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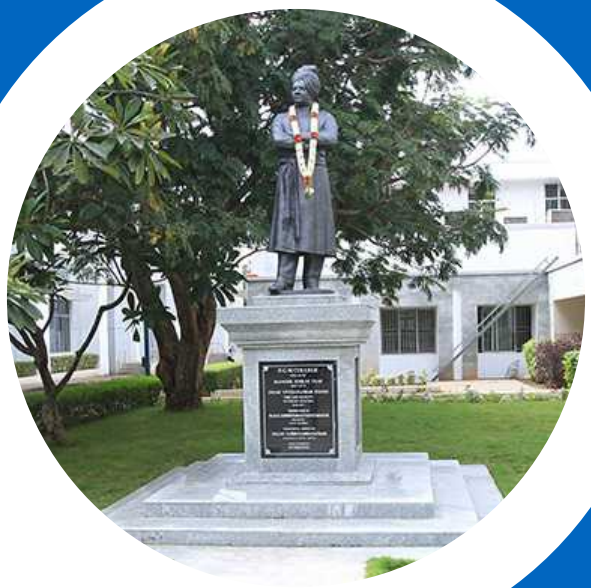

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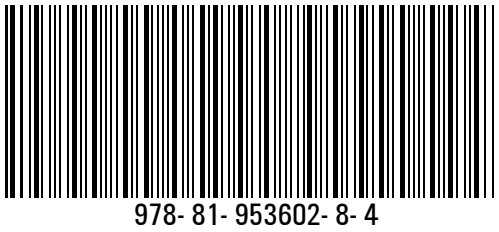

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A Systematic Literature Review - Green Internet of Things Based Smart Agriculture

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ABSTRACT: With the growth of the global population, one of the major problems is the availability of food to all inhabitants of the planet. It is important to overcome these challenges through the implementation of creative options to enhance soil capacity and the protection of environmental resources. Humidity, temperature, weather, crop diseases and water management in smart farming as well as predictive behaviour against parameter changes can be of great help to overcome these challenges. The Internet of Things (IoT) is an emerging technology with great potential to play its miraculous function in almost every area and to conquer it. The growth of intelligent IoT-based Smart Farming in developing countries is getting its space day by day. The Internet of Things (IoT) is a promising technology that offers successful and efficient solutions for multi-domain modernization. To automatically manage and track agricultural farms with minimal human intervention, IoT-based solutions are being created. In India, agriculture is practised on a large scale, and its contribution to the Indian economy is also greatest. In order to boost yields and cost-effectiveness, it is necessary to increase the efficiency of agricultural and farming processes with emerging technologies called the Internet of Things (IoT). In particular, IoT can make processes in the agricultural and agricultural industries more effective by reducing human interference by automation. This paper addresses several facets of the innovations involved in agriculture in the Green IoT domain. Green IOT based agriculture reduces more energy consumption.

Keywords: Green IoT, Internet of Things, Wireless Sensor Network, Data Analytics, Smart Farming, Sensor, Security, Agriculture.

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1. INTRODUCTION

The IoT (Internet of Things) based agricultural technology is a technology to create a high value such as improvement of production efficiency, quality increase of agricultural products in the whole process of agricultural production [1]. In addition, implementing smart agriculture, which is an alternative to the future agriculture, which allows prediction of supply and demand, real-time management and quality maintenance during the entire life cycle of agricultural products [13]. Different IoT policies have been formulated by Indian government in order to leverage the strength of their agricultural field in all over the world. Indians basic purpose is to monitor the earth density, soil conditions, temperature and alerts the farmers to control pest related issues. In 2015 a policy on IoT in India was released by Ministry of Communication and Information Technology to transform digital landscape by using IoT [6].

IoT is a combination of worldwide data, web associated items or things, and is an integral component of the future Internet. IoT focuses on the automation of processes by lessening human interaction. In the process of automation, IoT collects data using sensors and processes the data using controllers and completing the automation processes by using actuators. IoT in agriculture and farming focus is on automating all the aspects of farming and agricultural methods to make the process more efficient and effective [4].

Smart Farming is a development that emphasizes the use of information and communication technology in the cyber-physical farm management cycle. New technologies such as the Internet of Things and Cloud Computing are expected to leverage this development and introduce more robots and artificial intelligence in farming [2]. This is encompassed by the phenomenon of Big Data, massive volumes of data with a wide variety that can be captured, analysed and used for decision-making. This review aims to gain insight into the state-of-the-art of Big Data applications in Smart Farming and identify the related socio-economic challenges to be addressed. The review shows that the scope of Green IOT applications in Smart Farming goes beyond primary production; it is influencing the entire food supply chain [4].

Green IoT are being used to provide predictive insights in farming operations, drive real-time operational decisions, and redesign business processes for game-changing business models. The future of Smart Farming may unravel in a continuum of two extreme scenarios: 1) closed, proprietary systems in which the farmer is part of a highly integrated food supply chain or 2) open, collaborative systems in which the farmer and every other stakeholder in the chain network is flexible in choosing business partners as well for the technology as for the food production side. The Industry 4.0 trend is seen as a transforming force that will deeply impact the industry [12]. The trend is building on an array of digital technologies: Internet of Things, Big Data, Artificial Intelligence, and of digital practices: cooperation, mobility, open innovation. They imply a transformation of the production infrastructures: connected farms, new production equipment, connected tractors and machines. They will enable both an increased productivity and quality and environmental protection. But they also generate modifications in the value chain and business models with more emphasis on knowledge gathering, analysis and exchange.

2. SMART FARMING USING IOT

Smart agriculture makes use of a range of technologies that include GPS services, sensors and big data to optimize crop yields [3, 8, 11]. The complexity of smart farming is also reflected into the ecosystem of players. They can be classified in the following way: Technology providers – these include providers of wireless connectivity, sensors, M2M solutions, decision support systems at geomapping applications. Providers of agricultural equipment and machinery, farm buildings, as well as providers of specialist products (e.g. seeds, feeds) and expertise in crop management [17]. Customers: farmers, farming associations. Influencers – those that set prices, influence market into which farmers and growers sell their products. The end users of smart farming solutions include not only the growers but also farm managers, users of back office IT systems [7].

Directing at the current development condition of the internet of things and based on the available technology analysis of the internet of things, analysis and research on the internet of things in terms of technological levels and systems are made. Started from three aspects, respectively, data collection, network service, date fusion and computation, analyzing the technologies like RFID, ZigBee, sensors, Cloud Computing and so on are done, based on which further the technological system framework of the internet of things are brought forth. Moreover, analysis and research works on the sensor nodes of the system, analysis and discussion on the various technologies involved are carried on. Internet of Things refers to a network allows a series of intelligent activities like identification, positioning, tracking, monitoring and management by linking devices like RFID, Smart Sense, GPS (Global Positioning System) etc. in objects to wireless network via interfaces to endow objects with intelligence, therefore realize the communication and dialogue between human and objects as well as objects and objects. Moreover, series of research and exploring works have been launched.

In the process of agricultural production, the most critical part is the true time data collection in terms of temperature, moisture, and soil temperature and soil moisture content [1]. By making use of the IOT platform and GPRS/TD, by means of SMS, WEB, WAP and other methods, can make the users dealing with agricultural production acquire these real-time information. Monitoring System for Agricultural Standardized Production based on IOT aims at the target of making information collection in crop growing and carrying out systemic monitoring towards the plantation area, crop pattern, crop growing, the breaking out and development of agricultural damages, crop output and so on.

Monitoring system is composed by three parts: (1) sensor node, sending the information like atmosphere collected by the senor in periodicity to the monitoring. (2) Gateway. Located in the edge of sensor network. Realizing the interconnection and communication between the sensor network and internet. (3) Monitoring and management center of agriculture environment (user), being responsible for the information storage, procession, evaluation and so on. Users are able to visit the data of the environmental monitoring center by means of internet and they can make real-time inquiry via the center. Sensor network is basically comprised by sensor board which is set with sensors of air temperature and moisture, soil moisture and temperature, soil PH value, light intensity and CO2 concentration. Temperature and moisture sensors are more and more widely applied in the areas of industrial and agricultural

production, whether, environment protection and so on. Data procession module is comprised by microprocessor, data storage circuit and embedded operation system and it is the core component of sensor node. Moreover, it is responsible for data's storage and procession, scheduling system tasks, carrying out the communication protocols and so on.

3. IOT AGRICULTURAL NETWORKS

IoT agricultural network or IoT network for agriculture is one of the vital elements of IoT in agriculture. It helps to monitor agriculture data and facilitate the transmission and reception of agriculture data.

3.1 Structure of IoT For Agriculture

The system has three layers, namely, sensor layer, transport layer, application layer. Their functions are as follows:

- Sensor Layer: The main task of this layer is to achieve automatic and real-time transformation of the physical figures of real-world agricultural production into digital information or data that can be processed in virtual world through various means.
- Transport Layer: The main task of this layer is to collect and summarize the agricultural information. Transport Layer is the nerve center and cerebra of IoT for Agriculture, transmitting and processing data.
- Application Layer: The main task of this layer is to analyze and process the information collected so as to cultivate digital awareness of the real word. It is a combination of IOT and Agricultural Market intelligence.

3.1.1 Data Transmission Challenges

Poor connectivity: Due to the remote location of some farming communities, poor mobile network connectivity and reliability is a common challenge.

- Technologists - As a last resort, data can be collected manually, i.e., from a central hub connected to individual devices by a local wireless network. For some applications, satellite and LPWAN-based service providers are increasingly cost-competitive with conventional mobile data.
- Project managers - Check mobile network coverage in your implementation area using GSMA maps and cross-check with non-industry sources.
- Transmission cost - While data costs have decreased significantly, the recurring cost of providing IoT services was frequently identified as a challenge for commercial applications.

4. IOT IN GREENHOUSE MONITORING

In greenhouse plants are grown under controlled environment. This glasshouse technology provides benefits to growing plants anytime anywhere by monitoring appropriate environmental conditions. Cultivation of green house

is more intense, therefore in terms of controlling and monitoring it requires high precision. To monitor environmental or weather conditions there have been several studies on the applications of WSN's in greenhouse. Recent studies shows that how IoT can be implemented in greenhouse to minimize the human resources, accumulate energy and provides direct link of greenhouse from ranchers to customers. Most of the studies have focused only on remote monitoring and localized. In addition, for the purpose of high precision there have been a lot of studies which integrates meta-processing structure with data to transfer it on remote infrastructures through internet. By applying well evaluated crop models, assessment of the crop status helps the ranchers to take better decisions.

Wireless Sensor Network (WSN) has been implemented to monitor the greenhouse environment. Whole network is divided into multi parts which processes the data and gives feedback. Data can be obtained by corresponding sensors and detectors and then transferred to the main server for processing. In physical implementation the major components are the sensors and network for accurate data transmission. Growers setup the different monitoring devices and sensors according to the specific requirements and track or record the required information. Agriculturists make better decisions by analyzing the received information and achieve specific goals by obtaining optimal data. There are many IoT based greenhouse applications are available such as water management, plant monitoring, and climate monitoring etc.

5. IOT AGRICULTURAL SECURITY

In the coming years agricultural sector is expected to witness the extensive acceptance of IoT and grow through the new e-farming IoT applications and devices [14, 18]. These agricultural applications and devices are expected to deal with a large amount of sensitive data. Due to the distributed nature of IoT a single security protocol is not sufcient therefore, leakage of information is a major security concern [20].

5.1 Security Requirements

IoT based smart farming security requirements are similar to standard security scenario. Therefore, to achieve a secure farming solution we have need to pay attention on the following security requirements:

- Confidentiality - Agricultural information or personal data relevant to it should be accessible only by authorized users.
- Integrity - Here integrity means received and stored data or content is not changed.
- Authentication - Authentication means peer devices should have an identity to which it is communicating.
- Data Freshness - It consists of key freshness and data freshness because IoT agricultural networks sometime provides varying measurements, therefore it is necessary to ensure that every message is fresh.
- Non Repudiation - Its means a node can never deny to send a message that sent earlier.
- Authorization - Here authorization means for network or any other resources only authorized devices are allowed.

- Self Healing - If any device in an IoT based agricultural network fail or out of energy then other devices in the network should be able to provide security to some extent.

6. IOT SENSOR BASED APPLICATIONS IN AGRICULTURE

In today's modern world everything needs to be automatic with less man power by consuming less time. Sensor is such a device which can full this requirement by detecting same input from the existing physical environment and responds back. User set some setting over sensing devices to perform their task without the involvement of human. There are some major IoT sensors like: Motion Detector, PIR, Soil Moisture, Temperature, Humidity, Barometric Pressure, Ultra Violet, PH, and gas sensor.

- PH Sensor - PH Sensor is used to monitor the accurate amount of nutrients in the soil which is necessary for irrigation.
- Gas Sensor : Gas sensor measures the quantity of toxic gases in the greenhouses and livestock.
- Ultra Violet Sensor - UV sensors are used to monitor the ultra violet rays by converting photo current to voltage.
- Motion Detector Sensor - This sensor is very useful at the night especially for animals and theft detection in the field.
- Passive Infrared Sensors - A motion detector is fixed in passive infrared (PIR) sensor to detect the motion which is used to check range of a person movement.
- Soil Moisture Sensor - This sensor is used to measure the moisture content and water quantity in the soil.
- Temperature Sensor – Temperature sensor used to Check Soil temperature.
- Humidity Sensor - This sensor is utilized to sense and measures the comparative humidity level in air.
- Barometric Pressure Sensor - Barometric pressure sensor also used to control the water flow.
- The automation process of agricultural and farming reduced human interaction and improve the efficiency.

7. IOT AND DATA ANALYTICS IN AGRICULTURE

Accurate data analysis in farming plays a major role in improving the operational efficiency and increasing productivity [5]. Data Analytics has been categorized into types based on requirement of IoT applications [14]. This includes real-time analytics, off-line analytics, memory-level analytics, business intelligence level analytics, and massive analytics. The data consist of sensor data, audio, images, and video. Image processing has been extensively used in agriculture for various purposes ranging from detection of disease in leaf, stem, and fruit, quality of fruits, and weed detection and irrigation [19]. Recently, the combination of image processing and IoT in agriculture is being carried out to achieve higher quality produce and reduce crop failure. This involves the use of drones to capture aerial images at regular interval as well as monitoring of environmental factors using the IoT devices.

7.1 Prediction

IoT provides big data that can be studied over time to estimate the present environmental conditions [10]. The data collected across different types of networks sensors can be studied using data analytics and smart algorithm can be developed to predict the environmental changes and provide data driven solutions. Although IoT data can help in controlling various aspects of a farm, such as the irrigation systems, the data can also be used to predict and warn farmers against disease or extreme weather conditions, such as flood or drought. For instance, in forestry, the sensors can be used to monitor fire outbreak or predict the region in a forest that provides high risk of fire outbreak. This information can help the fire-fighters to take preventive measures on the exact location. Other area of prediction includes early warning against natural disasters to improve emergency response.

7.2 Storage Management

A large number of agricultural products are usually lost due to poor storage management system. While temperature, moisture and other environmental factors greatly affect the contamination of food products, insects, microorganism, rodent, etc. can affect the quality and quantity of the food products. The use of IoT and data analytics in storage management systems can help to improve agricultural product storage [9]. Sensors can be deployed to monitor the storage facilities and environmental conditions. The data are sent to the cloud and analyzed. A self-automated decision system, which relies on the analyzed data can be deployed to adjust the environmental conditions. Moreover, a warning alert can be initiated to farmers when extreme conditions are reached or if pest are reported in the storage facility.

7.3 Decision

Decision making requires reliable information which can be obtained from sensors data. The large data obtained from sensor offers learning opportunities to improve decision making in constantly changing environmental conditions, such decision making can be over a short, medium, or long term. Automated decisions can be made from the IoT system when certain conditions are reached, therefore requiring less or no human interventions. For instance, Such automated decision could range from regulating the temperatures to the control of water supply from an irrigation system.

8. ADVANTAGES OF GREEN IOT IN AGRICULTURE

There are several benefits that can be derived from the use of IoT in agriculture. some of the benefits are as follows.

- The use of IoT can help promote community farming especially in the rural areas. The IoT can be leveraged to promote services that allows the community to have a common data storage, share data and information, increase interaction between the farmers and agriculture experts.

- The challenge in the agriculture sector is not just limited to sufficient production but also the ability to ensure safe and nutritious food supply. There have been several reports in food fraud which includes adulteration, counterfeit, artificial .
- The increase in demand for food and the use of innovative technology is expected to make the agriculture sector very competitive. Also, the enabling of data driven agriculture using IoT will open new direction in trading, monitoring, and marketing.
- One of the perceived advantages of IoT is the ability to monitor remotely devices and equipment. The application of IoT in agriculture will help to save time and money in inspecting large fields compared to personnel physically inspecting the field either via use of vehicles or walking. The ability to know when and where to apply pesticides or insecticides using IoT will reduce cost and wastage.
- The operational efficiency not only relates to farmers but to decision makers related to agriculture sector, such as government and nongovernmental agencies. Data gathered from agriculture surveillance schemes via IoT can serve as a guide in agriculture interventions.
- IoT will enable real time monitoring of farm assets and machinery against theft, replacement of parts, and for timely routine maintenance.

9. CHALLENGES IN APPLICATIONS OF IOT

There are several challenges that are associated with deployment and application of IoT [16]. Such as

- The deployment of massive IoT devices for agricultural and other purposes will cause interference problems especially with the IoT devices using the unlicensed spectrum, such as ZigBee, Wi-Fi, Sigfox, and LoRa etc.
- The lack of adequate security may lead to loss of data, bridge of privacy, and access to raw information about on-field parameters and other sensitive intellectual properties [15].
- The right choice of IoT technology is a big challenge because a lot of investment is required for deploying new technologies. Many factors need to be considered, such as support for roaming, suitability of technology to small-scale, medium-scale and large-scale, suitability to different geographical location, soil types and climatic conditions.
- The IoT devices are expected to be deployed in out-door environment. This will expose the devices to harsh environmental conditions which may lead to degradation of deployed sensors with time as well as communication failures.
- Billions of IoT devices are expected to be deployed in the agriculture sector. Existing gateways and protocols will need to support large number of IoT devices/nodes.
- Farmers need resources optimization mechanism to determine how many gateways, IoT devices, amount of transmitted data, size of cloud storage are needed in order to have a breakthrough in profit margins. This is particularly challenging due to different farm sizes and different type of sensors needed to monitor farm variables for specific crops or livestock.

- Security and privacy, data convergence and ownership, lack of interoperability, heterogeneity of IoT devices.

10. CONCLUSION

This review presents a perspective of the current state of the Green IoT in agriculture. The goal of the IoT for agriculture remains: to collect enough data of the correct kind from the right place, at low cost and with adequate well-informed analysis and understanding for farmers to take action. The study shows that there is a lot of work going on in IoT technology growth that can be used to improve plant operational efficiency and productivity. In this paper, the advantages of green IoT and data analytics and transparent problems were described and addressed. The IoT is supposed to provide the agricultural sector with many advantages. However to make it sustainable for small and medium-scale growers, there are still a range of issues to be tackled. Security and expense are the main concerns. In this paper, in addition to technology implementation, the Green IoT based farming is evaluated by several researchers and a brief overview, benefits and challenges are highlighted.

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