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A SURVEY ON SMART AGRICULTURE USING WIRELESS SENSOR NETWORK ON IOT WITH CLOUD COMPUTING

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A B S T R A C T

IoT is one among the technology where the new developments are introducing day by day. The future computing and communication technology relies under integration of IoT and Cloud. This technology generally migrate with traditional agriculture methods to control the cost, maintenance and monitoring performance. Generally, precision agriculture sensors monitor to agriculture related temperature, humidity, Soil PH level, nutrition level, water level and so on. The development of geomatics in agriculture maintains economic viability with satellite and aerial imagery in farming enterprises. Advances in Wireless Sensor Networks (WSN) and image sensor identifies the landscape especially manageable as agriculture production zones effectively. This paper focused survey on typical applications of agricultural based IoT network with cloud support. This survey used to understand the different technologies to build and develop smart agriculture. This survey helps to create friendlier environments and efficient agricultural productions for the migration of people to the cities..

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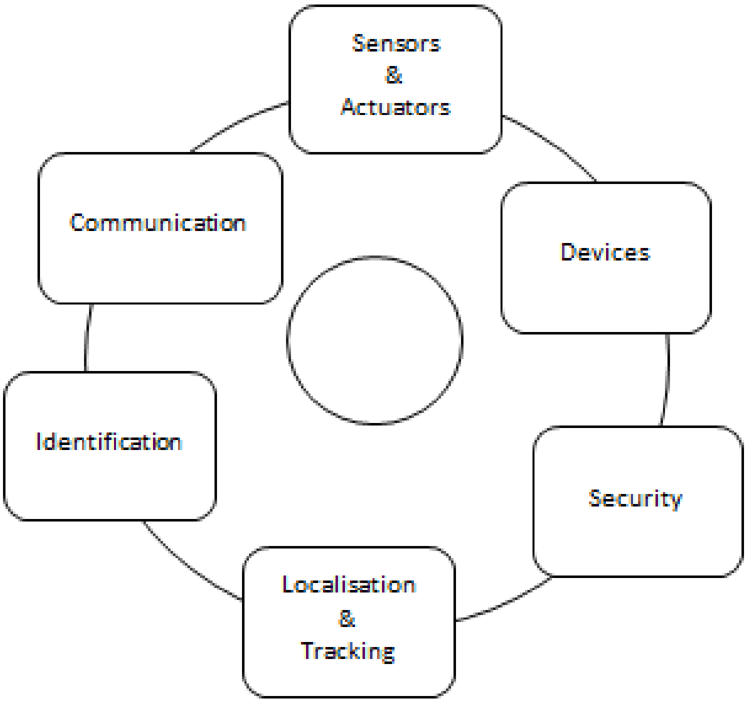


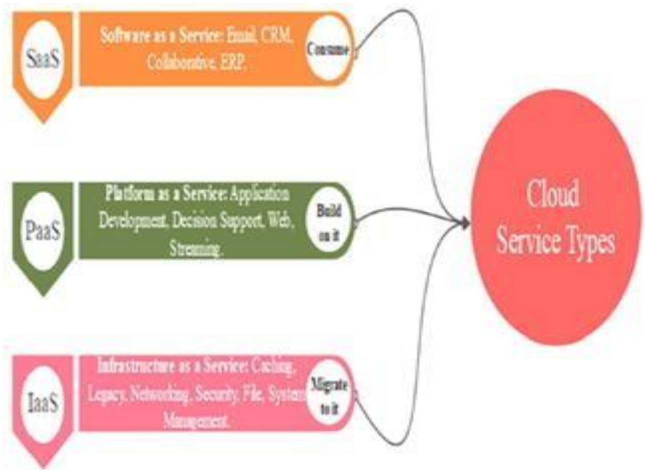
INTRODUCTION

The precision agriculture is emerged in the mid of 1980's through grid based sampling of soil chemical properties with early developed variable-rate application equipment for fertilizers [1,2]. After farming the management practice, precision agricultural service provides,

1. Fight on the epidemic diseases through applying appropriate amount of organic fertilizers and pesticides at the needy time,
2. Efficient water consumption through watering the plants with needed amount of water at the right time,
3. Reducing the harmful to the environment because of reducing the usage of spraying the pesticides and
4. High agriculture production by non-toxic, sage and healthy crops production.

Using of WSN in precision agriculture increases the efficiency, productivity and profitability of the agricultural production [2,3,4]. Through WSN, real-time environmental information can be gathered remotely and the data is utilised to discover the problems in the field.

The traditional agricultural approach where the decisions taken based on some hypothetical average condition are not reflect the reality where the WSNs precision agriculture provides a better decision. This integration between WSN with IoT results in plethora of applications for smart-cities, remote healthcare, energy and water control,



wildlife monitoring and so on. The Figure 1 shows the common characteristics of IoT.

Fig. 1. Common characteristics of IoT

A. Essential of IoT Applications in Agriculture

Addressing the security with sustainable agriculture for food security or water security with a sustainable agriculture provides supplementary solution and services as third-party agricultural services and other services for farmers. This provides a centralised repository for a variety of information such as traditional farming techniques, crop diseases and so on through various sources to allow interactive farming through various devices through mobile phone, IVR with multi-lingual support with traditional practice. The Figure 2 presents the role of IoT in agriculture. The system should meet the following requirements:

- ***Robustness:*** The model features with diversity, complexity, spatio-temporal variability and uncertainties to consider the development of right kind of product and services.
- ***Scalability:*** Whenever the solution is made for agriculture sector, it may vary based on the size of the farm from small to large. Through testing and deployment happens in the stages where the architecture scale up incrementally with fewer overheads.
- ***Sustainability:*** The issue of sustainability is important due to the economic pressure intensity and aggressive competition globally.
- ***Affordability:*** The key of success is the cost of appropriate substantial benefits. This standardised platform, tools and services brings down the cost and volume.

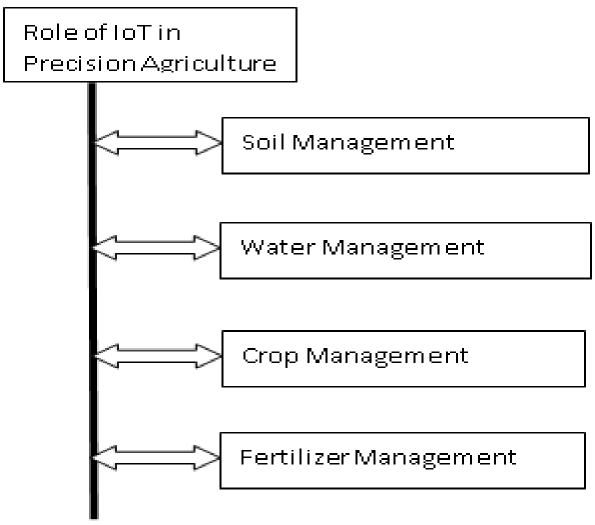


Fig. 2 Role of IoT in agriculture

B. Benefits of IoT in Agriculture

The following are some of the benefits of IoT applications in agriculture,

- Use of improved efficiency of inputs such as soil, water, fertilizer, pesticide and so on.
- Reduction in cost production.
- Increased profitability.
- Sustainability.
- Food safety and protection of the environment.

The integration of WSNs with IoT resulted in a plethora of applications such as smart-cities, remote healthcare, energy and water control, precision agriculture, wildlife monitoring, structural and ancient building monitoring, etc.

This contrasts with the traditional agricultural approaches in which decisions are taken based on some hypothetical average condition, which may not reflect the reality.

C. Cloud Computing

A new style of computing where dynamically scalable and virtualised resource services are provided over the internet is the general term for cloud computing. The integration of cloud computing with IoT provides a great significance of powerful storage, processing and service ability are combined together with the ability of information collection with composes a real network to comprises a network between people and items and items to items itself. Even though the differences in defining the cloud computing, the common layer architecture is exist. However, the hardware doesnot follows this common layer, as it is not fixed. All these layers provide service for the defined functions based on the defined APIs. The common layers of cloud are defined as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS) and Data as a Service (DaaS). The DaaS provides valuable data as a service over the internet on a pay per use basis. The Figure 2 shows the common cloud services.

Fig.3 Common Cloud Services

D. Cloud Computing in rural India

The rural area are not economical for the farmers to deal with the service providers on individual basis. The comprehensive service providers provides cost effective multiple services. MBR Consumer Services Pvt. Ltd. by Rama Krishna that is one venture to meet the rural market demand. It enables the consumers to have day-to-day transaction with the company. It is an example of a corporate to contribute the development of stores through developing a sustainable business model to provide a customised services for maintaining extensive rural consumer database with micro information. The MBR Consumer Services Pvt. Ltd. set up a chain of centres aims to provide end-to-end ground level support for Indian rural consumers, rural consumer's profit and productivity. Some of the common services provided by MBR includes, FMCG (Fast Moving Consumer Goods) sales and services, Agriculture Allied Services, Soil and water testing services, Crop finance, Supply of agriculture inputs and animal feeds, Information services and other services based on the consumer needs.

In this paper, a survey on smart agriculture IoT with cloud computing is detailed in Section II. Section III presents applications of CloudIoT for precision agriculture and Section IV presents the conclusion and future work.

LITERATURE REVIEW

The paper [1] presents agricultural application utilising WSN for monitoring the crop fields. This model comprised with two sensors to measure the humidity, temperature and an image-sensing node is to compare the information through taking crop images. The parameters to specify making healthy crops are to determine the temperature, humidity and so on. The high stability is maintained with low power consumption. Paper [3] proposed a greenhouse monitoring system using agriculture IoT with cloud environment. In a greenhouse, management monitors the different environmental parameters using light sensor, temperature sensor, and soil sensor and so on. Meanwhile on every 30 seconds, the sensors are collecting information from the agriculture field area and stored online through cloud computing and IoT based servers. The paper [4] explains the IoT based Crop-Field Monitoring and Irrigation Automation system. Crop-field system is developed using sensors and based on the decision from the server through sensed data, the irrigation system is automated. The data transmission is forwarded through wireless medium from the web server database. The automated irrigation is

carried out through the moisture and temperature field falls below the proposed potential range. The remote monitoring can control system helps the application that provides a web interface to the user.

In [5] proposed a smart drip irrigation system for crop management. Android application is used to reduce the human interventions in controlling and monitoring the crop area remotely. Wastage of water is reduced using drip irrigation system based on the water level sensors. Some other different sensors are used to monitor the environment. The work [6] proposed a smart irrigation system to calculate humidity and water level of soil through sensors. The sensed information forwarded through a gateway called generic IoT Border Router Wireless Br 1000. From the default gateway, data will be forwarded to a web service through a defined network [7]. The paper [8] presents a survey on Smart Agriculture Irrigation systems to understand IoT based development in agriculture with cloud computing. Weeding, Spraying, Moisture Sensing and other filed monitoring and services are performed using IoT based smart agriculture system [9]. A GPS (Global Positioning System) based robot is developed with an intelligent decision making to control and irrigate system to monitor the agriculture area along with the database management system [10]. The collected data from the database management system contains all soil information. The temperature sensor mainly focused on automatic controlling of water flow to the agricultural field. Prediction of rain using weather sensor is intimated to farmers through smartphone. WSNs automatically analyse the sensed data of the agricultural area using intelligent software application to take decision about healthiness of a crop informed to a farmer [11]. The paper proposed a low maintenance and better agricultural farming using novel Eco-friendly and Energy Efficient Sensor Technology. The various parameters such as temperature, moisture fertilizer control and water control is observed using various sensors through remotely.

The general classification of IoT platform is defined in [12], where this develops the top-level generic IoT architecture for smart city application to monitor the precision agriculture. Additionally, it presents a functional view to integrate the architecture of data acquisition and intelligent control system to acquire the greenhouse facility in agriculture. The author represents the functional architecture to promote the development of habitat intelligence monitoring platforms to integrate the development of open IoT platform to utilise the use case model to promote the digital agriculture. This format provides semantically enhanced agriculture ontology and it lacks in implementation as of the real world scenario differs to the above mentioned process.

With the several IoT systems are implemented to monitor the precision agriculture application [13], the goal of increasing crop production and crop monitoring systems are developed nowadays to collect the data from the crop and use the correlation analysis to monitor the production system between the collected information of statistical and information from the crop environment.

The water irrigation system for precision agriculture is under development due to the increasing agriculture based applications through IoT platforms. The author [14] presents a model that allow the user to control the irrigation process through smart phones. The collected information will stored in cloud database to monitor the crop irrigation system. The stored data will be analysed, the requirement for water to the agricultural farms is identified, and additionally the water flow will be monitored.

The IoT and data analytics are combined together to process various agricultural activities. The key parameters of IoT and data analysis are considered in implementing the IoT devices with cloud architecture. The emerged technologies are concerned with food production and quality of the food. Through using IoT applications each and ideal agronomics facet utilises the common logistic and qualitative traceability. The above and other benefits are obtained in combining the IoT and data analytics for agricultural specific areas [15].

This work [16] details the structure, application to use and challenges of IoT agriculture. This optimistic methods achieves precision agriculture through the IoT specific architecture and using the autonomous system to maintain the production and controls the production in accordance to the situation. Some of the problems based on atmosphere, irrigation, soil erosion and so on are eradicated to a maximum level through the IoT applications.

Moisture, yield and other properties are employed to agricultural applications. The mobile based sensor automation system for agriculture is introduced to identify and eradicate the agricultural problems. This solves the yield and protects the crop from the other problems. The agricultural applications are connected to WSN to observe the various details of the farms related to collected through the sensors that associated with the internet. The mobile app is developed and it installs the user device and the details will be updated through the internet.

The data-driven procedure is developed for precision agriculture to develop agronomic clarifications. The prediction framework for soil moisture and reactive wireless sensor nodes are developed for a specific application of agriculture and the developed application is tested and major problem for precision agriculture

will be implemented based on the real world scenario. Generally, the machine algorithm are utilised to built small scale applications. Based on the test performance results the application is added to the IoT based precision agriculture system to perform particular tasks. The prediction system that comprises vector machines for meteorological data, soil moisture and so on [17].

The proposed IoT and agricultural data analysis are used to make smart farms. The real-time monitoring is proposed for specific three villages where the crop yield and water irrigation management is proposed based on IoT and sensor devices. Receiving the agriculture field information through the deployed sensors, it passes the web and mobile application through the help of node that deployed with WiFi module. The three sensors soil sensor, moisture sensor and DHT22 sensor with ultrasonic sensor are deployed together to receive the information from the deployed agricultural environment to sense the moisture, temperature and other information of the fields [18].

The author developed a smart agriculture system for India using the IoT and cloud architecture. This IoT based smart agriculture system with different sensors and the support of Raspberry Pi devices efficient food yield is proposed to identify the pests, moisture of soil, intelligent seed identification to identify the seed properties to increase the yield. The design of the system is robust and high cost. Another model proposed by the author for a smart agriculture through soil moisture, temperature, humidity and water level indicator using ARM 7 Processor that analyse data and send to the cloud using Thingspeak. Through the WiFi module, the farmer receives data using smartphones. The four sensors interfaced together using ARM 7 that robust and compare to the other boards [19].

The author [20] introduced a survey on cloud of things for smart agriculture model that provide complete information about detection of rodents that reduces the yield of a crop through integration of cloud and IoT through three-tier architectures named as back-end layer, gateway and front-end layer. Enormous parameters are determined through sensors to identify the humidity and moisture sensors and the values are displayed in the given display board. The three-tier layer architectures are implemented and controlling & monitoring of plant growth conditions are processed using embedded systems. This system helps in monitoring the growth of a plant in excellent predefined working conditions with cost-effective applications to make farming an easier task. Various factors like temperature, moisture conditions, light intensity and pH level monitoring are focused and monitored for the growth of a plant.

The proposed work [21] implemented a design on identifying the soil moisture through sensor to smart water irrigation management. This helps the irrigation and minimise the loss of water resource for the farms than the previous other used techniques. Conventional oven methods is used to measure the water level of the farms and well to identify the need of farms and availability of the resources. The smart devices follow the comparison of resistive and capacitive moisture sensor values to determine the moisture for water management. Arduino Uno board is the hardware specs used for this research work. The energy efficient duty cycling algorithm is introduced with this work for precision agriculture and the collected data are forwarded to the cloud for future identification of the soil condition and weather conditions. The simulations are performed using NS2 scenario.

The proposed method [22] utilise the cloud IoT technique for disease prevention in precision agriculture and this work focus in prevention of potato late blight disease with the collaboration of WSN and cloud IoT Technology. Local gateway, network and cloud are the common three technology combined to form a new and novel technique to identify the above specified disease in potato plants. The sensors are made with low cost and power to deploy it in the any agriculture area. They future enhancement of the work is to enhance the disease prediction and prevention for all farms.

The another work [23] discussed a brief study on smart irrigation system and proposed a crop surveillance using IoT architecture with cloud integration. The above work associated with various sensors like soil moisture, temperature, humidity and so on. The sensors are interfaced using Arduino board and ZigBee module is enabled to process the irrigation system and the decision were recorded in cloud for further references. This work connects the farmers smartphone to communicate the information to the farmer at any time. Compare to the other works this work costs much cheaper and it makes the farmers to utilise the application widely.

After a brief review on effective agricultural monitoring system using IoT, the author [24] designed an architecture that consist of sensors such as humidity, temperature, CO2, intensity of the agriculture field through interfacing of Arduino and raspberry pi board. The data will be analysed and processed in cloud server and the same will be updated in the android app through WiFi connectivity. The architecture follows a low-cost design where the four sensors are integrated and it cost minimal.

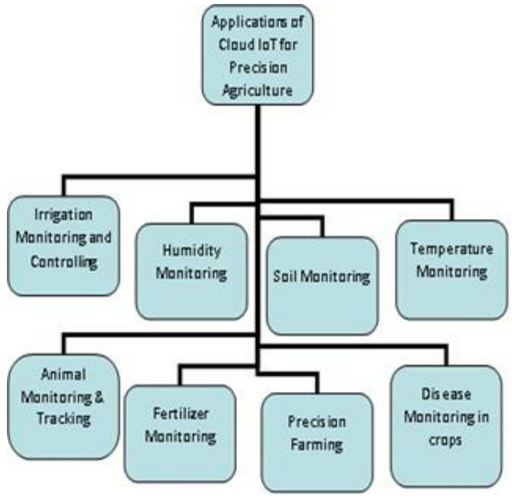
The IoT smart irrigation system for organic garden is proposed [25]. The author implemented the system to monitor home-based organic garden through various sensors to monitor humidity, temperature, soil moisture and water level prediction through ultrasonic sensor are identified with the help of Arduino and Raspberry Pi using IoT Technology. The aim of this work is to reduce the water wastage in irrigation with low and efficient cost. DHT11 temperature sensor with Arduino Uno and MCU are connected with cloud IoT operated with a mobile app named Blynk. The proposed system experimentally proves monitoring values of temperature and humidity of the organic field.

The proposed work [26] introduced the monitoring system through web of things in precision agriculture. With the help of IoT cloud integration the application prototype is proposed for precision farming. The architecture design system helps the farmer through different proposed tier architecture consists of data acquisition tier, gateway tier and IoT Cloud tier. Even though the architecture works well, the implementation of the proposed system costs high. The two sensors humidity and temperature are monitored the agricultural field and the values are stored in the cloud based application such as ubidots and so on. The intelligent IoT based automated system for smart irrigation system.

The proposed intelligent IoT based automated irrigation system [27] focused the paddy growth monitoring with aid of IoT. The author proposed a ML algorithm using K-nearest neighbor artificial nueral entworks (ANNs) and decision tree algorithm to obtain better-automated irrigation system to help the farmers regarding the sensor data on agriculture field using Arduino and Raspberry Pi board with the help of Ethernet communication to the cloud data. The data will be forwarded to the farmers through mobile application. The hardware block utilise the embedded devices and software designs using PHP. The moisture sensing section maintains the moisture data and displays the same in the webpage. The farmer can monitor the irrigation process remotely and this design cost low compared to the other models.

The smart agricultural model integrating IoT, cloud-based big data analytics and mobile technologies. The main aim of the author is identify the yield production of the crop and supports the data mining techniques to help the farmer to know about crop information such as yield level, water level and so on. The field monitoring and automation of water is developed through this proposed work. It designed an architecture for E-agriculture monitoring through TI-CC3200 launch-pad with specific sensors. The proposed system reduces the traditional agricultural procedure is water usage and thus reduces the cost. Moreover, the IoT devices reduces the complexity of utilising other technologies.

The Monitoring of soil moisture through home made soil sensors with the integration of Arduino Uno board. The author [28] implemented the two more methods to setup soil moisture measurement and identifying the depth of the water content. This data was observed continuously to determine the soil condition and when to irrigate the water to the crop. This system designed with low cost and it forwards the condition to the cloud through Arduino Uno3 using ZigBee module. The framework advise the better conditions to the farmers about cultivating and keep he records of agricultural conditions for further environmental setup and smart irrigation.



The proposed author [29] introduced a design and implementation of cloud based IoT scheme for precision agriculture and it cares about epidemic disease to prevent the crops through applying fungicides, pesticides and fertilizer through WSN, IoT and cloud network. This proposed system has three layers like back-end layer, gateway layer and front-end layer as a common architecture for cloud IoT. The farmers can receive advices about crop precautions through the mobile application and IoT connected mobile phone. This work proposed a low power consumption for proposed cloud IoT architecture.

This proposed work [30] developed an IoT based fertilizer intimation system for smart irrigation for smart agriculture. The novel design NPK sensor is proposed with LDR and LED connectivity through calorimetric principle. The sensor analysed the value of the crop such as protein, NPK value, water level, any disease symptoms in the deployed smart farm. One of the foremost advantage to develop a fuzzy rule-based decision-making system to analyse the present NPK values. Finally, the value will stored to cloud for monitoring the further development of crop and this system consumes less power and cost than the previous architectures.

The proposed work [31] concentrates in advancing the nitrate-N detection using detection sensor. Additionally, it monitors the N value in surface and groundwater along with the current temperature level. With the support of IoT system, the sensing is processed and the sensed information is forwarded to the cloud server for further communication. The soil nutrition level is detected along with the nitrate detection through Raspberry Pi board. It detects the soil content and decides whether the crop is suitable for the given soil or not. The work considers the water level and checks whether the given crop can yield better in the given soil or not. This work identifies the suitable crop list for the soil as per the soil specs received through the proposed architecture.

This efficient proposed work [32] developed an agricultural application system to monitor the soil. It details the moisture level, fertiliser usage, water level in well and soil and so on. This work identifies the soil nutrients like N (Nutrition), P (phosphorus), K (potassium) through the proposed Raspberry Pi board interfaced together with temperature, soil moisture, color sensor and so on. The integrated WiFi device will forward the collected information to the cloud, the cloud forwards the details to the farmer's mobile and mail id that already mentioned. The soil quality is also analysed to rectify the farmer's difficulty in identifying the right crop for their field. Through the above mentioned agro-sensors pest control, water level monitoring, fertilizer analysing and proper irrigation system is specified (analysed). The weather condition also analysed and made necessary arrangements before the unwanted rainfall or maintains good water level in summer to eradicate the water scarcity for the crops. This work adds the fertiliser analysis and reminds the farmer to complete the applying of right pesticides and right time to yield more.

Applications of cloudiot for precision agriculture

The decision making IoT system is proposed using sensor stipulation with the THAM index. The major advantage of this work is to develop an accurate decision-making system to determine the nutrition rate of the soil and identifying the NPK level of the fertilizer to determine the optimal soil nutrition rate. The crop with the pH value of 6 and high is detected as the best crop for the given soil. This proposed crop will yield more consumes less fertilizer and water for yielding. This architecture is proposed using Arduino Uno board and the same is implemented using Raspberry Pi to connect the device to the specific cloud to store and control the data and the field remotely. Figure 4 shows the agricultural application domain using IoT.

Fig. 4 Agricultural Application Domain using IoT

The primary focus of IoT based precision agriculture applications based on the major domains are monitoring, controlling and tracking is considered. The major applications used in this study are detailed in Figure 5.

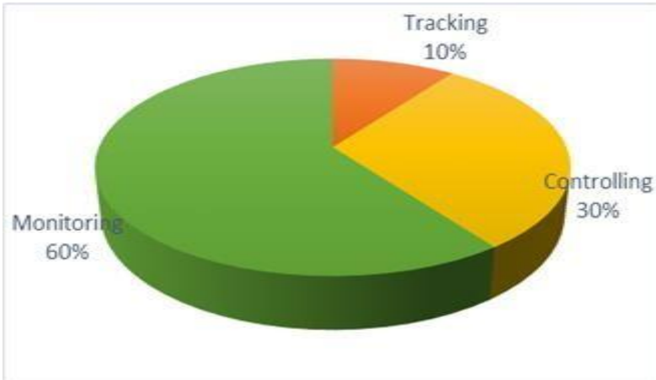


Fig. 5. Major applications of Cloud IoT

The percentage of CloudIoT application for precision agriculture identified through this study is present in Figure 6.

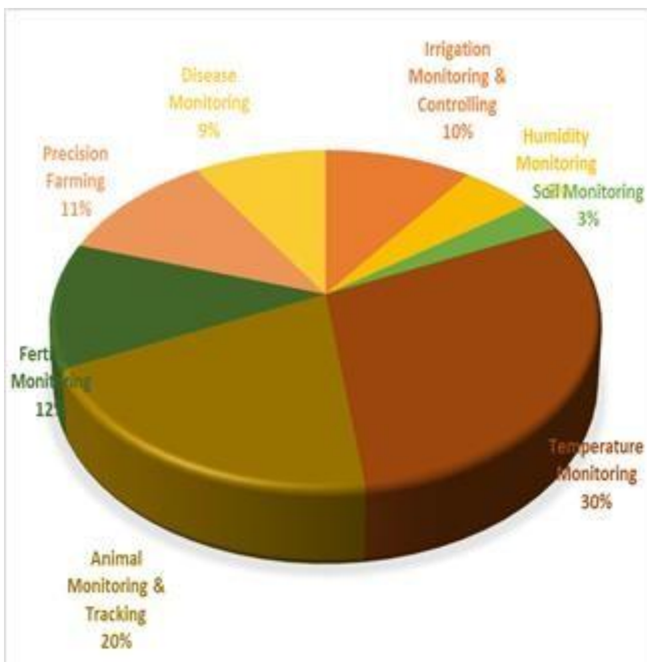


Fig. 6 Percentage of CloudIoT application for precision agriculture

A. Countries where the IoT agriculture policies implemented

Some technologies with evidence-based policy where the practical implementation are followed in most of the countries in which the precision agriculture is monitored to develop the agriculture and farming. Precision agriculture is the key where the existing government policies can accommodate the CloudIoT agricultural services and regulations to develop the farming worldwide. Some of the agricultural policies adopted by different countries are shown in Table I.

TABLE I. AGRICULTURE POLICIES ADOPTED IN WORLDWIDE

Name of the Country	Application Domain
India [33]	An IoT-based robotic has been presented in to measure the agricultural parameters such as pesticides, moisture, and animals movement. When the system was practically implemented, the obtained results were very satisfactory, which shows that the system is user friendly, robust, and reduces the labor cost. Moreover, a remote sensing control system is developed to monitor the greenhouse gas, temperature, soil moisture, and light. These variables were monitored for bell paper plants and the obtained results indicate the yield increment and facilitate the farmer to monitor the farm remotely.
China [33]	To monitor the greenhouse environment conditions, a low-power and low-cost system is developed. Implementations of the developed system show that the system is reliable and reduces the labor cost. Furthermore, IoT technologies implemented in the Shandong Province demonstration park of Zhongyi show that the fertilization and pesticides cost reduced up to 60% and 80%. Whereas, to deal with the 300-mu park, 60 laborers were required, but the utilization of IoT technology reduced the labor cost by approximately 60%.
Thailand [33]	The National Electronics and Computer Technology Center (NECTEC) in Thailand is implementing IoT technology to develop the smart farming, and their main focus is on four agriculture products, namely: rice, rubber, cassava, and sugar. The basic aim of this movement by the Thailand government is to facilitate the farmers in all rural areas for the ecient growth of crops.
Brazil [34]	An IoT-based Agri Prediction model is presented in that provides low-cost prediction methods to measure the soil humidity and temperature. After the implementation of the proposed model, the weight (up to 14.29%) and size (up to 17.94%) of arugula leaf was increased.

Name of the Country	Application Domain
Africa [34]	Authors proposed an animal behavior monitoring system that traces the animals' movement all over the field and monitors their pasture grazing. The designed platform is implemented in Africa to evaluate and track the animals' conditions.
Australia [34]	The Australian Government has invested AU$134 million to improve their current farming method. As a result of this large investment by a private company in Sydney, the local government created a center for the implementation of IoT technologies in agriculture fields. An innovative network was established in 2014 for the purpose of precision farming to create a collaborative framework in the agriculture fields of Australia. Moreover, in terms of security and privacy, an American farm bureau established a security and privacy set for farm/field data in 2015.
Ireland [35]	A program has been launched by Irish Farmers Association (IFA) to decrease the smart farming implementation costs and improve the soil quality by providing guidance to the famer regarding how to save the water and power by utilizing IoT technology. The farming community enthusiastically followed these guidelines and obtained results that were very encouraging and positive. Companies saved approximately 8700 euro, 21% savings were achieved in pasture management; there was also a 10% reduction in greenhouses gas emission and 47% savings in soil fertility. To track and trace the farm assets, Ireland VT-Networks launched a SigFox network.
France [35]	In France, the ministry of agriculture has become the partner of the Agriculture Innovation Project 2025, whose basic purpose is to increase the strength of agriculture land, monitor weather parameters, and improve the field conditions by creating incubators. Moreover, the ministry of agriculture shares benchmarked farm data with farmers to develop innovative solutions in agriculture.

USA [35]	In order to fulfill the basic requirements of food and energy, the USA government has initiated many research and development projects related to agricultural technologies. The National Institute of Food and Agriculture is working on a project called the Internet-of- Ag-Things and developed sensing technologies for agricultural practices. The major aim of the project is to provide precision farming techniques to increase the agricultural productivity and make better use of the fertilizers, water, and organic food. A project namely has been started by Department of Agriculture (USDA) to resolve the water management issues and design new techniques to overcome the challenges that are affecting agriculture. Moreover, technologists are using the datasets of the USDA to improve and design the existing agriculture services for water distribution.
Phillipines [35]	The Philippines used remote sensing techniques in order to boost the rice production and satellite imaginary techniques to get information about multiple agricultural conditions. The University of Southeastern Philippines (USeP) developed a smart solution to measure the crop heat stress through IoT technology by collaborating withWestern Mindanao State University (WMSU).

B. Future applications for Agriculture

The future applications for agriculture is presented below [36, 37]. They are,

- Weather Tracking for agriculture field
- Vertical Farming for agriculture
- Machine learning and analytics for agriculture farms
- Satellite imaging for crop detection
- RFID Sensor tracking for field development
- Robots for agriculture monitoring
- **Weather Tracking For Agriculture Field:** This application checks and monitor the climatic conditions of the agriculture field. Farmers can access the advanced notice about fog, hail and other climatic conditions of the land and surroundings of the land to identify and monitor the exact condition of the climate that affects the crop or that develops the crop. Through these applications, the farmer can easily assess the yield and other conditions on time.
- **Vertical Farming For Agriculture:** Through these applications the farmer can easily identify the stacked layers vertically to produce the food in such domains to increase the yields and maintain better earnings through the crops. The agriculture land is also well utilised through these applications in such a way that can yield more from the proposed farming methodologies.
- **Machine Learning and Analysis for Agriculture Farms:** The machine learning algorithms proves that the one among the best algorithm in worldwide for crop production through giving best suggestions for crop breeding based on the location and climate of the field. This algorithm studies the previous market conditions additionally for the benefit of the farmers not to produce a wrong crop in the field which may yield less due to climatic conditions or the crop production may high that turns less profit from the crop production. These applications provides better suggestions for the farmers to do agriculture in a peaceful way. The Figure 7 shows the future applications for agriculture.

Fig. 7 Future Applications for Agriculture

- **Satellite Imaging for Crop Detection:** This technology captures real-time image to identify and monitor the growth of the crop. These images are of more than 5-meter pixel resolution to identify the exact level of growth. Through adding crop sensors for soil and water monitoring reduces the consumption of water level (wastage of water) and identifies the moisture and seed status through soil sensor. These technologies generally saves the crop from the natural disasters and save amount and time of the farmers in various terms and conditions.
- **RFID Sensor Tracking for Field Development:** This applications generally identifies the food from the field to store and track through RFID sensors. It helps providing fresh produced products and harmful bacteria were identified and reduced easily by these technological inventions.. These products follows the barcode to scan the field through smartphone so that the farmers can easily monitor and sale the product in online.
- **Robots for Agriculture Monitoring:** The robots that supports agriculture is termed as abbots. This technology developed to support all process of agriculture such as harvesting, ploughing, fruit pocking, soil monitoring, weeding, and irrigation and so on. These abbots reduces the farmers work enormously. Figure 8 presents the taxonomy of various IoT cloud platforms.

IoT cloud platforms	Cloud service type	Application development	Monitoring management	Visualization	Cost research
Aekessa	Private (SaaS)	Yes	Yes	Yes	Pay Per Access
Arrayant connect TM	SaaS	Yes	Yes	Yes	Low
Axeda	Private (PaaS)	Yes	Yes	Yes	Pay Per Access
Echelon	Private (PaaS)	Yes	Yes	No	High
Etherios	PaaS	Yes	Yes	Yes	Pay Per Access
AWS	PaaS	Yes	Yes	Yes	High
Google server	Public	Yes	Yes	No	Pay Per Access
IBM Watson IoT	PaaS	Yes	Yes	Yes	Pay Per Access
Jasper control centre	Private	Yes	Yes	Yes	High
KAA	Public	Yes	Yes	No	Pay Per Access

Fig. 8. Taxonomy of various IoT Cloud platforms

CONCLUSION AND FUTURE WORK

This paper presents a detailed study on Cloud IoT in the field of agriculture. In future the sensors, actuators and other sensor devices with cloud integration will rule the agriculture world to intercommunicate between the farms and precise decision making in providing innumerable benefits for the end user through acquiring various services. As discussed above the embedded technologies like Raspberry Pi for interfacing various models used to identify the usage of fertiliser, water irrigation, crop monitoring, weed detection and so on to improve the production from the farms. The wireless technologies like WiFi, ZigBee, Z-Wave, GSM integrate with Node MCU, Arduino boards and Raspberry Pi Boards to detect the disease early to avoid the spread of the disease to the other crops as well as through machine learning applications and it analyse the previous records and helps the crops to avoid affecting from the disease in future. Hope this paper presents modern CloudIoT architecture and applications on precision agriculture for the modern extensive and sophisticated research improvements in agriculture. The future enhancement of this study is to provide CloudIoT architecture for Internet of Agriculture Things (IoAT) with trust management mechanism. The absolute trust degree will be identified and the performance will be monitored against several potential attacks.

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