture Sensors, Water Monitoring, Ph Level Monitoring, Smart Agriculture.	To improve crop productivity and soil fertility.
Agricultural Production System based on IoT [11]	IoT, decision support; agriculture, monitoring, Statistics.	Helps the farmer to forecast agricultural production using some IoT sensors.
IOT Agriculture to improve Food and Farming Technology [12]	Internet of thing, cloud Computing, Big data	Improve agricultural generation also, accessibility of information identified with research extends in the fizzled, the effect of doing this will spare the cost and time makes the correspondence less demanding and quicker.
A Novel Technology for Smart Agriculture Based on IoT with Cloud Computing, [13]	Internet of Things (IoT), Li-Fi, Agriculture Monitoring, Routing Protocol, Cloud Computing, GPRS, Irrigation	Li-Fi technology has been used for fixed area structure topology for better performance. Usually GPRS technology gives better results within low cost.
Enabling Smart Agriculture in Nigeria: Application of IoT and Data Analytics [14]	Agriculture, data analytics (DA), internet of things	In Nigeria which is the inability to meet domestic food requirements and export at quality levels required for market success.

Implementation of IoT (internet of things) and image processing in smart agriculture [15]	Internet of Things (loT), Image Processing, Sensing network, MATLAB	Determine the man-made or man-made factor (pesticides/fertilizers) which is specifically hindering the growth of the plant.

Table 1: Gives the overview of the various technologies used for smart agriculture.

III. APPLICATION OF IOT AGRICULTURE

The applications of IoT in the agriculture industry are many in number. Some of them are:

a) Precision Farming

The precision farming which is also known as precision agriculture, precision agriculture can control the farming practice and can be accurate when it comes to growing more crops and raising livestock of the farmers. The farm management is a key component is the use of IT and various items like sensors, robotics, automated hardware, variable rate technology, autonomous vehicles, control systems, and so on.

Some of the key technologies for the precision agriculture are adapted to access low-cost satellites, mobile devices, high-speed internet and reliable.

Precision farming is one of the popular applications of IoT in the agricultural sector and numerous organizations. Crop Metrics is a precision agriculture organization focused on ultra-modern agronomic solutions while specializing in the management of precision irrigation.

Some of the products and services of crop metrics include soil moisture probes, VRI optimization and virtual optimizer PRO, and so on. VRI (Variable Rate Irrigation) optimization increases profitability on irrigated crop fields with soil variability, increases usage of water and improve yields.

The soil moisture probe technology provides complete local agronomy support, and recommendations to optimize usage of water. The virtual optimizer PRO combines various technologies for water management into cloud based, single central and powerful location designed for farmers to have benefits by precision irrigation.

b) Agricultural Drones

Since technology keep on changing over time, agricultural drones are best example for this. Today, agriculture is one of the important industries to incorporate drones. Drones are being used in agriculture in order to enhance various agricultural features. The ways ground-based and aerial based drones are being used in agriculture are field analysis, crop health assessment, crop monitoring, planting, soil, irrigation, and crop spraying.

The benefits of using drones increases the yields, ease of use, crop health imaging, integrated GIS mapping, and saves time. The planning and strategy depends on real-time data collection and processing, the drone technology will provide a high-tech makeover to the agriculture industry.

Precision Hawk is an organization that gathers valuable data via a series of sensors that are used for mapping, surveying, and imaging of agricultural land by using drones. These drones perform in-flight monitoring and observations. The farmers enter the details that are needed to perform on fields, and select a ground resolution or an altitude.

From the drone data, we can monitor plant health indices, plant height measurement, canopy cover mapping, scouting reports, stockpile measuring, chlorophyll measurement, plant counting and yield prediction, nitrogen content in wheat, field water posing mapping, weed pressure mapping, drainage mapping and so on.

The drone collects thermal, multispectral, and visual imagery during the flight and then lands in the same location when it took off.

c) Livestock Monitoring

Large farm owners can make use of wireless IoT applications to collect data regarding the well-being, location and health of their cattle. This information helps the farmers in identifying animals which are sick so the animals can be

separated from the herd, so they can prevent the spread of disease. It also decreases the cost of labours as ranchers can locate their cattle with the help of IoT based sensors.

JMB North America is an organization that offers cow monitoring solutions to cattle owners. One of the solutions helps the cattle owners to check whether the cows are pregnant and about to give birth. From the heifer, a sensor powered by battery is expelled when its water breaks. This sends information to the herd manager or the rancher. In the time that is spent with heifers that are giving birth, the sensor enables farmers to be more active.

d) Smart Greenhouses

Greenhouse farming is a methodology that helps in improving the yield of vegetables, crops, fruits etc. Greenhouses control the environmental parameters through proportional control mechanism or a manual intervention. As manual intervention results in energy loss, production loss and labour cost, these methods are less useful. A smart greenhouse can be designed with the help of IoT; this design intelligently monitors and also controls the climate, therefore by eliminating the need for manual intervention.

By using smart greenhouse for controlling the environment, the different sensors are used that measure the environmental parameters according to the plant requirement. We can create a cloud server for remotely accessing the system which it is connected using IoT.

This eliminates the need for periodic manual monitoring. Inside the greenhouse, the cloud server also enables data processing and applies a control action. This design provides low cost and optimal solutions to the farmers with minimal manual intervention.

Illumine Greenhouses is a drip installation and Agri-Tech greenhouse organization and uses new recent technologies for providing services. It builds modern and affordable greenhouses by using solar powered IoT sensors. With these sensors, the water consumption and greenhouse state can be monitored via SMS alerts to the farmer by an online portal. Automatic Irrigation is carried out in these greenhouses.

The IoT sensors in the greenhouse provide information on the humidity, light levels, temperature and pressure. These sensors can control the actuators automatically to open or close a window, turn on or off lights, control a heater, turn on/off a mister or a fan, all controlled through a internet.

e) Crop water management

Adequate water supply is an essence for agriculture and the crops can be damaged in either of situation of excess of water supply or in lack of water supply. Agriculture Internet of Things with integration of Web Map Service (WMS) and Sensor Observation Service (SOS) provides a solution to manage water requirement or supply the water for crop irrigation. Agriculture Internet of Things smartly analyses the water requirement of crop and utilizes the scarce water resource available to reduce wastage of water.

f) Integrated Pest Management or Control (IPM/C)

Once the farmer's hard work is destroyed by pests and they suffer from huge monetary losses. To prevent such situation the internet of things has a system that monitors and scans the environmental conditions & growth of the plant, further this data is utilized to control the pest by pest control sensors.

g) Food Production and Safety

Agriculture Internet of Things not only focuses on attaining optimum food productivity along with quality matching the standards but also focuses on food security at various levels like storage, transportation etc.,. To ensure food safety Agriculture Internet of Things has a system that monitors the different factors like shipping time, storage temperature and cloud based record keeping etc.

IV. CHALLENGES OF IOT AGRICULTURE

Some of the challenges of IoT in agriculture are:

a) Ensuring the interoperability of a huge heterogeneity of IoT devices and data with open IoT architectures, platforms and standards, including the alignment of horizontal technical IoT standards and domain-specific (especially semantic) standards in the agri-food domain.

b) Scaling-up the usage of IoT technologies based on early adopters, especially by the simplification of existing solutions and improving its affordability to ensure attractiveness and fitness for use many farmers and food companies, for this reason also appropriate business models are needed that are suitable for less companies and include a systematic economic analysis for the costs and benefits.

c) Further improvement of IoT technologies to provide a broad usability in the diversity of the agri-food domain, e.g. various climate conditions, crop and soil types.

d) Development of IoT devices for harsh environments and for natural objects , which have less number of possibilities to embed IoT devices in the objects themselves; this holds for devices that integrate modern technological advances, since there is a many number of progress in the adaptation of more mature technologies to agriculture-specific requirements.

e) Ensuring reliable and stable wireless communication in remote areas (fields, stables, etc.) which often have less coverage and bandwidth.

f) Development of energy efficient IoT technologies, which include devices and connectivity components for rural areas.

g) Analytics to combine devices data with a wealth of archives such as historical and forecasted meteorological data, soil, air-analyses, water, satellite data, logistic systems, and data on prices, retail, and consumers, diets, etc.

h) Availability of trustworthy security, privacy, and data ownership solutions that is appropriate for dynamic and complex networks of stakeholders, in which a huge number of very small firms and SMEs on the one hand and large international corporations and authorities on the other hand, have to collaborate.

V. CONCLUSION

This paper reviews that the Internet of Things (IoT) can be incorporated clearly and seamlessly in many number of heterogeneous end systems. In agriculture IoT based system has the ability to connect physical devices on the farm and allow their accessibility through the Internet, thus providing users with the opportunity to remotely monitor farm conditions and production process. The sensors and microcontroller are successfully interfaced and wireless communication is achieved between various objects. By implementing this smart agriculture it improves the crop yielding and reduces the human work.

The idea to be carried out is to identify the intrusion of animals in the agricultural field and run the animals out from the field and also to irrigate the filed with the help of IoT.

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