Chapter 4

Farming in the Cloud Computing Applications in Agriculture

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Abstract
With the objective to address constraints and promote sustainability in climate-smart agricultural practices, this study investigates the technological foundations of cloud-based Internet of Things (IoT) applications in agriculture. This study explores the establishment of a cloud-based and artificial intelligence (AI) platform for digital agriculture that provides farmers with a complete solution. Leveraging knowledge from previous research, it analyzes the benefits of combining cloud computing and AI. The aim of climate-smart agriculture is to promote sustainability and productivity in agriculture. Agricultural digitization can be greatly supported by cloud computing, an emerging field. This survey examines at the technology behind cloud computing and how it's employed in climate-smart agriculture, with an emphasis on trends and limitations. In an effort to maintain food production while boosting resource management, cloud-based monitoring can be streamlined in an array of industries, including agricultural. The objective of this chapter is to implement Agriculture 4.0 by exploring the application of IoT, cloud computing, and big data in agribusiness. It also discusses emerging trends and a conceptual design for the Digital Farming ecosystem.

Keywords
Agri-Tech Innovations, Cloud Computing, Digital Farming, Precision Agriculture, Smart Agriculture,

1. Introduction

For the purposes of cost control, upkeep, and performance monitoring, smart information technology (IT) solutions must be integrated with agriculture. Remote crop and equipment monitoring is made possible by precision agriculture, Internet of Things (IoT), and satellite imaging [1]. Smart Agriculture

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has emerged as a result of the integration of IoT and cloud computing technologies in a number of industries, including agriculture. This has streamlined crop production, cost control, and performance monitoring, which benefits farmers and advances national wealth [2]. While experts provide guidance and historical data for cutting-edge cultivation practices, cloud and IT solutions in agriculture promote crop growth, forecasting, fertilizing, and disease management [3]. By streamlining farming procedures, giving farmers access to the most recent data, and allowing cloud-based intelligent models for crop management, IoT technologies are revolutionizing the agricultural industry. By gathering information, evaluating circumstances, and anticipating the best course of action, these systems maximize crop yield and reduce losses [4]. Precision agriculture (PA), leverages cloud computing and IoT to optimize communication. However, concerns with cost and relevance for semi-arid environments prevent PA from being managed effectively [5]. Especially in climate-smart practices, cloud computing could assist farmers establish effective networks, streamline services, and share resources more easily. All of these things may minimize costs and maximize productiveness [6]. The framework leverages the latest advancements in IT to boost the functioning of an IoT-based agricultural monitoring system by integrating data mining and other relevant technologies in a prototype [7]. Significant prospects for climate-smart agriculture can be explored by the integration of cloud computing and IoT in agricultural applications. This could strengthen services in rural areas and automate the entire food supply chain and production process [8]. Utilizing sensors and a 4duino, a sustainable agricultural approach monitors temperature, moisture point, ambient temperature, soil moisture, and humidity. Data is subsequently transmitted to a cloud platform that is self-implemented [9]. With the enhancement of quality security, full traceability, and agricultural practice monitoring, IoT has revolutionized the agricultural industry. Leveraging open-source hardware and a cloud platform, this cutting-edge solution ensures precise farming techniques and sustainability through extensive monitoring [10]. How IoT revolutionizes smart agriculture is shown in figure 1 below.

2. Cloud Computing Applications in Agriculture

The digital transformation of agriculture, known as “Agriculture 4.0” or “Digital Farming,” is driven by data acquisition and management technologies, IoT, cloud computing, and big data analytics [11]. Crop surveillance, logistics, expert advice, and student learning are all supported by cloud computing, which also improves e-commerce and agriculture in a variety of real-world domains [12]. When cloud computing and IoT technologies are integrated, the agricultural sector can undergo a revolution as a result of accurate and up-to-date information being made available and methodical decision-making procedures that boost farming's overall efficiency and output [13]. An architecture of Cloud computing for smart agriculture is shown in figure 2 below. Smart Agriculture is transforming our agricultural operations by leveraging customized Cloud infrastructures that can manage enormous amounts of data [14]. The convergence of cloud computing and IoT in agriculture creates potential for effective data management. An autonomous information system called Agri-Info makes simpler to manage heterogeneous data in a variety of business domains [15]. Agriculture is evolving as a result of cloud computing and artificial intelligence (AI), making it feasible to store data, perform predictive analytics, and recognize illnesses. Deep neural networks have shown potential in yield forecasting [16]. The AI-driven machine learning model known as Support Vector Machine (SVM) is utilized in cloud computing to precisely categorize and manage enormous volumes of digital data, improving farming methods while assisting farmers prepare for emergencies [17]. Agri-tech innovations that promote efficiency and sustainability, including Big Data, AI, robotics, IoT, and virtual and augmented reality, are reshaping agriculture. By maximizing

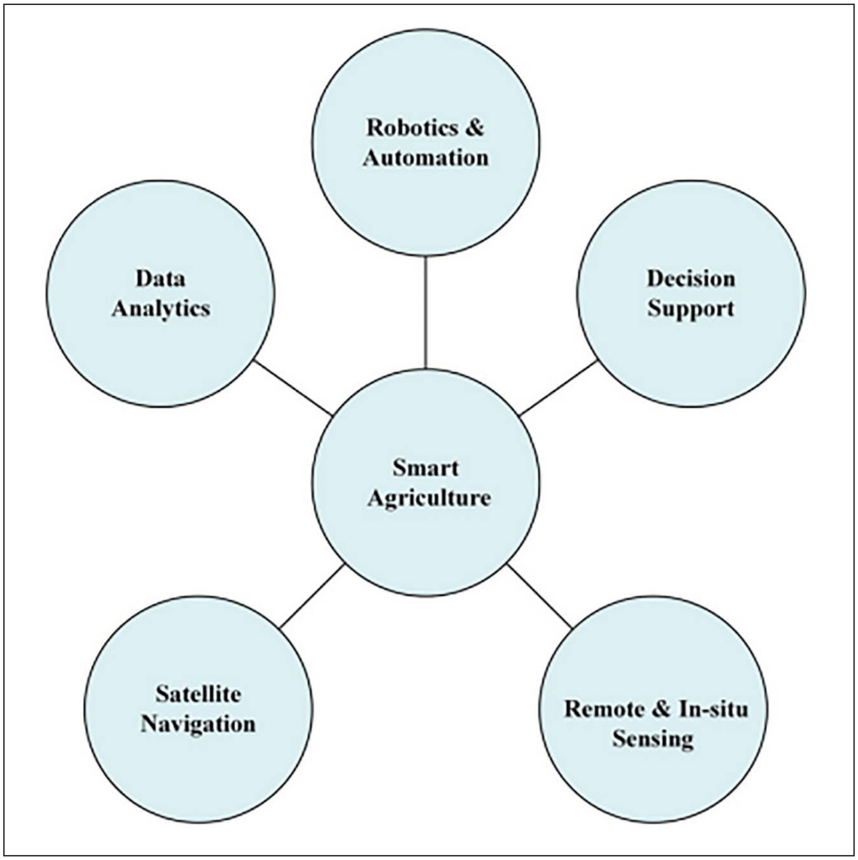

Figure 1. Smart agriculture enabled by IoT technologies

utilization of resources and producing enormous amounts of data throughout the supply chain, these advancements facilitate precision agriculture [18]. AI, cloud computing, fog computing, edge computing, IoT, and agricultural robots are some of the cutting-edge technologies that modern agricultural systems are employing for boosting efficiency and cost-effectiveness through real-time monitoring, recording, evaluation, and execution [19]. By employing specialized sensors for monitoring crop health and weather, the agriculture industry is embracing Wireless Sensor Networks (WSNs) for enhanced sustainability. This will lead to better cultivation and future decision-making [20]. Agriculture 4.0's sustainable expansion is facilitated by Precision Farming (PF) approaches. In light of the substantial quantity of raw data acquired by Wireless Sensor and Actuator Networks (WSANs), integrating PF into IoT presents challenges [21]. By addressing the barriers posed by technological, social, and economic considerations, edge computing offers a viable strategy for increasing the accessibility of smart agriculture and possibly fostering its adoption in a variety of global environments [22]. A user-centered design approach that includes farmers in the design cycle makes it less complex to integrate IoT applications in agriculture. The integration and exploitation of IoT technology is enhanced by this approach, which streamlines decision-making through the adoption of edge and fog computing techniques [23]. The Smart-Farm Agri-Tech System integrates Arduino and Raspberry Pi microcontrollers to record and manage water usage,

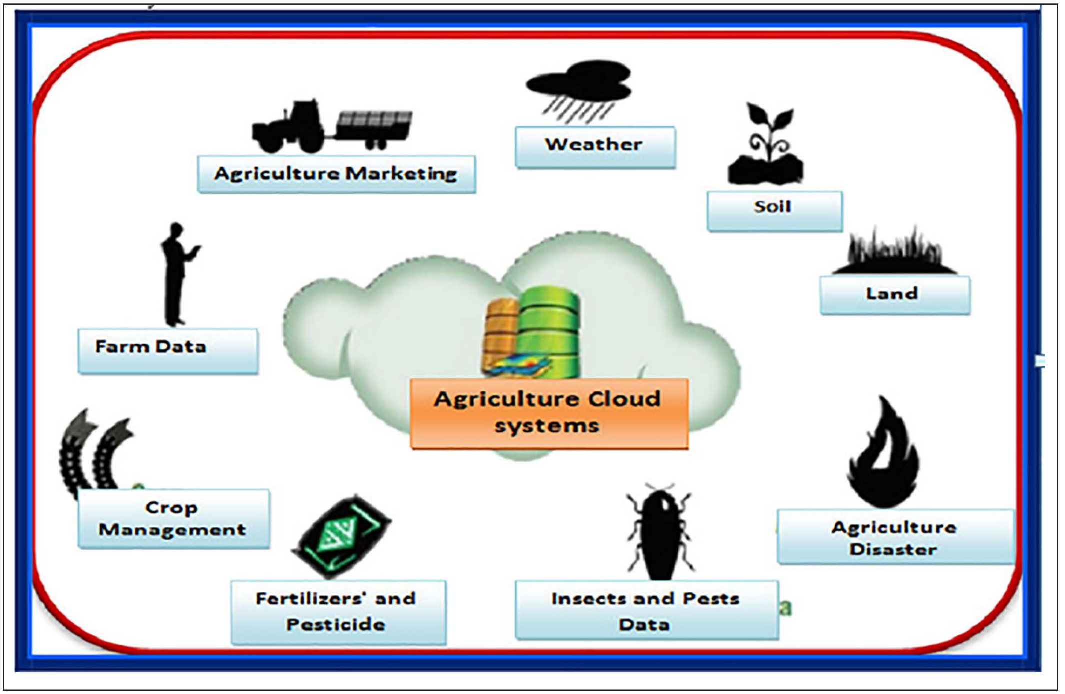

Figure 2. Cloud computing for smart agriculture

fertilizer application, weather, and agricultural products in real time. With a graphical user interface (GUI) for managing and monitoring data, the AWS and ThingSpeak platforms make collection and storage smoother [24]. A smart agricultural system integrates programmable logic controllers (PLCs) with an affordable wireless sensor network, IoT, and Long Range (LoRa) technologies to monitor machinery and operations. Remote device control and analyzing are made possible via a web-based monitoring program [25]. Technological developments in agricultural production, including Multispectral Photogrammetry and Unmanned Aerial Vehicles (UAVs), offer enormous potential for variable analysis and evaluation to address critical agricultural hurdles [26].

3. Recommendations

On the basis of the literature review we propose following recommendations.

- Innovative approaches have accelerated agriculture's progress and improved utilization of resources, minimized dependency on fossil fuels, maintained ecosystems, and advanced sustainable development. Future development depends on embracing cutting-edge, farmer-focused technological advances like cloud computing.
- In precision agriculture, prescription mappings are essential for maximizing production and promoting healthy crop development at various growth stages by managing resources like water, nutrients, and pesticides.

- Different digital standards create hurdles for precision agriculture, making it challenging to implement IoT technology and limiting efficiency improvements. To facilitate optimal data sharing between machinery and organizational information systems, encourage equipment interoperability, and collaborate machine communication standards, innovative approaches and protocols must be developed.
- Inadequate internet connectivity hinders edge computing capabilities, limiting the provision of smart agriculture services within communities. In order to alleviate food insecurity and promote sustainability, this issue must be rectified.
- Agriculture digitisation lowers transaction costs, improves communication, and has the potential to revolutionise the farming and food industries. It improves predictability, empowers controls, and enables remote operations, contributing considerably to food safety.
- By analyzing weather-dependent variables, data analytics techniques are being utilized for improving farming management and predictions. Positioned adjacent to weather stations, these instruments collect data significant to a specific crop, such as temperature, precipitation, leaf water potential, and crop health. They are also capable of independently controlling environmental variables.
- To foster interoperability and standardization that comply with cutting-edge standards, future research will evaluate the model's effectiveness by combining several production prediction environments across multiple crop cultivations and communities.

Conclusion

Many crop metrics are utilized in precision agriculture (PA) to assist in decision-making, however there are limitations. In order to support business and research in creating smart agricultural applications, this article provides an overview of contemporary innovations for PA platforms. Particularly in agriculture, which faces challenges due to population growth, limited resources, and climate change, the integration of communication and information technologies, including smartphones, IoT, and AI, into human beings, urban areas, and businesses has significant potential for recognition and exploitation. The potential of edge computing for smart agriculture is there, even though its application in this field is still in its early stages. While some of the properties of edge computing are already shown by current prototypes, issues related to interoperability and scalability persist. To grow stronger, edge-enabled services must choose well-established platforms. Research on Agriculture 4.0 is anticipated to concentrate especially on the specified technique, which incorporates WSANs within IoT. Regardless of intricacy, this framework may be developed, adjusted, and tailored to accommodate any application in any PF system environment. Many industries, including agriculture, utilize cloud computing extensively owing to its multitude of benefits. These consist of access to state-of-the-art equipment, weather monitoring, plant and breeding approaches, production management, and information transmission among farmers that promotes learning. The paper presents a revolutionary strategy which utilizes cutting-edge communication techniques and cost-effective sensor technology to engage farmers in the design and implementation of precision agricultural technologies. The edge and fog nodes, two innovative processing and communication nodes, are part of this design.

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