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An overview of smart agriculture using internet of things (IoT) and web services

Vijaya Choudhary [a,b,c,***], Paramita Guha [a,b,*], Giovanni Pau [d,**], Sunita Mishra [e]

[a] Academy of Scientific & Innovative Research (AcSIR), Ghaziabad, 201002, India
[b] CSIR-National Physical Laboratory, New Delhi, 110012, India
[c] School of Computer Science and Engineering, IILM University, Greater Noida- 201306, India
[d] Kore University of Enna, Italy
[e] CSIR-Central Scientific Instruments Organization, Chandigarh, India

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ABSTRACT

The presented work provides an insightful overview of the Internet of Things (IoT), emphasizing its role in enabling real-world objects to communicate through networking technologies. IoT integrates wireless sensor networks, artificial intelligence, and cloud computing to boost productivity while minimizing costs and losses. The abstract underscores the importance of GUI applications for user-friendly interaction with IoT systems and the widespread use of RFID for tracking items, especially in supply chain management and inventory tracking. IoT devices equipped with RFID tags are highlighted as integral components of a broader network, with cloud computing offering a scalable infrastructure to manage the substantial data generated by IoT components. Data collection in IoT relies heavily on wireless sensor networks, with data uploaded to the cloud for synchronized analysis. The abstract suggests a comprehensive exploration of IoT applications across various fields, with a focus on smart-enabled applications. Overall, it sets the stage for a detailed examination of IoT's impact and potential in diverse contexts.

1. Introduction

Over the last few years, different types of ICT have enabled precision farming techniques, allowing farmers to optimize resources to use as water, fertilizers, and pesticides. This is achieved through the use of sensors, GPS technology, and data analytics, which provide real-time information on soil conditions, crop health, and weather patterns. Farmers can make data-driven decisions to enhance productivity and reduce waste. FMIS collects and analyses data from various sources, including weather stations, satellite imagery, and on-farm sensors. This data is used to monitor crop growth, predict pest and disease outbreaks, and assess environmental conditions. Analyzing this information helps farmers make informed decisions about planting, irrigation, and harvesting. FMIS facilitates better management of farm resources such as seeds, fertilizers, and machinery. With the help of technology, farmers can track inventory levels, monitor usage, and automate reordering processes, reducing the risk of shortages or overstock (Nikkila et al., 2010). It is well-known that the global population has increased severalfold; however, the growth in agricultural outputs has not increased to that extent to feed hunger. Also, there is an urgent need to introduce modern techniques to improve productivity and mitigate the farmer's time, cost, and effort. Emerging technologies based on IoT have a significant prospect in smart agriculture, permitting for big haul productivity increments. It offers several new perspectives for smart agriculture allowing management of cultivated fields for real analysis. In this frame of reference, IoT is not only for establishing connectivity but also can assist in getting live information from the agricultural fields. Collected data is further processed and utilized to make some major decisions related to crop management. Wireless Sensing techniques are found most often technologies for the deployment of smart farming. At the various levels of parameters either using images or sensors helps to monitor all kinds of crops and vegetation. Observation from the past reveals that remote sensing (for data collection) techniques are based on images from various sources such as satellites or images captured with

* Corresponding author. Academy of Scientific & Innovative Research (AcSIR), Ghaziabad, 201002, India.
** Corresponding author.
*** Corresponding author. Academy of Scientific & Innovative Research (AcSIR), Ghaziabad, 201002, India.
E-mail addresses: vijayachoudhary16.iiest@gmail.com (V. Choudhary), paramguha@gmail.com (P. Guha), giovanni.pau@unikore.it (G. Pau).

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the help of manned aircraft to monitor crop information at all its growth phases. However, experiments implemented on images collected from satellites found an unsuitable choice since it has a poor resolution of collected pictures and limitations on pixel size. Besides, for the long period between the addition and reception of images, there is a waiting period. Selecting manned aircraft as a method results in very expensive and most of the time it is impossible to run several flights to get crop images. Hence Wireless Sensor networks are the most suitable technique to monitor crops. In this section, we discuss the Internet of Things, Wireless Sensor Networking, and cloud computing and services which are the basics of modern precision agriculture.

1.1. Internet of things

The term Internet of Things was first coined by Kevin Ashton of Auto-ID labs in 1999. To understand intelligent manufacturing in the context of Industry 4.0, the authors of (McFarlane et al., 2003) provide a detailed review of related topics on smart manufacturing, IoT-enabled manufacturing, and cloud-based manufacturing. Internet of Things in the criteria of cyber-physical systems also connected to digitalized homes & modern metropolis, smart networks, and transport systems with intelligence. It can be recognized with a combination of activating automation covering Radio Frequency Identification, and remote sensing networks to analysis of data, web services, and ARPAnet protocols. WSN technology enhances many areas of modern-day living. This offers the capability to calculate, conclude and understand surrounding indicators, from fragile ecologies and resources getting from nature to urban environments (Gubbi et al., 2013). The IoT name itself is defined as millions of physical devices connected (via wired or wireless) to collect and share information. It is an application area that combines various technologies (software) and devices (hardware) as explained in (Abbasi et al., 2019). “Internet” is the connectivity that helps in communications and the term “Things” means a combination of sensors, computing devices, smart mobile phones, Radio Frequency Identification (RFID), *etc*. Transparency and homogeneity in a large number of different and heterogeneous end systems can be maintained by the Internet of Things,/while giving open access to selected sets of data for the deployment of a large number of digital services (Granda Cantuna et al., 2017; Zanella et al., 2014; Sanchez, 2014) automatic industry (Sanchez, 2014) with communication technologies and infrastructure. In the global information and communication technology industry IoT has become a promising sector (Park et al., 2017), smart energy, driverless cars, digital agriculture, and soon. All the advanced technologies linked with the IoT have the significant possibility for great approaches to smart agriculture, particularly when we talk about societal and environmental real issues faced by this area. The idea of the Internet of Things as a platform in the smart campus has become increasingly popular. Hence such systems implementation needs related architecture which includes communication networks, nodes with various sensors, and gateways to connect to the web (Sastra and Wiharta, 2016b), connected buildings and campus (Sastra and Wiharta, 2016a), and painless health care. The IoT revolution is redesigning the latest health care with technological, economic, and social prospects (Islam et al., 2015) green agricultural supply chain traceability system can be established to provide a guarantee with the development of the internet of things (Li, 2011) and among other domains to meet the requirements of food across the world in the coming future IoT networks become the trendiest technology with web services with its applications (IERC, 2015), (Dlodlo and Kalezhi, 2015a). An overview of different technologies used in IoT is discussed below.

Radio Frequency Identification Technology is the basic implementation of IoT and RFID is still in use. For transmission of stored data of target, there is a need for radio wave methods. Remote sensing is practiced for sensing conditions of products. These are distributed networks of sensors with self-networking capabilities, and low power consumption, and Bluetooth is a wireless technology standard for exchanging data over short distances. Bluetooth Smart, also known as Bluetooth Low Energy (BLE), is a power-efficient version of Bluetooth that is commonly used in devices like fitness trackers, smartwatches, and other low-power applications. Wireless Fidelity is a wireless networking technology that allows devices to exchange data wirelessly within a local area network. It is widely used for high-speed internet access and local network connections in devices such as smartphones, laptops, and smart home devices. ZigBee is a specification for a suite of high-level communication protocols using low-power digital radios. In applications such as home automation, industrial automation, and sensor networks. ZigBee is designed for low data rates and low power consumption. NFC is a short-range wireless communication technology that allows for the exchange of data between devices over very short distances, typically a few centimeters. It is often used for contactless payment systems, data sharing between smartphones, and identification/authentication processes. Devices that support these wireless standards can be part of the Internet of Thing (IoT) ecosystem, enabling seamless communication between devices and allowing for automation and data exchange without requiring constant human intervention. This is especially relevant in the context of smart homes, wearable devices, industrial automation, and other IoT applications (Liu et al., 2014). Cloud computing allows organizations to scale their computing resources up or down based on demand. This flexibility is particularly beneficial for businesses with fluctuating workloads, as they can easily adjust their infrastructure to accommodate changing needs and Cloud services operate on a pay-as-you-go model, allowing businesses to avoid large upfront investments in IT infrastructure. This cost efficiency is especially attractive to startups and small to medium-sized enterprises (SMEs) that may have budget constraints of the future internet (Botta et al., 2014) including some other essential devices of IoT which is lead like a front end for storing data captured from sensors. Hence analysis of data performance can be done on captured data and it also allows clustering towards various services. A typical IoT-based model for the agricultural field is shown in Fig. 1. In this model, data is collected using different types of sensors from the agriculture field. The proper working of the IoT Environments system is given below.

1.1.1. Collection of data

In the agriculture field, data get recorded, and factors for data collection depend on the division of agriculture under examinations. While in hunting crop farming, many circumstances affect crop farm production. Obtaining such a model aid in acknowledging the understanding that Adequate water supply is crucial for crop growth. Different crops have specific water requirements at different growth stages. Monitoring rainfall patterns helps in planning irrigation schedules. Each crop has an optimal temperature range for growth. Understanding day-to-day temperature variations is essential for selecting suitable crops and determining planting times. Humidity levels can affect crop development, especially in relation to diseases. Certain crops thrive in high humidity, while others may be susceptible to fungal infections under such conditions. Monitoring soil moisture levels is essential for efficient irrigation. Soil moisture sensors can help farmers determine when to irrigate and how much water is needed. Different crops have specific soil requirements. Understanding soil composition helps in selecting appropriate crops and implementing soil management practices like fertilization and mulching, etc. (Zhao et al., 2010; Hassan et al., 2018; Wang et al., 2006).

1.1.2. Data transfer

Transfer of data must follow some specific way for processing. There is a need for programming and authentication of data while doing the processing of data transfer. Costing and designing of the process play a key role in the development of boards and need good connectivity between source and destination. Proper compatibility is important between the source hardware/software and the end-user. While implementing IoT network developers have good plan work and must be

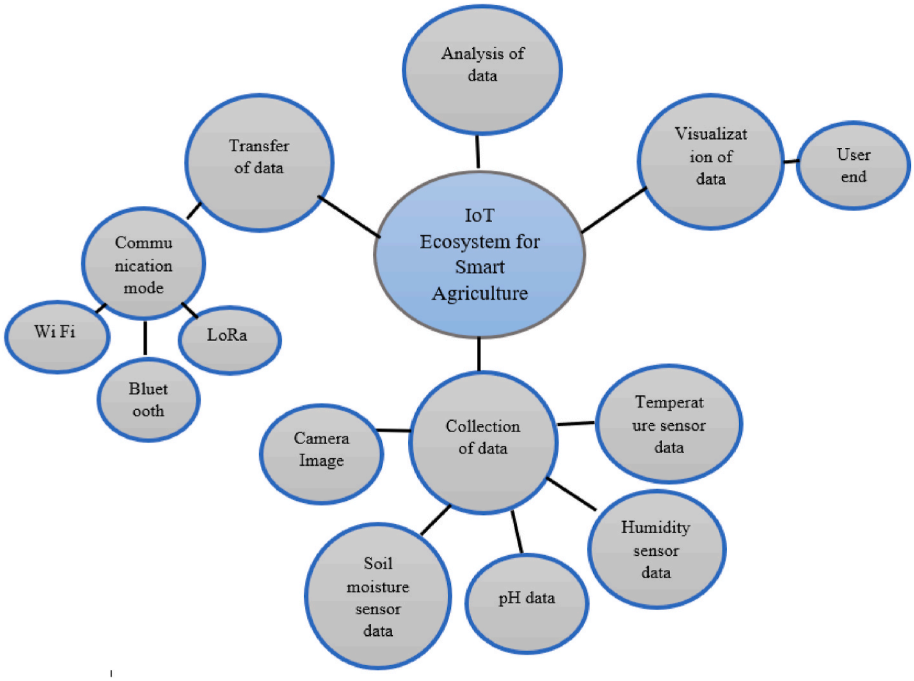

Fig. 1. Overall schematic view of IoT environment.

aware of the need for near-field communication and Far-field communication. The demand of the hour is the combination of various IoT sections for deploying all interconnectedness. FTP-file transfer protocols are the most suited applications for web services while messaging protocols are best suited for the development of IoT environment while FTP is not suited in the previous format for IoT deployment,/since the Internet of things, data are basic sensory nodes used in raw data collection for desired application fields.

1.1.3. Analysis of data

When we talk about data analysis data and IoT get connected. Production of data from different sources keeps growing at an ever-enlarging rate. IoT is a combination of various components, technologies, networks, and human resources to achieve a great goal. IoT-based applications are used in heterogeneous sectors and have big credit for providing enormous benefits directly to the end-users in various areas. Generation of data from various IoT devices such as cameras and sensors produce count or value only if it is put through to analysis, which leads to data analysis in the picture. Data Analysis (DA) is explained as a process, used to examine large and tiny data sets with varying data properties to expand meaningful conclusions and action can be taken further. Such conclusions are generally in the form of trends, patterns, and statistics that help business organizations dynamically engage with data implementation successfully. Hence Data Analysis tools allow business groups to make successful use of their datasets in the form of Volume: IoT applications make use of huge clusters of data sets. Hence business organizations require to manage such a large amount of data and need to analyze the same for extracting relevant patterns. All these gathered datasets along with real-time data can be analyzed effortlessly and efficiently with data analytics software. Structure: Data sets involve the internet of Thing Applications may have a structure such as unstructured, semi-structured, and structured data sets. Data analytics enable the business executive to analyze all of the different sets of data using automatic tools and software. Driving Revenue: IoT investments will allow data analytics to use the business units to gain within the organization and customer preferences and choices. Hence such a systematic way may lead to the development of services and offers demands and expectations of the customers or agronomists. However, it will improve the revenues and profits earned by the organizations. Table 1 shows the comparative analysis of Communications that must be used with the internet of Thing. Table 1 also depicts the details about the most popular technology that has been opted while implementing IoT in its enabled applications. Table 2 shows details of comparative study using various cutting edge techniques.

1.1.4. Visualization and management of data

Visualization and management of data explore information using graphs, pie charts, pictograms, bar charts, etc. IoT console is a channel for the showcase of acquired data from different IoT devices. Such collected data form in such a way that it can visuals get effortlessly understood by the end-users. Moreover, management and visualization in IoT and AI are capable to introduce unstructured data into a well-organized form. Some data visualization types are:/Histograms, Bar graphs, Statistics, pictograms, Line graphs, Graphs, Location maps, Infographics, Tables, dotted clouds, Graphical lines, mathematical plots, etc. AI and IoT consoles are specially designed for presenting the acquired data through the sensor's combinations while the development of the IoT network. Data can also be visualized for different variables such as the temperature of the atmosphere, the Moisture level in the environment, Level of different elements, pH value, Weather conditions, Proximity, Chemical level, Current or voltage, Location, Pressure, and Humidity. Data management for the development of the IoT console is completely synchronized to data from the preferred storage type created on the webserver and transformed into the desired format. Internet of Thing's console must be capable to sort data based on the parameters and values. So that end-users can highlight, rescale and transport the data shown on the webserver as per their requirements. Emphasizing the data is abstracting important facts and figures from gathered data. Highlighting the data and including some extra features with different colors can immediately grab the heed of end-users. Data resizing allows end-users capable to zoom in or zoom out detailed data.

1.2. Remote wireless sensor network

A Wireless remote system (WSN) is a combination of nodes/junctions put down under the command of a router/base station. Acquiring data

Table 1
Complete information of communication technology.

Type of Communications	Scale	Transmission Distance	Network Type	Frequency Bands	Bi-directional link	Rate of Data
802.11a/b/g/n/ac	Unlicensed	6–50 m	WLAN	2.4/5 GHz	Yes	2 Mbps- 7 Gbps
802.11ah	Unlicensed	1000 m	WLAN	1 GHz	Yes	78 Mbps
802.11p	Licensed	<1 km	WLAN	5.9 GHz	Yes	
Lora WAN	Licensed	<20 km	LPWA	sub-GHz	Yes	0.3–37.5 kbps
Ingenu/Onramp	Licensed	15	LPWA	2.4 GHz	No	78 kbps (UL), 500 bps (DL)
Bluetooth	Unlicensed	<100 m	WPAN	2.4 GHz	Yes	2 Mbps-26 Mbps
3GPP NB-IoT	Licensed	<35 km	LPWN	450 GHz–3.5 GHz	Yes	250 kbps
3GPP LTE-MTC	Licensed	<5 km	WWAN	1.4 MHz	Yes	200 kbps
EC-GPRS	Licensed	<5 km	WWAN	GSM licensed bands	Yes	240 kbps
WiMAX	Unlicensed and Licensed	Up to 50–80 km	WWAN	10–66 GHz, 2–11 GHz	Yes	70 Mbps
MiWi	Unlicensed	<50 m	WPAN	2.4 GHz	Yes	256
ZigBee	Unlicensed	<1 km	WHAN	2.4 GHz	Yes	250 kbps
Z-Wave	Unlicensed	<100 m	WHAN	900 MHz	Yes	100kbps
NFC	Unlicensed	<20 cm	P2P	13.56 MHz	No	424 kbit/s
WirelessHART	Unlicensed	<228 m	WFAN	2.4 GHz	Yes	250 kbps
5G	Licensed	15–600 m	OFDM	6 GBz	Yes	100 Mbps
6G	Licensed	Under testing	6G wireless	24.25 GBz	Yes	1 Gbps

Table 2
Comparative study on latest technology.

Points	Machine to machine (M2M)	Internet of Things (IoT)	Internet of Everything (IoE)
Size	It is a subset of the IoT	IoT is a Superset of M2M	IoE is a superset of IoT
Key	Devices, Communication, and Application	Sensors or Devices, Communication, Storage services, and Application	People. Things, Data, and Processes.
Communication Type	Point to Point	IP Networks	Network connection of people, process data, and things.
Internet	Maybe without the internet	Devices in IoT need internet	Devices and their application required internet

with physical parameters like temperature, humidity, pressure, and sound most of the time using remote sensing techniques. Each single junctions comprise an order of transducer unified with an MCU-Microcontroller. The set of collected data is going to transfer to the router/base station along with wireless techniques. When transmission of acquired data of every part of the field to a far location is essential then WSN most suited choice always. The main aim of WSNs is to deploy for smart farming and crop production by concentrating on atmospheric-based parameter monitoring, smart agriculture, and machine and process control for details (a), (Ivanov et al., 2015). The A lightweight and open-source operating system for the Internet of Thing (IoT), Contiki supports a range of low-power wireless communication standards. Another open-source operating system designed for IoT devices and WSNs, RIOT OS focuses on low-power, energy-efficient communication. Part of the Contiki OS, Cooja is a network simulator specifically designed for WSNs. It allows developers to simulate large-scale networks and assess the performance of protocols and applications. While not exclusive to WSNs, OMNeT++ is a modular simulation framework that supports the modeling and simulation of various communication networks, including WSNs. Integration of machine learning techniques for node localization, enabling more accurate position estimation in WSNs. Predictive models that estimate the energy availability of sensor nodes based on environmental conditions, helping optimize energy consumption. Each node in a WSN is equipped with one or more sensors to monitor specific environmental parameters. These sensors can vary widely in their types and capabilities. Examples include temperature sensors, humidity sensors, accelerometers, cameras for high-resolution imagery, and threshold detectors for specific events. The sensor nodes are typically equipped with embedded computers or microcontrollers that process the data from the sensors and manage communication within the network. These embedded systems are responsible for data aggregation, local processing, and communication with other nodes or a central base station (Merrill, 2010). Smart agriculture is an area that includes one of the most suitable outlines for the deployment of wireless sensor networks (Díaz et al., 2011), (Amin et al., 2004). Such devices are distinguished by narrow processing steps of data and have lesser steadiness. These restrictions can be resolved by dropping the refinement and warehousing from physical equipment to the web. Web Services play a vital role in finding the solutions for estimation because of high demand, calm, and flexible behavior for the future scope. However, evaluating materials on a web portal can host in big data centers and set up places instant from end-users. Additionally, observing a surge in data amount to transfer from different components will also enlarge the haul on the network to the web (cloud).

1.3. Cloud computing and services

Cloud computing and Services allow the whole world and all companies to make use of computation available. Cloud servers comprise many benefits in merchandising undertakings, industries, and corporates that exit. A few of the benefits of cloud computing and services are as follows:

Resilience: If the calculative request is up, the industries extend their business and if the calculative request is down then the industry scales cut down.

Self-oriented counter: Customers or users can use the calculative assets for every kind of work to be maintained on request.

Pay as you go: When we talk about paid basis, it is found that cloud computing resources could be both public and private. Such a module provides accuracy, flexibility, and stability. Inside consumers every so often are not giving with any charge. Now by using the public cloud, a minor party retailer provides the resources via the internet. Working customers have to finance themself for the number of rotations need used. For example, widely useful cloud service providers are Azure (from Microsoft), AWS (from Amazon), IBM cloud computing (from IBM), and soon. Many companies run complex applications with various weighted workloads on the private cloud.

1.3.1. Aim of study and contributions-

The aim of utilizing IoT and AI-enabled smart agriculture is to transform traditional farming practices into data-driven, efficient, and sustainable systems that meet the challenges of feeding a growing global population while minimizing environmental impact. Utilize IoT sensors and AI algorithms to monitor crop health, growth stages, and environmental conditions in real-time. This could involve deploying various sensors such as soil moisture sensors, weather stations, drones, and satellite imagery. Implement AI algorithms to analyze data collected from sensors and historical data to predict crop yields and optimize farming practices. This can involve predictive modeling to anticipate crop diseases, pest outbreaks, and optimal harvest times. IoT devices and AI to enable precision agriculture techniques such as variable rate application of water, fertilizers, and pesticides. This ensures resources are used efficiently based on specific conditions in different parts of the field. Develop systems that automatically adjust irrigation schedules and nutrient delivery based on real-time data from sensors, weather forecasts, and crop needs. This reduces water and nutrient wastage while maximizing crop yields. Utilize AI algorithms to identify early signs of pest infestations and crop diseases by analyzing sensor data and images. This enables timely interventions, reducing the need for broad-spectrum pesticides and minimizing crop losses. Implement data analytics and visualization tools to provide farmers with actionable insights derived from the vast amounts of data collected through IoT devices. This empowers farmers to make informed decisions to improve productivity and profitability. Assess the environmental impact of agricultural practices using IoT and AI technologies. This includes monitoring soil health, water quality, greenhouse gas emissions, and biodiversity conservation to ensure sustainable farming practices. Explore the integration of AI-enabled robots and automated machinery for tasks such as planting, harvesting, and weeding. This reduces labor costs, enhances efficiency, and addresses labor shortages in agriculture. Utilize IoT and AI to optimize the entire agricultural supply chain, from farm to fork. This includes improving logistics, inventory management, quality control, and traceability to ensure food safety and meet consumer demands. Facilitate knowledge sharing and collaboration among farmers, researchers, and agricultural experts using digital platforms enabled by IoT and AI. This fosters innovation, accelerates technology adoption, and promotes sustainable agricultural practices.

2. Web services and IoT

The Internet is the only way for Web Services/Cloud Storage, where numbers of data are collected for storage and processing. Web Services is an application layer protocol hence it involves end-users interfacing operations, management, services, and communication (TongKe, 2013). Getting the various level of connection with miscellaneous layers and components over the web, IoT middle layer, and connection models are mostly developed. Examples of the IoT middle layer are the user interface under service-based architecture, web services Internet of Things middle layer, and actor-oriented IoT middleware in detail (Xu et al., 2014). The Internet of Thing deploys the capability for anthropoid and mainframe (computers) to become masters to interact with millions of things (systems) that comprise sensors, transducers, services, and other web-connected devices (Ngu et al., 2017). Service-oriented architecture for the Internet of Thing comprises multidimensional architectures. There are several layers of IoT are:/recognizing, examining, circulating, middle-layer interfacing, and user application layers (Ngu et al., 2017). These could be sensors, actuators, cameras, and other IoT devices that are distributed across different locations or platforms. This is likely a centralized or distributed computing infrastructure where the collected data is processed, analyzed, and stored. This could involve powerful servers, cloud computing resources, or a combination of both. Devices are collecting data from their surroundings. This could include information from environmental sensors, cameras, temperature sensors, motion detectors, etc. The collected data is processed to filter out irrelevant information and match it against predefined criteria. This might involve using algorithms to identify patterns or anomalies in the data. Once the data is filtered and matched, various applications can use this information for control purposes. These applications might include automation systems, monitoring tools, or other software that can make decisions or trigger actions based on the processed data. (Liu et al., 2014). This suggests that the discipline involves multiple interconnected aspects or domains. It could refer to a diverse set of technologies, processes, and methodologies, especially considering the mention of various devices and data types in the previous context. Managing observation requires a strategic approach to the development of the system or process. This involves establishing clear criteria and goals for the development of the observed system. These criteria could include efficiency, accuracy, scalability, security, and more, depending on the specific context. Those managing the observation process need a deep understanding of the system, including the devices, data, and applications involved. Analysis of the collected data is crucial for extracting meaningful insights, identifying patterns, and making informed decisions. Various visions of these IoT models are reported and authorizing technologies are evaluated in (Atzori et al., 2010). An adaptable architecture allows for easy scalability, accommodating the growth of IoT devices and data. It can handle an increasing number of connected devices and evolving requirements without requiring a complete overhaul. IoT solutions often involve diverse devices and technologies. An architecture that supports interoperability ensures seamless communication and integration between different components, devices, and platforms. Technology evolves rapidly, and IoT solutions must be able to adapt to new devices, protocols, and standards. A flexible architecture provides a foundation that can be easily updated to incorporate emerging technologies, helping to future-proof the solution (A Reference Architecture for The Internet of Things, 2019). The IoT depends on several physical layers interconnected with each other (Cecchinel et al., 2014). A combination of technology like the internet of Thing, Artificial Intelligence, and web applications are capable of resolving complex problems related to exchangeability, automatic, workable, and easy/self-configurable jobs (Sheth, 2016). Fig. 2 depicts the complete architecture of the data preprocessing pipeline in connection of devices, sensors, and machine-level for movement towards a keen autonomous application layer.

A layered view of Web Services and the Internet of Thing as shown in Fig. 2 is explained below.

2.1. Layer 1: devices, sensors, and microcontroller

Hence this is Layer 1 and layer 1 is always the beginning of the architecture. This layer includes all the ground-level equipment such as/, industrial robots, PLCs, advanced robots, and various microcontrollers including smart tools like/, smartwatches, digital glasses, various actuators and sensors, and smartphones to provide an enlarged human-machine interface. Hence, the latest equipment with embedded technology allows such modern devices to communicate with IoT communication modes such as MQTT, RFID, Zigbee, Bluetooth, Wi-Fi, LoRa, and soon.

2.2. Layer 2: communication, protocols, and networks

This layer convert data collected from the previous layer as raw data into information. Development of base station/gateways is done under this layer; hence this layer is more powerful compared to the previous one. Realistic actions include response to many manufacturing events such as/, deploying a protocol-based alerts system to the production equipment. Even developers can impel scientific capabilities by posting functions like lambda from the AWS cloud server (Patel et al., 2017).

2.3. Layer 3: cloud infrastructure

In this layer, the collected data from various sources have to be set as per need with the help of different data analysis techniques. The Preprocessed data is original because it is the collection of data that is stored as per requirements. Cloud-oriented services are concentrating on

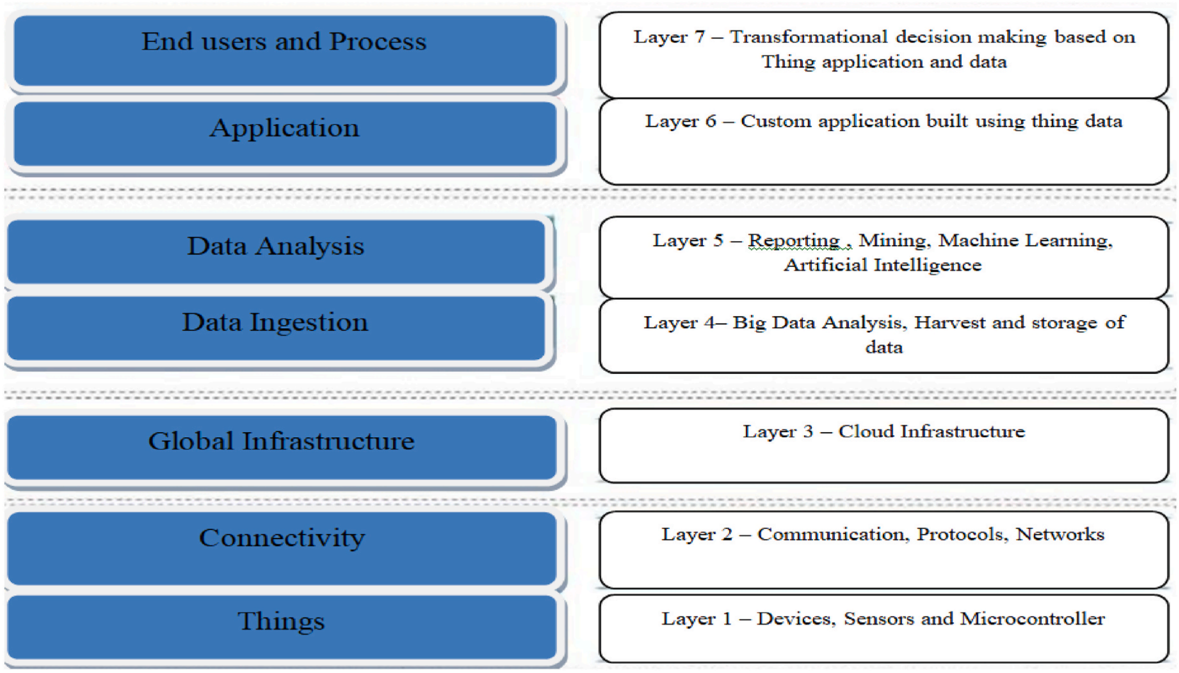

Fig. 2. A layered view of Web Services and the Internet of Things.

a single place to make users apply some analysis on top of set aside data. cloud-oriented services authorize end-users to reserve structured and unstructured data at any point in time. Region-based data resources comprise the connected data and connected services. Such methods help to reuse data and services from the web/cloud (Gyrard et al., 2016).

2.4. Layer 4: big data analysis

End users can show various analyses, for example, data visualization to compound analysis such as real-time analysis of machine learning (ML) and big data processing. As per the data generation process when connected to the internet of Thing, there are chances to generate a huge volume of data and that data must be analyzed using various approaches. Recent algorithms/Optimizers maybe get edited to implement while using big data (Zanella et al., 2014), (Chen et al., 2015). It sounds weird to get connected everything on the earth together via the internet, but web services and IoT is going to change our lives in the coming future by making things impossible to possible (Tsai et al., 2014).

2.5. Layer 5: reporting, mining, machine learning, and AI

A huge amount of data available may cause different data lakes, which generates a big opportunity for researchers and research cutting-edge technology like Machine Learning (ML) algorithms. The purpose of doing so is to recognize unseen relationships between data shown on the upper layer. Hence, this layer boosts the decision-making powers of the entire model. AI catalog provides services that perceive many ML algorithms which are discussed in detailed (Mahdavinejad et al., 2017), (Toshniwal et al., 2013).

Layers 6–7: Transformational decision-making on the Application Layer: Since the application layer is at the top of the network it shows information about data that is collected from the previous layer to end-users to make their decision-making. The application layer talks about building efficient and useful applications on top of the services. The development of machine learning (ML) models is going to use to analyze and extract upper-level information from a variety of IoT environments (Mahdavinejad et al., 2017). However, customers can interact with modern technology through various powerful devices to recognize its internal sections. There are several numbers Web Services are available, some of them are explained below considering Fig. 3. Gateway Services: Increasing demand internet of Thing and AI technology in agriculture because of its very useful applications and fast information distribution methods. We can consider India as an onlooker for modern techniques in agricultural websites. The formation of web services encourages spreading knowledge and utilizing information to mitigate comprehensive stake, investment, and business expenses, and increase the assurance backup. Services based on Voice Recognition: Conversations over the internet for transmission of voice are based on the principle of Voice over Internet Protocol (VoIP). In this service, agronomists will be able to access all the services across the world. At present, specifically in rural areas connection such as mobile/telephone broadband penetration is at a peak point. Hence voice recognition is a very helpful key to getting connected with the agronomist. With the help of voice call service agronomists' ability to utilize benefits and can be able to get details and directions on the latest methods, smart farming techniques, retailing, or other related details. SMS Based Services: Currently, SMS Based Services are quite easy and low-priced services for the farmers to get services from other organizations. Since/, SMS Services are inexpensive and the main transmission media for agronomists for trading activities related to agriculture in routine life for communicating across the globe. Such services are very useful for sending the latest news which works wirelessly on the web. Now farmers having their mobile phones is increasing day today, and the information spreading via text messages has become a modern assistance model. Communal Farm Online Pinging Services: Agronomists and other collaborators can form a group to aid each other. In this grouping system, the main collaborator is a smallholder. The members connected to agronomists are bankers, governmental agricultural officers, crop insurance representatives, income officers, agronomy scientists, and researchers. Hence, information technology provides a base for agronomists and related associations to share details. By using such services, agronomists have the option to go online by using their PCs, tablets, and cell phones. Face-to-Face Video Conferencing Services: The well-known facet of such a model reclines in a visible and face-to-face reaction. An agronomist can get this assistance remote-based system. Farmers can watch those videos and get relevant information on agriculture which can be used for their practices. Farmland and agricultural officers can have online individuated interactions. World Wide Web Services: Because of the low bandwidth

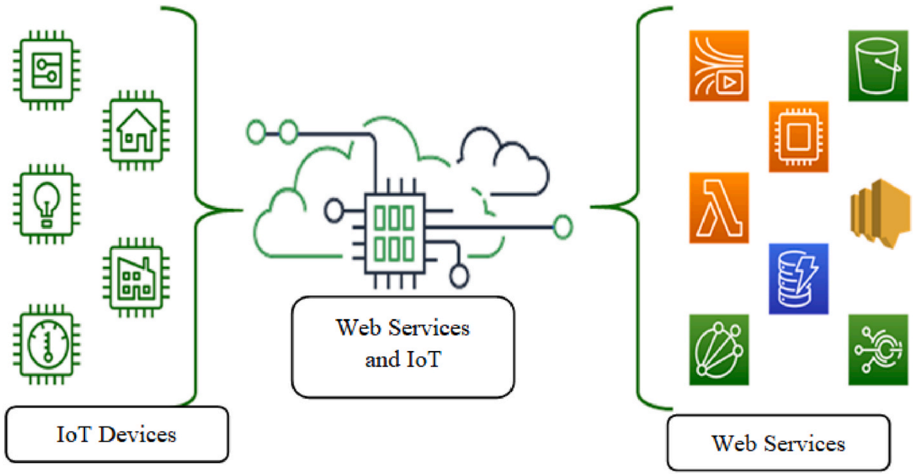

Fig. 3. Overall schematic view of IoT core and web (cloud) services.

penetration of PCs in rural areas, high usage of mobile phones is evolved proceeds the benefits of computer network technologies. Horticulture is accessible to the agronomist in motion or comes across the agricultural sector. Not only omnipresent is a mobile service but also transportable and geomorphology identifiable. Such models are going to dominate the coming future information distribution models. Unified High-Definition Model: A unified high-definition model has been planned and evolved to the utilized transfer of data using different transmission media. Such Web service model success requires a two-way motion of information. This approach recognizes the importance of both sending information to users and allowing users to actively engage and interact with the content or service. One-way communication is often associated with delivering content to users, such as news updates, announcements, or other information. On the other hand, two-way communication involves a more interactive exchange, allowing users to provide feedback, participate in discussions, and engage in real-time communication.

Fig. 3 also shows the overall architecture of IoT devices and web services as discussed so far. It indicates that all the IoT devices will generate raw data since it is sensory data, so a huge volume of information will be generated and such data would need a large volume of space hence there may be a chance of to shortage of storage. However, this large volume of data cannot be stored in a physical system manually, hence we need cloud/web storage to store such big data with the help of various cloud services.

IoT Hub and Web Services include the basic architecture of Web Services-based systems including the following major points. Pictorially it is shown in Fig. 4.

IoT Hub and Stream Analytics: An IoT hub is a central component that facilitates communication between IoT devices (front-end smart devices) and a backend server. It manages device-to-cloud and cloud-to-device communication. A lightweight and efficient messaging protocol designed for low-bandwidth, high-latency, or unreliable networks. It's commonly used in IoT scenarios where devices need to send and receive messages. Another messaging protocol that is more feature-rich and supports broader communication scenarios compared to MQTT. Microsoft's cloud-based business analytics service that allows you to visualize and share insights from your IoT data. It integrates well with other Microsoft Azure services, including IoT Hub. AWS offers various tools and services for IoT, including visualization and analytics tools that can be integrated with IoT data streams. Both Azure and AWS provide services that seamlessly integrate with IoT Hub, allowing you to process and analyze data generated by IoT devices.

Machine Learning: ML is a subset of artificial intelligence (AI) that focuses on the development of algorithms and models that enable computers to learn and make predictions or decisions without being explicitly programmed. ML models process input data, identify patterns, and use statistical analysis to make predictions or classifications. The model "learns" from the data it processes. In supervised learning, the algorithm is trained on a labeled dataset. The user provides both input features and their corresponding target or output. The algorithm learns to map the input data to the correct output during the training phase. Once trained, the model can be used to predict or classify new, unseen

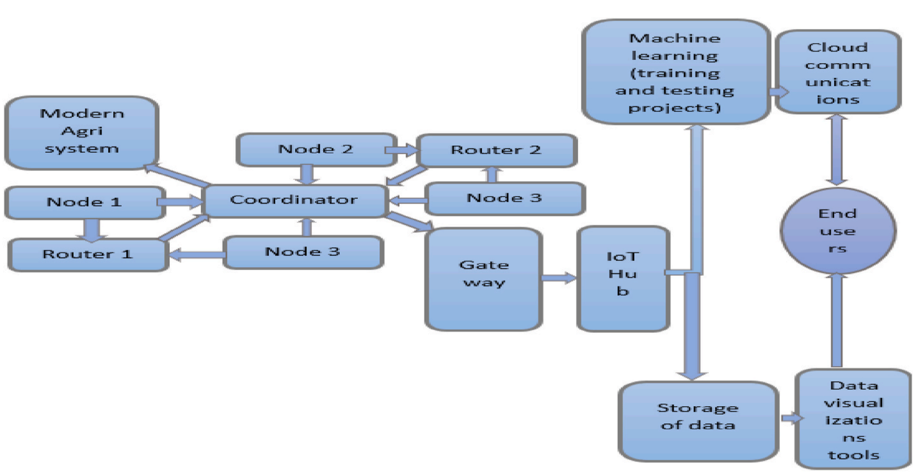

Fig. 4. Architecture of Web Services based system especially for application agriculture.

data. In supervised learning, the training process involves adjusting the model's parameters to minimize the difference between predicted outputs and actual outputs. Once trained, the model is evaluated on a separate set of data not used during training (testing set) to assess its generalization to new, unseen data. Machine learning is a versatile tool used in a wide range of applications, from image recognition and natural language processing to predictive analytics and autonomous systems. The choice between supervised, unsupervised, or reinforcement learning depends on the nature of the task and the type of data available for training and testing the model.

Cloud-Based Services: The use of cloud computing allows for scalable and flexible resources. Users can access the service over the internet without the need for on-premises infrastructure. Users can input data into the system from various sources, which may include databases, spreadsheets, APIs, or other data connectors.

Cloud Communication: This involves using cloud-based resources and services to facilitate communication processes. This can include various communication channels such as voice, messaging, and more. PaaS is a cloud computing service model that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the underlying infrastructure. Users can leverage the cloud communication platform to initiate and receive phone calls. This is often done through Voice over Internet Protocol (VoIP) technology, where voice calls are transmitted over the Internet.

3. Application of IoT and AI-enabled techniques for smart agriculture

Sensors can be embedded in the soil or placed in various locations across a field to monitor different parameters. Common sensors. These sensors collect real-time data on the conditions in the field. Drones equipped with cameras and other sensors can fly over fields to capture high-resolution images and data. This can be particularly useful for assessing crop health, identifying areas of stress or disease, and monitoring overall crop development. The collected data from sensors and drones are transmitted to a central system, often through the use of web services or the Internet of Thing (IoT) platforms. This data can include information on soil conditions, crop health, weather patterns, and more. The transmitted data is stored and analyzed in the cloud. Agronomists and farmers can access this information through web interfaces or mobile applications. Web services and IoE enable better traceability and visibility throughout the entire agricultural supply chain. This is crucial for tracking the journey of products from the farm to the consumer, ensuring quality, and optimizing logistics. RFID tags, GPS tracking, and temperature sensors can be integrated to monitor the transportation and storage conditions of agricultural products. IoE technologies can be integrated into farming equipment, such as tractors and harvesters, making them more intelligent and efficient. These devices can communicate with each other, optimizing tasks like planting and harvesting based on real-time conditions. Remote monitoring and control of machinery are also possible through web services. With the help of analytics platforms, agronomists can analyze the vast amounts of data collected by IoT devices. This data-driven approach allows for more informed decision-making, leading to better crop yields, reduced resource usage, and improved overall productivity. (Brewster et al., 2017a), (Nukala et al., 2016). By collecting farmers information, the web services system can tailor its offerings to the specific needs of each agronomist, provide personalized insights based on their land and location, and ensure the security and privacy of their data. It's important to implement robust security measures and adhere to data privacy regulations to build trust among agronomists using the platform, *etc*. Once agronomists get registered, then they can approach the information from anywhere and anytime throughout the country. When we discuss IoE, Artificial Intelligence (AI) is always present in it and Machine Learning (ML), and Deep Learning (DL) together will form subsets of AI. AI is a subset of ML, which is again a subset of DL, and the combination of all these is termed data science and all these come under the same set. A Neural Network (NN) based algorithm for classification through the tensor flow and Keras platform and a Decision Tree Ensemble algorithm for classification through a machine learning platform have been explored in (Sinha et al., 2017). In the agri-sector, selection of every crop is very important in agriculture planning; crop selection is dependent on different parameters like/, market price, production rate, and the different government policies. A huge number of changes are required in the agriculture field to improve changes in the economy. Hence, agronomists can improve agriculture methods such as machine learning and deep learning techniques which can be easily applied in Agri-sector. With all the improvements in the machines and technologies used in farming, skillful and reliable information also play a key role in it. Hence implementation of the crop selection method in smart farming helps in solving many agriculture and agronomist problems. Additionally, it improves the economy by maximizing the yield rate of crop production (Jayaraman et al., 2017). Authors of papers (Gubbi et al., 2013) and (Treboux et al., 2018) explains for combining these technologies with agricultural practices, researchers can enhance crop production and make predictions about crops at an early stage. This integration can lead to increased yield rates, contributing to the improvement of the economy. Such methods also help in providing information on crops and how to increase yield rate from time to time. To make it executable, the algorithms used there were artificial neural networks (ANN), Bayesian Belief Networks (BBN), Decision Tree Algorithms, Clustering, Regression analysis, Logistics analysis, etc. In (Abbasi et al., 2019), (Ramesh et al., 2019) the authors have included reviews that apply to various applications of machine learning algorithms in the agriculture sector. They also present insights into the troubles faced by our Indian farmers and how these can be solved using such techniques. Machine Learning models can be one of the most suited solutions for the issues faced by agronomists to get a variety of good crops (Hari Santra et al., 2016). Automatic detection of plant disease using neural network (NN) models and image processing techniques is the latest advanced research (Hari Santra et al., 2016). The convolutional neural network (CNN) system is based on plant images of various crops and reorganization of disease based on types of images. The CNN technique has been used to identify the issues regarding diseases based on images taken by plants with good accuracy in several papers like, (Sanchez, 2014), (Hari Santra et al., 2016). Authors in (Park et al., 2017), (Karan deep Kauri, 2016) present an improved technique based on image processing and artificial neural network (ANN) for the early detection of pests in crops. In those papers authors significantly tried to recognize various categories of plant diseases such as 1) fungus infections 2) organisms and 3) ailments within plants. In their experiments, they obtained an accuracy of 98.59% using ANN modeling techniques. Prediction of various types of diseases that affect plants can be detected by using Deep Learning (DL) Techniques will be of big help to agronomists. These articles cover various image processing techniques to recognize diseases of plant leaves and such diseases are severe to strike at any part of the plantSuchch disease losses encountered and can cause low productivity along with a huge economic crisis within the sector. To make agronomics highly profitable there is a need to encourage and grow from such hindrances. IoE and AI technologies have rolled out their large-scale extension in many areas like the health sector, home automation, and Autonomous but in agriculture, the sector does not rehash c to the mark. Agriculture still agronomists using manual methods which is a very time-consuming process. If we talk about plplantisease, Inappropriate analysis, and prediction lead to big losses in the form of manufacture, time-saving, cost-cutting, and quality of products. For profitable cultivation of agriculture, there is a need to monitor regularly the plants growing stages day today. Hence Image processing techniques are the best-suited methods for monitoring and analyzing issues related to plants. AI and DL models are designed in such a way that it is very useful to analyze and applied for identifying all kinds of plaplantsease and to avoid losses, there are affordable treatments made available (Husni et al., 2016), (Khairunniza-Bejo et al., 2014). There are many sets of examples of the benefits of IoE in agriculture. The sample of such use cases is crop management and animal management. Hence measurement devices on cows are energy bounded, and features of the off-body wireless channel between the on-cow sensor components and the back-end base stat are needed for an optimized classification of these networks in outbuilding (Mohanty et al., 2016). WSNs consist of sensor nodes that communicate wirelessly to monitor and collect data from the field. Sensors can be designed to detect various parameters, such as the presence of pests, temperature, humidity, soil moisture, etc. WSNs provide real-time data, are cost-effective, and can cover a large area (Dhakal and Shakya, 2018), Using mobile cellular networks for machinery maintenance allows for remote monitoring, control, and maintenance of equipment. Sensors on machinery can collect data related to performance, usage, and potential faults, which is then transmitted over mobile cellular networks. Real-time monitoring, quick response to issues, predictive maintenance, and potential cost savings through efficient management. mobile cellular networks provide the infrastructure for radio communication, enabling devices to connect to the internet wirelessly. Devices, including machinery with embedded sensors, can communicate with servers, cloud platforms, or other devices over the internet through the mobile cellular network (b), water sprinkling and water quality observer includes IOE with a sensor to measure and monitors the humidity in the mushroom farm. The humidity data processed through NETPIE was developed and provided by NECTEC as a free service for IoT (Gopalakrishnan et al., 2020). Agronomists from their previous experiences and irrigation practices have modeled the Machine learning These models simulate the interactions between soil, crops, and the environment to predict how different factors will affect crop growth. Numerical models use mathematical equations to represent processes such as soil water dynamics, nutrient availability, and crop growth. They take into account various parameters like soil type, weather conditions, and crop characteristics. The models generate data and predictions related to soil moisture levels, crop growth stages, and other relevant factors. Rule sets are predefined guidelines or conditions based on agronomic knowledge and best practices. Rule sets establish criteria for making decisions about irrigation, taking into account factors such as current soil moisture levels, crop growth stage, weather forecasts, and water availability (Benaissa et al., 2017). A maximum number of sensors makes use of the smart mobile phone to click and precede Digital images of the soil in the root zone are captured using optical sensors or cameras. Various imaging technologies, such as RGB cameras or multispectral/hyperspectral sensors, can be used to capture different bands of light. Calibration is essential to establish a relationship between the optical properties of the soil and its water content (García-Lesta et al., 2017). Continuous pumping of groundwater at rates higher than the natural recharge can lead to a lowering of the water table. Reduced groundwater levels can impact the availability of water for agriculture, drinking water supplies, and ecosystems that depend on groundwater. As water levels decline, areas that were once irrigated may transition into unirrigated or dry lands. The reduction in available water can adversely affect crop yields and may force changes in agricultural practices or land use. Addressing the challenges associated with declining water levels involves a combination of sustainable water management practices, regulatory measures, and community engagement. Efforts to promote efficient water use, enhance recharge mechanisms, and implement conservation strategies are essential for ensuring the long-term sustainability of water resources and preventing the expansion of unirrigated lands (Oksanen et al., 2016). WSN allows for the deployment of sensors throughout the field to monitor various environmental factors in real time. Soil moisture levels influence irrigation decisions. If the soil moisture is too low, farmers may decide to initiate irrigation to ensure optimal crop growth. Conversely, if the soil is adequately moist, they may postpone irrigation to avoid water wastage. Temperature affects various aspects of plant growth, development, and pest activity. Farmers can adjust planting schedules, choose suitable crop varieties, and implement frost protection measures based on temperature data. Extreme temperatures can also influence decisions on irrigation and nutrient application (Chieochan et al., 2017). Install soil moisture sensors at various locations to measure the contents of moisture of the soil. Real-time data on the actual water needs of the plants. Such information helps the system adjust irrigation schedules based on current and predicted weather conditions. Use automated valves and pumps to control the flow of water to different zones in the field (Viani et al., 2017). Install soil moisture sensors at various measure the moisture content of the soil. These sensors provide real-time data on the water needs of the plants. Integrate weather stations to gather data on temperature, humidity, wind speed, and precipitation (Jagüey et al., 2015). Deploying sensors in the field (e. g., soil moisture sensors, weather stations) allows farmers to collect real-time data on various environmental factors. Analyzing large datasets generated by these sensors enables farmers to make precise decisions, optimizing inputs such as water, fertilizers, and pesticides. Automated irrigation systems equipped with IoT sensors can monitor soil moisture levels and weather conditions. By analyzing this data, farmers can implement dynamic irrigation schedules, ensuring efficient water usage and reducing water wastage (Kavianand et al., 2016). By irrigating based on soil moisture levels, water is used more efficiently. This helps in conserving water resources, which is crucial, especially in regions facing water scarcity. Plants require specific amounts of water for optimal growth. Over-irrigation or under-irrigation can negatively impact crop health. Automatic drip systems, guided by soil moisture thresholds. Precision irrigation systems can lead to cost savings by mitigating water and consumption of energy. This is particularly important in agriculture, where resource management directly affects the economic viability of farming operations. Efficient irrigation practices contribute to environmental sustainability by minimizing the environmental impact associated with water use in agriculture (Abedin et al., 2017), (Zaire et al., 2015). These sensors can detect factors like temperature, humidity, and atmospheric pressure. IoT-enabled traps can be used to monitor pest populations. These traps may use sensors to detect the presence of specific pests, and the data is transmitted in real-time to a central system. Collected data is analyzed in real-time to identify patterns and trends related to pest infestation. Machine learning algorithms can be employed to predict potential outbreaks based on historical data. Drones equipped with sensors or cameras can provide real-time imagery of the crop fields. This imagery can be analyzed to detect early signs of diseases, pests, or weed infestations (Sureephong et al., 2017), (Zhang et al., 2017). Deploy sensors capable of collecting relevant data in the physical environment. This could include sensors for temperature, humidity, pressure, and other environmental factors, depending on the application. Enable communication capabilities in IoE devices to facilitate the exchange of data. This is typically achieved through the use protocols such as Wi-Fi, Bluetooth, or specialized IoT protocols like MQTT or CoAP (Kodali et al., 2016).

The Internet of Things (IoT) offers numerous applications and benefits for smart agriculture, revolutionizing the way farming is done by integrating various technologies and devices. Fig. 5 shows the application based work flow for smart agriculture using IoT and web services.

3.1. Applications and role of IoT in smart agriculture

3.1.1. Precision farming

IoT enables precision agriculture by collecting and analyzing data from sensors installed throughout the farm. These sensors can monitor soil moisture, nutrient levels, temperature, humidity, and even crop health. With this data, farmers can optimize irrigation, fertilization, and pest control, leading to improved yields and resource efficiency.

3.1.2. Livestock monitoring

IoT allows farmers to track the health and behavior of livestock using connected sensors and wearables. By monitoring parameters such as body temperature, activity levels, and location in real-time, farmers can

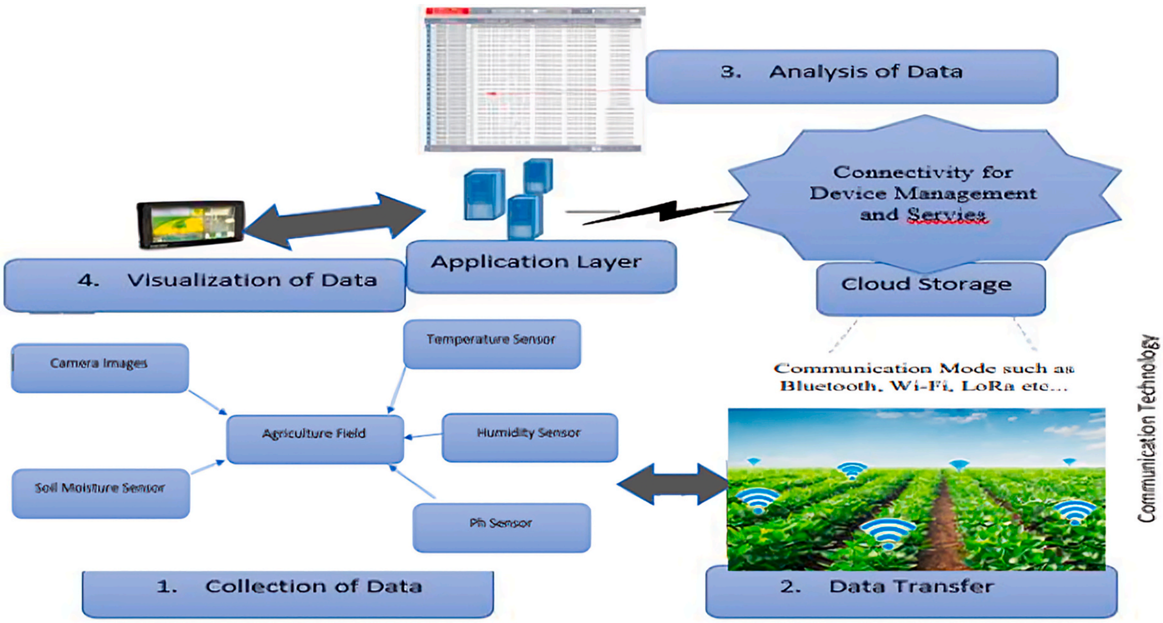

Fig. 5. Smart Agriculture applications using the Internet of Things.

detect signs of illness, optimize feeding schedules, and improve overall animal welfare.

3.1.3. Automated machinery

IoT facilitates the automation of farming equipment such as tractors, harvesters, and drones. These machines can be equipped with sensors and GPS technology to perform tasks more efficiently and accurately. For example, drones equipped with cameras and sensors can monitor crop growth, detect diseases, and even apply targeted treatments.

3.1.4. Supply chain management

IoT can enhance supply chain visibility and efficiency in agriculture. By tracking products from farm to fork using connected sensors and blockchain technology, farmers can ensure the quality and safety of their produce while minimizing waste and optimizing distribution routes.

3.1.5. Environment monitoring

IoT enables farmers to monitor environmental conditions such as weather patterns, air quality, and water levels. By integrating data from weather stations, satellite imagery, and IoT sensors, farmers can make informed decisions about planting, harvesting, and resource management, while also mitigating the impact of climate change on their operations.

3.1.6. Predictive analytics

IoT facilitates the use of predictive analytics and machine learning algorithms to forecast crop yields, pest outbreaks, and market demand. By analyzing historical data and real-time sensor data, farmers can make data-driven decisions to optimize crop production, reduce risks, and maximize profitability.

3.1.7. Remote management

IoT allows farmers to remotely monitor and control their operations from anywhere using mobile devices or computers. Whether they're checking irrigation systems, adjusting feeding schedules for livestock, or monitoring security cameras, farmers can stay connected to their farms 24/7, improving productivity and peace of mind.

AIM OF STUDY: The Internet of Things holds great promise for transforming agriculture into a more connected, efficient, and sustainable industry, helping farmers overcome challenges and meet the growing demand for food in a rapidly changing world.

4. Application and role of internet of things

IoE along with Web services has multidimensional applications. Some are given below.

4.1. Healthcare sector

As we all know the largest industry worldwide is the health care sector. IoE uses different sensors and data collection tools over the internet to deliver an environment of transparency and perfect connections between various resources and services. IoE devices often consist of embedded systems, which are specialized computing systems dedicated to specific tasks. These devices can include sensors, actuators, and other components that gather data from the physical world. IoE devices are connected to the internet, allowing them to communicate with each other and with centralized servers. This connectivity enables real-time data exchange and remote control of devices. IoE devices generate and collect data from their surroundings. This data can be shared with other devices or sent to cloud-based servers for processing and analysis. This information can be valuable for monitoring, decision-making, and automation. IoE applications often involve interactions with users. This can be through web services, mobile apps, or other user interfaces that allow individuals to monitor and control connected devices remotely. The combination of embedded systems, internet connectivity, and data sharing opens up a wide range of applications across various industries. Examples include smart homes, industrial automation, healthcare monitoring, and smart cities. While IoE offers numerous opportunities, it also presents challenges such as security and privacy concerns, interoperability issues, and the need for robust communication protocols. IoT devices can facilitate remote health monitoring, allowing individuals in distant or underserved areas to access healthcare services without the need to travel long distances. Patients can use wearable devices or sensors that collect and transmit vital health data to healthcare providers in real-time. In remote areas where healthcare facilities are scarce, IoE-based health monitoring systems enable healthcare professionals to remotely monitor patients' health conditions. This allows for proactive intervention and reduces the need for frequent visits to healthcare centers. Implementing IoE technologies for health monitoring can potentially reduce the overall cost of healthcare. By preventing the progression of diseases through continuous monitoring, the system may contribute to cost savings by avoiding expensive treatments that result from late-stage interventions. IoT devices can continuously monitor various health parameters, enabling early detection of potential health issues. This proactive approach can lead to timely interventions, preventing the development of more severe conditions and reducing the overall burden on the healthcare system. The data collected through IoT devices can be analyzed to derive valuable insights into population health trends. This information can aid healthcare providers and policymakers informed about allocation of resorces, preventive measures, and the design of targeted healthcare interventions. Scanning might refer to the collection of medical data, including diagnostic images (such as X-rays, MRIs, CT scans), laboratory test results, and other relevant information. This data collection can be distributed across different devices, departments, or even healthcare facilities. Continuous monitoring of patient health can involve real-time data from wearable devices, in-hospital monitoring systems, and other sources. This distributed monitoring can provide a comprehensive view of a patient's health status. Machine learning algorithms and artificial intelligence can be employed to assist in the diagnosis process. These algorithms can analyze medical data to identify patterns and anomalies, providing valuable insights to healthcare professionals. Predictive analytics can be used to anticipate potential health issues, allowing for proactive and preventive measures. This involves analyzing historical patient data to identify trends and predict future health outcomes. Electronic Health Records (EHRs) play a crucial role in managing and cataloging medical data. This information needs to be organized, accessible, and secure. Cloud-based solutions can facilitate the storage and retrieval of patient records from various points within the healthcare system. Ensuring the security and privacy of patient data is a critical consideration. Access controls, encryption, and other security measures need to be distributed across the system to protect sensitive information. SPES appears to be a service or organization that specializes in real-time diagnosis. This suggests the use of advanced technologies or methodologies to provide timely and accurate diagnostic information. Medical non-adherence refers to patients not following prescribed medical treatments or not taking medications as directed by healthcare professionals. This can have significant consequences, including extended recovery times, financial issues, and an increased risk of early-stage deaths. When patients do not adhere to prescribed treatments, the recovery process may be prolonged, and the desired health outcomes may not be achieved on time. SPES seems to be positioned to provide support to individuals and institutions dealing with medication-related challenges. This support may involve real-time diagnostic services, possibly incorporating technology to monitor and manage adherence to prescribed treatments.

4.2. Wearable/daily life accessories

The Internet of Everything is the possible solution to establish a connection between human and embedded systems and showing chances for the development and improvement of smart recovery systems and helps in the e-Health sector. The major objective of such systems is to identify works involving IoE and web services that deal with the deployment, architecture, employment, execution, and use of technological equipment in the area of patient recovery. Nowadays several wearable ECG and heart rate monitoring systems such as digital watches, digital glasses, smart belts, *etc*. are developed which have architectures comprising of flexible singlets redesigned with apparel electrodes, apparel threads, snap fasteners, sponges, and an ECG circuit. BLE is a wireless communication technology designed for short-range communication with low power consumption. In this context, it likely facilitates communication between the wearable garment and the smartphone. The smartphone serves as a user interface and a central hub for the system. Users can interact with the wearable garment, receive data from the apparel electrodes, and possibly control or configure the system through a dedicated mobile application. The web server likely acts as an intermediary for communication between the smartphone and the web page. It could store and process data, handle authentication, and facilitate communication between the smartphone and the web page. Along with the exploding growth of data available on the Web, recommender systems have been used as functional technologies to sieve useless information and seek to recommend the most useful data. The augmentation of smart mobile phones, digital wearable devices, and relevant other IoE devices have slowly driven many appearing services which are intermission-sensitive and computation-intensive with inflated quality-of-services. Hence, the data resources consist of various key characteristics. Block-based Integrated Platform for Embedded Systems (BIPES) is an open-source software platform and service that is candidly available through the website and has been formulated from our existing experiences of many years deploying embedded systems and IoE applications. Devices can monitor and analyze physical activities, providing insights into a person's fitness levels and overall well-being. Patients with chronic conditions can be monitored remotely, allowing healthcare providers to intervene early in case of abnormalities and reduce the need for frequent hospital visits. Wearables can be used to remind patients to take medications and track adherence. Accelerometers and gyroscopes in wearables can detect sudden falls, triggering automatic alerts to emergency services or caregivers. GPS-enabled wearables can provide the location of individuals, especially useful for patients with cognitive disorders or those prone to wandering. Wearables can track sleep patterns, helping individuals improve their sleep hygiene. Sensors can measure physiological indicators of stress, prompting users to engage in relaxation techniques. Aggregated and anonymized data from wearables can contribute to population health studies, helping authorities understand trends and plan public health interventions. Data collected from wearables can be used to tailor treatment plans and interventions based on individual health data. Individuals can use apps to set personalized health goals and receive recommendations based on their activity levels and health metrics.

4.3. Traffic monitoring sector

Implementation of a digital panel has been placed over Metropolitan Zone (especially in Guadalajara, Mexico) which will be providing an informative screen, a digital camera, and internet access to the city is done with the help of IoT and web-based services. Hence, it is in charge of requesting the traffic monitoring information from the nearby zone with the help of web services, capturing pictures of its observation field to be later uploaded, providing traffic monitoring information of different road sections, and downloading pictures of other nearby board also shown on its informative screen. Because of the fast increasing usage of public transportation in routine life, mitigation of traveler's time plays a key role in travelers' comfort as well as in his productivity that affects the economy of the country. Besides, in developing countries, bus transportation is the most popularly used way for a citizen to travel to their work, universities, *etc*. IoT delivers a productive way of communication among the web devices with the traffic embedded system sensors, and other interconnected networks. Hence, the effect of development in the hardware sector, size of the network, and usage of the scope of the Internet are frequently growing. latest smart devices, such as home appliances sensors, actuators, and automobile equipment are becoming stronger to communicate and interchange information over the internet. IoT applications such as/, healthcare, environment monitoring, supply chain tracking, and automobile networks, are frequently gathering large volumes of data with an extremely high throughput.

4.4. Hospitality

The social Internet of Everythings allows systems to repeatedly produce posts, live share content, and location (GPS) information, and aid the construction of an online section of users depending on their manufacturer's products, such that marketing employers can also get a useful review. IoT enables guests to control various aspects of their hotel room, such as lighting, temperature, and entertainment systems, through a mobile app or voice commands. Hotels have implemented IoE-based keyless entry systems, allowing guests to use their smartphones for room access, providing convenience and security. IoT devices collect data on guest preferences and behavior, allowing hotels to offer personalized services, such as recommending restaurants, activities, or room settings based on individual preferences. IoT devices facilitate real-time feedback collection, enabling hotels to quickly address concerns and enhance the overall guest experience. Theme parks and restaurants use IoT to create immersive experiences. For instance, smart wristbands or mobile apps can provide interactive features, personalized recommendations, and queue management in theme parks. Restaurants and themed venues can use IoT to adjust lighting, music, and other ambiance factors to create a more engaging and enjoyable atmosphere. Cruise ships utilize IoT for monitoring and managing various systems on board, including navigation, safety, and entertainment. Passengers on cruise ships can benefit from IoT-enabled services such as personalized itineraries, location-based notifications, and smart cabin controls. IoT devices help in collecting and analyzing data related to guest preferences, energy usage, and equipment performance. Optimize operations, reduce costs, and enhance overall efficiency explain in details. These are the physical devices or things that are embedded with sensors, software, and other technologies to collect and exchange data over the internet. This suggests that there is some form of communication or coordination happening at the network level. This could involve protocols for data exchange, decision-making, or resource allocation among IoT devices. Fog computing refers to a decentralized computing infrastructure where computing resources are placed. This likely refers to the overall structure or framework that integrates IoT devices, fog computing nodes, and possibly cloud resources. The architecture determines how these components interact and work together to achieve specific goals. Fog computing can reduce the need for extensive cloud resources, potentially lowering costs associated with data transfer and storage. By processing data closer to the source, fog computing can lead to faster response times compared to traditional cloud-based solutions. For a decade biometric authentication is most in use. Hence biometrics in automatic transfer machines (ATM) provides exodus and boundary control, hospitality and tourism, etc. Hence capability of the palm layer acquiring system can be enhanced using an altered thinning algorithm. The development of IoT and web services gained great interest. Organizations are trying to maintain transparency, along with benefactors and governments calling for improved transparency and information interchange in the hospitality sector.

4.5. *Water supply sector*

the population of the world increasing day by day and climate changes are also increasing. Hence, the request for high-quality water has become a need for the entire world. Such surveys and fact-making pressure on humankind to innovate new water management techniques. IoT technology is successfully applied in smart cities. Freshwater smart management system provides precision irrigation in the agriculture sector which is essential for the productivity of crop yield and mitigating costs, efforts, and losses the environmental sustainability. Such technologies offer intense use of the exact amount of water needed by plants. IoE is the innate choice for the smart water management sector, although the combination of various technologies needs to make it work perfectly in execution. In some places such as the southeast of Spain, water is scarce and its cost is very high. Hence management of water is an important resource. Accordingly, irrigation strategies application is used to improve the watering process, and impact the productivity of crops increasing subsequently. A huge amount of water gets wasted daily because of several leakages in pipelines. Hence need to mitigate such waste and preserve water, to use some advanced systems. The major objective of monitoring real-time water supply, the work unrevealed the scalability of the solution in a real atmosphere. Hence water management processes need across the world.

4.6. *Home automation*

Home automation becomes more practical since the 20th century which is because of the frequent use of electricity and fast development in information technology (Asplund and Nadjm-Tehrani, 2016b). A survey on IoE Based on Home Automation systems has been presented in (Chen et al., 2017). based on surveyed studies, the comparison among home automation systems microcontroller, user interface (GUI), communication bonding, and presentation factors are compared. Several do-it-yourself (DIY) platforms are available that allow various ideas to create home automation systems fast and easy along with low cost and efficient performances (Varga et al.). Hence, protocols involved in home automation systems are known as Home Automation Device Protocol (HADP). HADP aims for the interworking of home automation components on various platforms. IFTTT (IF-This-Then-That) model involves a set of components that follow communication protocols where components get activated and steps are involved to produce and control the introductions via the center of the node (Varga et al., 2017). There are several techniques involved in the smooth functioning of home automation systems *viz.*, Bluetooth, smartphone/mobiles, services related to SMS, General Packet Radio Service (GPRS), Dual Tone Multi-Frequency, and Internet/intranet, *etc.* (Duan et al., 2014).

4.7. *Automobile sector*

The transformation from the Internet of Vehicles (IoV) to web services-based Vehicular Cloud (VC), the equivalent of the Internet cloud for vehicles, provides all the services required by autonomous vehicles. It mentions the evolution from intelligent vehicle grid to autonomous, IVs, and VC. Install sensors on the vehicle to measure various pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), and hydrocarbons. These sensors could be based on technologies like electrochemical sensors, infrared sensors, or other suitable technologies depending on the pollutants to be measured. Connect the sensors to a microcontroller or an IoT device capable of processing the sensor data. Integrate a communication module (like GSM, 4G, or 5G) to transmit the collected data to a central server. Verify the accuracy of the sensors in measuring pollutant levels. This can be done by comparing the sensor readings with a reference standard or a calibrated instrument. Assess the system's ability to provide real-time monitoring of pollutant levels. The latency between data collection, transmission, and display should be minimal. In the context of vehicles, RFID tags can be embedded or attached to vehicles for identification purposes. Each vehicle is equipped with an RFID tag that contains unique identification information. RFID readers placed at key points, such as entry and exit points of roads, intersections, and toll booths, can read these tags.

4.8. ***Yield estimation***

Yield estimation is among the most important and trendy areas in Modern agriculture. Plotting and evaluation of yield, parallelly equal of crop supply with demand, and crop management. Modern approaches have gone far beyond simple prediction based on the previous data, but with the help of modern computer vision technologies to provide data on the go and complete multidimensional analysis of crops, weather, and economic conditions to make the many yields for farmers and population. Authors in (Sastra and Wiharta, 2016a), (Plantix. Accessed) discuss and develop various methods of utilization of remote sensing data in the field Furthermore, it appears that a non-linear Quasi-Newton multi-variety optimization method is employed to address the inconsistency and errors in yield prediction. This method aims to optimize the least square loss function through renewable convergence, using a pre-defined empirical equation. The results indicate acceptable lower residual values, with predicted values closely matching observed ones, as reflected by the R2 values of 0.78 for Corn and 0.86 for Soybean crops in Iowa state.

5. Advantages

There are many advantages of IoT implementation get acquired from the use of IoT in the agriculture sector. However, we restate and encapsulate some of the advantages in the following points.

5.1. Competitive environment

With the increased demand for food and to feed the hunger of the country, there is an urgent need to develop cutting-edge technology, it seems that the agriculture sector would be highly competitive in the coming days. As part of this enabling of data analytics systems, IoT play a key role in exploring trading, monitoring, and marketing in agriculture. Hence to apply the realistic data for controlling purpose-making tools come up with aggressive behavior among agronomists who wanted to acquire the IoT environment.

5.2. Productivity and administration

Agricultural profit with IoT will bring forth the latest trendy models for business, where the single agronomist keeps away from the squeezing of mediator and can establish a direct relationship with the purchaser (Symeonaki et al., 2020), [112] foremost to huge benefits.

5.3. Mitigation of cost and wastage

Implementing the internet of Thing has major benefits because it is having the capability to monitor remote devices and equipment explained in detail (Na et al., 2016). The advantages of the Internet of Thing assist to save time and funds to examine a hectare of fields in contrast to personnel physically examining the field using with or without vehicles. For management of pesticides or insects of crops in agriculture are quite a low cost and low wastage with the help of IoT Implementation.

5.4. Mitigation of risk

IoT helps farmers mitigate risks associated with unpredictable factors such as weather events, pest infestations, and market fluctuations. By continuously monitoring environmental conditions and crop health, farmers can detect early signs of problems and take proactive measures to minimize losses and optimize yields.

5.5. Automation and robotics

IoT enables the automation of various farming tasks through the integration of sensors, actuators, and autonomous machinery. Automated systems can perform activities such as planting, harvesting, and weeding with greater precision and efficiency, freeing up farmers' time and labor for other tasks.

5.6. Working effectiveness

The working effect is directly associated with agronomists and higher authorities who are associated with agricultural sectors like government and non-governmental bodies. In addition, the Implementation of IoT helps to increase the supply chain of agriculture crops and such a system of supply chain mostly assists to produce real-time stabilization.

5.7. Spreading relevant consciousness

Deploying the Internet of Thing with the hope to manage budget applications by using wireless network services in the agricultural area. Accordingly, mobile applications may play a key role to get information from markets related to prices and services while the government provided services and authoritative standards related to various farm production feasibly available. All the organic, fresh and nutritious products easily can get located for customers who are interested to buy.

5.8. Security and interception

Major provocation in the agriculture division is sufficient production and the ability to make sure a safe and nutritious food supply chain. Many reports of food swindling include adulteration, artificial enhancement within Identify and map the entire food supply chain, from farm to table, including production, processing, distribution, and consumption stages. Understand the flow of food products, ingredients, and information across the supply chain. Conduct a comprehensive risk assessment to identify potential hazards at each stage of the supply chain. Consider environmental factors such as climate change, weather patterns, and geographical considerations that may impact food safety. Evaluate the impact of technology on food safety, including advancements in food processing, packaging, and monitoring systems (Zhang et al., 2014). Fraudulent mislabeling can involve incorrect information regarding the origin, species, or quality of a food product. For instance, mislabeling farmed fish as wild-caught, or misrepresenting the geographical origin of a product. Fraud can extend to copying or counterfeiting premium or branded food products. This may involve replicating packaging and labels to deceive consumers. Fraudsters may provide false documentation or certification to mislead consumers about the production practices, such as claiming a product is organic or adheres to certain quality standards when it does not. Implement transparent and traceable supply chains to ensure visibility at every stage of the production and distribution process. Thoroughly vet and verify suppliers to ensure they adhere to proper production standards and ethical practices. Employ testing and analytical methods to verify the authenticity and quality of raw materials and finished products (Lee et al., 2017). Many types of equipment related to safety and food fraud are explained well in the paper (Giri et al., 2016) where product morality, process ethics, people conscientiousness, and data security are addressed using IoT technologies. IoT sensors can monitor and transmit real-time data on environmental conditions such as temperature, humidity, and soil quality. This is crucial for maintaining optimal conditions during cultivation, storage, and transportation. Monitoring of crops' health, detecting diseases, and optimizing irrigation and fertilization processes (Dlodlo and Kalezhi, 2015b).

5.9. Bunch agriculture

Deploying IoT environments can aid to encourage a bunch of farming mostly in the rural sections. Internet of Things can support to encourage services that allow a group of farmers to have some kind of data storing strategy, exchange information with each other, and enlarge coordination among the agronomist and agriculture officers (Asplund and Nadjm-Tehrani, 2016a). In addition, while using mobile applications and IoT resources can be split inside the group using free or paid services.

6. Issues and challenges

There are many challenging issues related to the implementation of IoT infrastructure. A few key issues introduced in the literature survey are the protection of data, absence of interoperability, diversity of devices, and unreliability in business model systems. Modern techniques are directly beneficial to the domain of food and agriculture to get solutions faced by societal and atmospheric issues in this division (Marvin et al., 2016). As devices communicate with each other, ensuring the security of data transmission and storage becomes critical. Encryption, secure authentication, and secure protocols are essential components (Tähkäpää et al., 2015). A few major running issues are as follows.

6.1. Marketing strategical issues

When we talk about profit in the agriculture sector, it is very low. Hence proper balance is the need to deal between the distribution of IoT enabling technologies and the expecting profits. Therefore, some issues related to the IoT distribution by considering a few parameters such as a price index, build-up, managerial costs, etc. Price index is related to the distribution of the Internet of Thing in agriculture that may be classified into two types 1) build-up cost and 2) management cost. Pick up of hardware (Sensors, gateways, communication infrastructure) comes under the build-up cost while management cost includes regular contributions mostly used for amalgamation facilities or IoT environments that allow different forms of collection of data, administration of Internet of Thing sensors, and distribution of information among all services. In addition, management costs are healed from the interchange of information between IoT sensors, gateways, cloud services, and maintenance.

6.2. Scientific issues

Trespass: The categorization of the group of IoT components for agricultural division and other purposes will be the sources of trespass issues mostly with the Internet of Thing's components using the prohibited range. The trespass production may conduct mislaying data and mitigate the authentication of such great environments.

6.3. Safety issues

Many safety issues need to be talked about within the layered architecture of the AI environment. In the absence of requisite safety may conduct loss of major details, and obtain primary information about field-based parameters and other delicate conceptual properties. Issues related to how to secure and keep the IoT ecosystem safe are explained in detail (Manning, 2016). The IoT attaches various sensing devices to the web for interchanging data. Relocation of information is one of the most challenging issues as discussed in (Folinas et al., 2006), (Bo and Wang, 2011). IoT devices in agriculture are unsafe to corporal tampering, for example, robbers or attacks by carnivores and animals (Brewster et al., 2017b). Hence, rugged systems are required to be installed at strategic locations. Planning of the trust assessment process is highly governed by trust derivation, as it dominates the overhead in the process. The performances of components of IoTs, especially, the WSNs are sensitive to overhead due to the limited bandwidth and power (Chen et al., 2014). The safety and position of relocation of data and the Internet of Everthings allowed GPS-based facilities that can be used for smart agriculture in the path-based, or multipath-based communication to establish secure links. A new multipath model depending on an encoding scheme tailored for WSNs has been proposed in (Asplund and Nadjm-Tehrani, 2016b) and analyses of the effects of key pre-distribution on multipath key establishment are also discussed in (Asplund and Nadjm-Tehrani, 2016b).

6.4. Reliability

The components of the Internet of Things is looking for inside and outside environment. Such phenomena lead to exposure of the gadget to severe environmental situations again leading to their indignity of them in due course along with the collapse in communication networks. The corporal security of the delivered IoT devices and network systems is necessarily secured to protect the expensive apparatus from poor weather conditions, such as flash floods and cyclones.

6.5. Scalability

Millions of IoT components are hoped to be deployed in the cultivation field. Previous approaches and protocols need to support the huge amount of IoT communication media Such as Sigfox gateway, Ingenue, and Lora WAN. Each identification numbers and node are the requirements for a smart IoT management system network.

6.6. Replacements

Indeed, many features may require for the implementation of the Internet of Things eco-environment. Such features incorporate the capability for IoT components to support many functionalities. Hence placed anywhere and connected to the entire world with the coming version of transfer models, the most suitable example is Fifth Generation (5G) as a version of data speed rate, which will give a better world. Instead of using the old and traditional way to handle voice call services, there will be technology like the Internet of Everythings (IoT) and Deep learning model, Machine learning (ML) Algos, Artificial Intelligence (AI), etc. Such technology will use low power consumption for data transfer and the rest of its services will be very beneficial for precision farming with or without human intervention (Chen et al., 2017).

6.7. Augmentation of resources

Agronomists need a capital enlargement strategy to regulate getting area about how many approaches, what kind of AI devices, amount of data transmission, and data storage for cloud services is a requirement concerning development in gross profit. Such issues occurred because various farmland and various types of AI components need to monitor farm variables for special crops.

6.8. Divisional issues

There are millions of IoT components needed for progress work on protocol and to maintain standards to interoperate. Such opinion demands formulated, technical, semantic, and organization interoperability are major issues for IoT rapid progress. Hence it can be essentially attributed to the existence of several various sets of technologies including old and new. Interoperability is too crucial in IoT as most communication channel approaches machine-to-machine learning-based models (Varga et al.).

8. Conclusion

The implementation of the Internet of Thing (IoT) and Artificial Intelligence (AI) techniques in smart agriculture holds immense potential to revolutionize traditional farming practices, improve productivity, and promote sustainability. Through the integration of IoT devices such as sensors, drones, and automated machinery with AI algorithms for data analysis and decision-making, farmers can gain real-time insights into crop health, environmental conditions, and resource utilization. This facilitates precision agriculture techniques, optimized resource management, and proactive pest and disease management. However, despite the promising benefits, there are several challenges and research gaps that need to be addressed. These include issues related to interoperability and standardization, scalability and affordability, data privacy and security, user acceptance and adoption, customization and localization, robustness and reliability, as well as ethical and societal implications. Addressing these gaps requires interdisciplinary collaboration, innovative research, and stakeholder engagement to develop solutions that are inclusive, equitable, and sustainable. Overall, the successful implementation of IoT and AI techniques in smart agriculture requires a holistic approach that considers technological advancements, socioeconomic factors, and environmental concerns. By harnessing the power of IoT and AI, farmers can optimize resource efficiency, minimize environmental impact, and ensure food security for a growing global population. It is imperative that research and development efforts in this field continue to innovate and evolve to address emerging challenges and opportunities in agriculture. With concerted efforts, smart agriculture powered by IoT and AI has the potential to transform the way food is produced, distributed, and consumed, paving the way for a more resilient and sustainable future. A review of cutting-edge technology such as IoT, Web services, and AI within the agriculture sector was broadly introduced in the presented paper. Many sections associated with the development of cutting-edge technology for precision farming are explained properly. The literature review reveals that a lot of work going on for the implementation of the Internet of Things, AI, and web services across the world. The advantages of web services and IoT, and key challenges are also addressed and discussed in this paper. The Internet of Things and Web Service's combined goal is to offer many benefits to the agricultural sectors. Although there are number of issues, privacy and price index, pending to be labeled to make it modest agro-processing for agronomists. Observations indicate that as competition within the market increases day by day in the agriculture sector, strategic approaches involving WS and IoT will increase consistently. The communication channel is one of the major components that need more surveillance while implementing an IoT environment.

9. Future scope and observations

Integration with Emerging Technologies leads future smart agriculture systems can integrate IoT with emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), and Blockchain. These integrations can enhance decision-making, predictive analytics, and secure data management across the agricultural supply chain. Scalability and Cost-Effectiveness research focus on developing cost-effective and scalable IoT solutions tailored to small and medium-sized farms. This would ensure widespread adoption in developing regions with limited resources. Standardization and Interoperability in lack of standardized protocols and interoperability among IoT devices and platforms remains a challenge. Future efforts aim to establish universal standards for seamless integration and communication. Data Security and Privacy as IoT adoption grows, safeguarding sensitive agricultural data will be critical. Future work should prioritize the development of robust cybersecurity measures to protect data integrity and farmer privacy. Sustainability and Energy Efficiency exploration of energy-efficient IoT devices powered by renewable energy sources can reduce the carbon footprint of smart agriculture systems. This aligns with global sustainability goals. Advanced Weather Adaptation Models IoT systems can be expanded to include advanced weather prediction models and climate adaptation tools, enabling farmers to mitigate the risks of unpredictable climate changes. Real-Time Multilingual Interfaces Developing user-friendly interfaces that support real-time multilingual interactions can enhance accessibility for farmers worldwide, especially in linguistically diverse regions. Global Collaborative Frameworks Establishing collaborative frameworks involving governments, private sectors, and academic institutions can accelerate innovation and deployment of IoT-based smart agriculture solutions.

CRediT authorship contribution statement

Vijaya Choudhary: Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paramita Guha:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Giovanni Pau:** Writing – review & editing, Validation, Supervision. **Sunita Mishra:** Supervision.

7. Future scope

The age of IoT has brought a major and positive impact on almost all areas, especially in the agriculture sector. Hence with the help of IoT, agronomists can use several automatic systems and shift to wireless forms of communication from the wired ones. Here we discuss broadly three out of many.

7.1. Modernization

There are many Internets of things (IoT) solutions that will carry on to appear and it will give commencement of latest, trendy and unruly technologies mainly in the field of agriculture. Some areas are discussed below.

Global Programming: The implementation of an IoT environment with the aim of better agriculture now moving from a set of fixed specific crops to a global program that can support any kind of crop at any time. Such facilities will permit the modification of the system in an easy way to support heterogeneous approaches that fluctuate from observing and controlling crops and to make marketing products to nearby shops and purchasers.

Reliability and Security: Research work gets more interesting when it is concerned to end data encryption security and safety of IoT devices. Lots of scientific effort is required for the implementation of IoT components that must hold up-to-date security measures, for example, sign encryption is a type of cryptographic technique for performing both digital signature and data encryption at the same time. Such techniques aid to protect the confidentiality of communication over the internet or in an IoT environment (Varga et al., 2017)

Implementation of technologies: Low power wide area is an extremely beneficial technology for smart agriculture; there are tremendous benefits of using this technology for agronomists. Hence low power and long-range communication release 3rd Generation Partnership Project and narrowband (NB)-IoT standard. Hence these are for large-scale major test enhancement of IoT in the agriculture division. The technologies related to the IoT have noble development for precision farming when we consider societal and environmental issues. Hence for farm-fresh, IoT high tech can shift the area, moving towards the security of foods, and effective mitigation of inputs of agricultural lands and unnecessary wastage of foods (Duan et al., 2014).

Artificial Intelligence: In the coming future, there is a lot of research needed in the use of artificial intelligence models for crop growth and pest management based on agriculture data and weather information. Hence, the use of machine learning algorithms for the recognition of disease from images uploaded either with a camera or smartphone is helpful for further research (Newell et al., 2015).

Web Services: Web services in agriculture facilitate agronomists with great options including automata and decision-making tools which will combine products, awareness, services, and facilities for superior outcomes, qualitative products, and huge benefits. The Internet of Thing within agriculture has concentrated on the most recent issues and constraints for broad-scale experiments in agriculture is to food supply areas within the supply chain (Duan et al., 2011).

Quality Of Service: Previous observations on the quality of service in the Internet of Thing manifest that QoS is the requirement for the architecture of each IoT layer of the network. In the IoT environment, the presence of a huge number of heterogeneous components, which are strongly resource-oriented, and mobile, has led to quality-of-service concerns (Biral et al., 2015). The fruit industry occupies a central position in all agricultural productions; hence, related research sets ahead of the construction of an e-commerce service platform considering the analysis of the selling criteria of localized fruits (Tayur and Suchithra, 2017). NB-IoT communication technology assures high quality of services, the fast growth of the IoT market, and low power wide area technologies. Hence LPWA technologies, NB-IoT, and long-range (LoRa) are the leading technologies (Shi et al., 2017).

Privacy protection: All the time privacy protection procedures provide knowledge extraction from details to protect the privacy of each individual. IoT-enabled systems saddle the information that is given by the union of such IoT devices and provide an unmatched chance to solve internet-scale issues that are big and too difficult to tackle before (Brewster et al., 2017c). Latest Medicare systems depend on automatic computation like DL models, AI techniques, ML algorithms, and cloud services, to collect and analyze people's health data, and home automation data at an unparalleled level (Plantix. Accessed), (Duan et al., 2011). The system is designed in such a way that it will assure privacy while increasing the use of that details. While collection and analysis of data are adjoining growing due to the common of computing devices, the inspection of information is encouraging business and proving a benefit to the society in many aspects (Huang et al., 2017)- (Sinha et al., 2017).

Compactness of data: As enormous IoT components are getting connected. Hence exchanging data with each other would be the requirement to develop trendy, modern, and smart technologies related to the information shown in (Jayaraman et al., 2017).

7.2. Application outline

Presently, IoT devices using different software are being developed. Hence research and development of many industries, governmental and non-governmental organizations already working on wireless technologies that may deliver at an affordable cost for IoT implementation. IoT and its applications are very useful for the agriculture sector explained in detail (Sharma et al., 2018). A survey about resource management using the cloud explains in detail (Song et al., 2017) (Mendes and Vilela, 2017). About border gateway protocols authors have explained in detail (Yang and Shang, 2021). For smart agriculture, the authors presented monitoring in the loess plateau in detail (Elijah et al., 2018) (JOUR et al., 2022/04). Smart agriculture using the Internet of Thing is challenging represented by authors in detail (JOUR et al., 2022) (Hu et al., 2023). The authors explained machine learning techniques for banking applications in detail. (Khan et al., 2023) (Srokosz et al., 2023). Let's agricultural field talk using the Internet of Things details in (Srokosz et al., 2023). For sustainable agriculture usefulness of artificial intelligence explored in (Ayaz et al., 2019) (AlZubi and Galyna, 2023). Middleware refers to software that acts as an intermediary between different systems or applications. Context-aware middleware specifically adapts its behavior based on the context of the environment or situation in which it operates. In the context of agriculture, this might involve software that can adjust farming processes based on factors like weather conditions, soil quality, and crop health (Symeonaki et al., 2020). Palladium phthalocyanine is likely a type of material used in the fabrication of the sensors. Phthalocyanines are a class of synthetic organic compounds often used in applications such as dyes and sensors due to their interesting electronic properties (Otero Vélez et al., 2024). study involves using data collected from wearable devices. Wearable devices could include smartwatches, fitness trackers, or other types of sensors worn by individuals to monitor various physiological parameters (Kasl et al., 2024). An Internet of Things (IoT) architecture for smart agriculture typically involves a system that integrates various sensors, devices, actuators, and communication networks to collect, process, and analyze data related to agricultural processes (Verma et al., 2018). CNN is a type of neural network architecture that incorporates dilated (or atrous) convolutions. These convolutions allow for an increased receptive field without a corresponding increase in parameters, which can be beneficial for capturing contextual information across different scales (Zhao et al., 2024).

7.3. E-commerce and saleability

Cost-Cutting: When we talk about cost and budget the first things that come into the picture are the need for electricity or power for equipment used in IoT, mitigation in dimension, and mass manufacture is also coming in the picture to estimate the cost of the solutions in the agriculture sector. To obtain future work, there may be the development of lower budget sensors, innovation, and development on the combination of various deployment strategies, investigating related to both legal and illegal transfer mediums to mitigate setup and working budget.

Law and Rule: While working on Rule and regulations there need to be more involvement from the government side. Hence department of Agriculture must ensure points while working on policies related to IoT in the agriculture sector which depends on the area to area.

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Abbreviations

IoT	Internet of Thing
AI	Artificial Intelligence
5G	Fifth Generation
6G	Sixth Generation
WSN	Wireless Sensors Network
Lora WAN	Long-range wide area network
NB-IoT	Narrowband Internet of Things
Z-Wave -	wireless communication protocol used primarily in smart home networks

Data availability

No data was used for the research described in the article.

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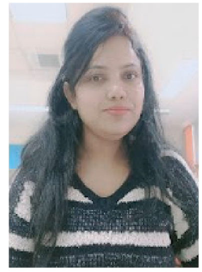
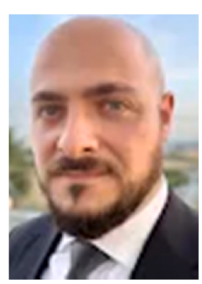


Vijaya Choudhary PhD is from the AcSIR-CSIR-National Physical Laboratory, New Delhi, India. She has completed her Master's in Technology from the Indian Institute of Engineering Science and Technology (IIEST), Shibpur, India, and her Bachelor of Technology from RIMT-IET Mandigobindgarh, Punjab, India. Vijaya Choudhary is currently working as an Assistant Professor at the School of Computer Science and Engineering, IILM University, Greater Noida, India. Vijaya Choudhary has published many research papers in SCI-indexed and peer-reviewed journals, conferences, and book chapters. She has worked on robot design research under the DST, Govt of India Project. She is also a multi-disciplinary design and development practitioner with experience in Deep-learning model establishments. Her research interests are Computer Vision, Agriculture Imaging, Deep Neural Networks, and Image processing. She has been awarded with Best Researcher Award for her excellent contribution by Elsevier publisher. Her research on deep learning-based agricultural imaging has contributed to advancements in smart agriculture. She is a member of the IEEE (WIE-UP Section) and ACM. E-mail: vijayachoudhary16.iiest@gmail.com

Paramita Guha graduated from Jalpaiguri Government Engineering College, India in 2001. She received her master's degree from Bengal Engineering College (Deemed University), India in 2003 and a Ph.D. degree from the Indian Institute of Technology (IIT), Delhi, India in 2013, both in electrical engineering. She is presently working as a scientist at CSIR-National Physical Laboratory, New Delhi, India. She has published several papers in international journals and conferences. Her research interests include distributed parameter systems, coupled systems, modeling and simulation, model reduction, and control theory. E-mail: paramguha@gmail.com

Sunita Mishra did her graduation and post-graduation in physics in the years 1983 and 1985, respectively from Allahabad University, Allahabad. She obtained her Ph. D. degree in physics-electronics engineering from the Institute of Technology, Ba-naras Hindu University, Varanasi in 1993. At present, she is working as a Chief scientist in CSIR-Central Scientific Instruments Organization, Chandigarh. She has completed projects in the area of agricultural electronics, gas sensors, semiconductor devices, and NIR spectroscopy. She has published about 25 papers in journals and conference proceedings. She is a life member of the Semiconductor Society of India, Solar Energy Society of India, and Material Research Society of India and a fellow of the Institution of Electronics and Telecommunication Engineers (IETE). Her research interests include sensors, semiconductor devices, and NIR spectroscopy. E-mail: Sunita_mishra@csio.res.in



Giovanni Pau (Member, IEEE) received the bachelor's degree in telematic engineering from the University of Catania, Italy, and the master's degree (cum laude) in telematic engineering and the Ph.D. degree from the Kore University of Enna, Italy. He is currently an Associate Professor with the Faculty of Engineering and Architecture, Kore University of Enna. He is the author/coauthor of more than 80 refereed articles published in journals and conferences proceedings. His research interests include wireless sensor networks, fuzzy logic controllers, intelligent transportation systems, the Internet of Things, and network security. He is a member of the IEEE (Italy Section). He has involved in the organization of several international conferences, as the Session Co-Chair and a Technical Program Committee Member. He serves/served as a leading guest editor in the special issues of several international journals and the Editorial Board Member and an Associate Editor of IEEE ACCESS, Wireless Networks (Springer), EURASIP Journal on Wireless Communications and Networking (Springer), Wireless Communications and Mobile Computing (Hindawi), and Future Internet (MDPI). giovanni.pau@unikore.it