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Literature Review: Utilization of Cloud Computing in Drip Irrigation System

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Abstract

Low levels of food production can be caused by some countries still using traditional farming methods, which can affect crop yields. Farmers who still use conventional farming methods often cause inefficient use of resources. This can be overcome by using smart farming methods by utilizing technology. This technology is known as the Internet of Things. IoT technology in agriculture is utilized in irrigation systems to create smart irrigation systems. In addition to utilizing IoT in the use of smart irrigation systems in agriculture, irrigation systems also utilize Cloud Computing. The purpose of this literature review is to examine the use of Cloud Computing in IoT-based smart irrigation systems, as well as to identify the benefits and challenges associated with efficient water use and agricultural consumption. This study uses a narrative literature review method by collecting literature studies related to the use of IoT and Cloud Computing in drip irrigation systems. From the results of the analysis of journals discussing the use of Cloud Computing in IoT-based smart irrigation systems, it can be concluded that the use of Cloud Computing technology in smart irrigation systems provides various significant benefits, especially in terms of water use efficiency and better irrigation management.

Keywords:
Internet of Things (IoT);
Cloud Computing;
Drip Irrigation System
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1. Introduction

Agriculture plays a very important role in the process of human survival. Agriculture is the primary source of food production and a great concern to humanity because of its vital role in meeting basic needs. Low food production can be caused by several countries that still use traditional farming methods, which can affect the harvest. So, to overcome this, smart farming efforts are needed with more modern and efficient farming methods, in order to increase the harvest. These efforts are also carried out by utilizing existing technological developments [1].

Farmers who still use conventional farming methods, farmers usually require manual labor to handle crops and livestock, which often causes inefficient use of resources. This can be overcome by using smart farming methods by utilizing technology. The use of technology in agriculture can be an important factor for development activities in the food sector today. In addition to being useful for reducing harvest time, the technology it contains can provide other conveniences. This technology is known as the Internet of Things (IoT) [2].

Internet of Things (IoT) is a new paradigm with functionality for modern and fast wireless telecommunication settings. IoT technology can connect certain equipment with the use of the internet to carry out certain activities or various functions. There are many benefits that can be obtained from the use of IoT in agriculture. For example, in monitoring and managing water resources efficiently using the Internet of Things-based Wireless Sensor Network. The development of IoT technology can provide changes in agriculture, especially in irrigation systems for crop farming [3].

IoT technology in agriculture is utilized in irrigation systems to create smart irrigation systems. IoT is used to connect physical devices, such as sensors, agricultural tools, and irrigation systems, to the internet to collect, send, and analyse data in real time [4]. This allows farmers to remotely control and manage irrigation systems, as well as gain data-driven insights into soil conditions, moisture, weather, and plant health [5].

In addition to utilizing IoT in the use of smart irrigation systems in agriculture, irrigation systems also utilize Cloud Computing. Cloud computing is a computing model that allows users to access shared computing resources, such as networks, servers, storage, applications, and services, via the internet in a flexible and on-demand manner. This smart irrigation system allows for real-time monitoring and management of irrigation operations by utilizing IoT devices, sensors, and actuators. Utilizing Cloud Computing allows data storage, analysis, and decision-making that results in better irrigation control and optimal water utilization. It can also improve the accuracy, effectiveness, and sustainability of irrigation operations [6].

While numerous studies have explored the use of IoT in smart irrigation systems, the specific role of Cloud Computing in improving drip irrigation systems has not been thoroughly explored. Most existing studies focus primarily on the deployment of IoT sensors or modern agricultural frameworks in general, without conducting a detailed analysis of how cloud computing plays a role in improving water use efficiency, data management, and agricultural sustainability, specifically in drip irrigation. Furthermore, research comparing various Cloud Computing platforms and their effectiveness in supporting IoT-based drip irrigation systems is currently lacking in the existing literature.

The purpose of this literature review is to address this gap by examining the use of Cloud Computing in IoT-based smart irrigation systems, identifying the benefits and challenges associated with efficient water use and agricultural sustainability, and providing a clearer understanding of how this integrated technology can contribute to the future of precision agriculture.

2. Methods

This research utilizes a narrative literature review approach, which involves comparing and analyzing various relevant theories and searching for theoretical references relevant to the problem being studied. A narrative literature review can also be defined as a study conducted to evaluate the content of selected literature drawn from various sources, resulting in new conclusions and ideas.[7].

A literature review involves reviewing, summarizing, and analyzing the author's thoughts to provide a comprehensive understanding. This approach is very helpful in finding appropriate ideas, objectives, and theoretical foundations, thus providing a clearer picture of the topic being studied [8]. This study uses a literature review technique, namely by collecting literature studies related to the use of Cloud Computing in IoT-based smart irrigation systems.

The research flow for the narrative review model begins with topic determination, literature search, literature selection, results and discussion, and conclusions, as illustrated in Figure 1.

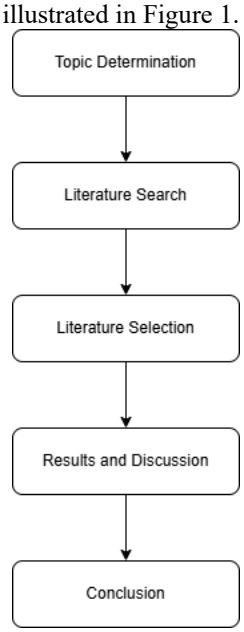

Figure 1. Narrative review framework flow diagram

2.1 Topic Determination

This research begins with selecting a primary topic to investigate. The chosen topic is the integration of Cloud Computing with IoT in smart irrigation systems, with a particular emphasis on drip irrigation. This topic selection aims to address a gap in existing research, where previous studies have primarily discussed the general application of IoT in smart agriculture without deeply exploring the specific functions of Cloud Computing in drip irrigation systems and their impact on water use efficiency and sustainability in agriculture. Therefore, this research aims to analyze the utilization of Cloud Computing in smart irrigation systems based on IoT, identify the advantages and challenges in its implementation, and assess its overall impact on irrigation efficiency and sustainability in agriculture.

2.2 Literature Search

The next step was to conduct a literature search. This literature search was conducted to collect articles discussing cloud computing applications in IoT-based drip irrigation systems. The search was conducted using well-known academic databases, such as Google Scholar, ResearchGate, and IEEE Xplore, with particular attention to journals listed in Scopus. The keywords used in this search included combinations of the following terms: "IoT," "Internet of Things," "Cloud Computing," and "drip irrigation." All articles searched were written in English and published between 2021 and 2025 to ensure the information presented was relevant and up to date. First, an initial search was conducted, which was then filtered using predetermined inclusion and exclusion criteria, resulting articles being selected for the final review.

2.3 Literature Selection

After conducting the literature search, the next step was to determine whether the articles were suitable for use and whether they met the research requirements. The selection process was conducted in two stages to assess whether the collected documents met the requirements for this study. In the first stage, all documents found during the initial search were screened based on their titles and summaries to ensure they aligned with the research theme. Articles that were clearly irrelevant to cloud computing or IoT applications in irrigation systems were removed at this stage for further review.
In the second phase, the full text of each paper was carefully reviewed to ensure that all inclusion criteria were met. Papers that did not meet the inclusion criteria or met any of the exclusion criteria were removed from the selection process. This two-step process ensured that only the most relevant papers were included in the literature review. After reviewing the full text and applying the inclusion and exclusion criteria, papers were selected for the final analysis. Papers were excluded if they were published outside of 2021–2025, were not written in English, or did not specifically address the use of cloud computing or IoT in irrigation systems.

2.4 Results and Discussion

After completing the journal selection, the next step that needs to be outlined is analyzing each journal. At this stage, the analysis focuses on the application of cloud computing in IoT-based smart irrigation systems in each journal. The analysis process is carried out by evaluating the methods applied, the findings obtained from each journal, and the strengths and weaknesses of each journal, as well as identifying research gaps within the journals. This analytical method allows for a comprehensive and critical comparison of the existing literature on the topic.

2.5 Conclusion

The final stage of this research focuses on drawing conclusions based on the analysis. The purpose of the conclusions is to identify the meaning and significance of the data obtained. The conclusions are presented in clear and concise sentences, reflecting the overall findings of the reviewed literature. In this study, the conclusions specifically review the role and influence of cloud computing in drip irrigation systems utilizing IoT in each analyzed journal.
The following are the journals that will be analyzed.

Table 1. Analyzed Journal Data

No	Title	Year	Author
1	Enhancing water management in smart agriculture: A cloud and IoT-Based smart irrigation system [9]	2024	Bouali Et-taibi, Safae Bourhnane, Mohamed Riduan Abid, Tareq Abu Hamed, El-Mahjoub Boufounas, Driss Benhaddou
2	High-technology agriculture system to enhance food security: A concept of smart irrigation system using Internet of Things and cloud computing [10]	2024	Abdennabi Morchid, Ishaq G. Muhammad Alblushi, Haris M. Khalid, Rachid El Alami, Surendar Rama Sitaramanan, S.M. Muyeen
3	IoT-based Smart Agriculture Using Cloud-Based Storage [11]	2022	Rakesh Mali, Shailesh Bendale
4	The Development of Smart Irrigation System	2021	Burhanuddin Badrun, Murshal Manaf

	With IoT, Cloud, and Big Data [12]		
5	IoT-based smart irrigation management system to enhance agricultural water security using embedded systems, telemetry data, and cloud computing [13]	2024	Abdennabi Morchid, Rachid Jebabra, Haris M. Khalid, Rachid El Alami, Hassan Qjidaa, Mohammed Ouazzani Jamil
6	Renewable Energy Integration Into Cloud & IoT-Based Smart Agriculture [14]	2022	Taibi Bouali, Mohamed Riduan Abid, El-Mahjoub Boufounas, Tareq Abu Hamed, Driss Benhaddou
7	Efficient IoT-Based Control for a Smart Subsurface Irrigation System to Enhance Irrigation Management of Date Palm [15]	2021	Maged Mohammed, Khaled Riad, Nashi Alqahtani
8	Empowering power distribution: Unleashing the synergy of IoT and cloud computing for sustainable and efficient energy systems [16]	2024	Arul Rajagopalan, Dhivya Swaminathan, Mohit Bajaj, Issam Damaj, Rajkumar Singh Rathore, Arvind R. Singh,Vojtech Blazek, Lukas Prokop
9	Fuzzy logic-based IoT system for optimizing irrigation with cloud computing: Enhancing water sustainability in smart agriculture[17]	2025	Abdennabi Morchid, Zafar Said, Almoataz Y. Abdelaziz, Pierluigi Siano, Hassan Qjidaa

Source: Google Scholar, ResearchGate, IEEE.

3. Results and Discussion

This section analyzes papers relevant to the topic under study. Each paper provides different insights into the theory, methodology, and research findings. The papers used in the literature review were retrieved from leading international journals using the Scopus database, Google Scholar, ResearchGate, and IEEE, addressing the use of cloud computing in IoT-based drip irrigation systems. The journals used were written in English and published between 2021 and 2025.

Table 2. Analysis Journal

No	Title	Method	Results	Advantages & Disadvantages
1	Enhancing water management in smart agriculture: A cloud and IoT-Based smart irrigation system [9]	Cloud-based smart irrigation system integrating IoT and solar energy.	Using the cloud to optimize irrigation and water conservation with big data analysis and weather prediction.	Reduces water usage and supports efficient water management, but relies on cloud, hardware, and system maintenance costs.
2	High-technology agriculture system to enhance food security: A concept of smart irrigation system using Internet of Things and cloud computing [10]	Smart irrigation system based on IoT, an embedded system (ESP32), and cloud computing with sensors to monitor humidity, temperature, and water level.	Use of cloud-based system (ThingSpeak) to monitor environmental factors in real-time, improve irrigation precision, and reduce water consumption by up to 70%.	Reduces water consumption and supports efficient irrigation management, but relies on cloud and hardware that require maintenance and operational costs.
3	IoT-based Smart Agriculture Using Cloud-Based Storage [11]	IoT and cloud-based smart irrigation system to monitor water usage in real-time and renewable energy integration.	Reduction in water usage thanks to real-time monitoring via the cloud, compared to conventional systems.	Reduces water usage, increases energy efficiency, and supports sustainable agriculture. However, it requires reliable infrastructure and higher implementation costs.
4	The Development of Smart Irrigation System With IoT,	IoT and Big Data for irrigation management, with mobile applications for	Cloud technology facilitates real-time data collection and analysis,	Improving irrigation management and data-driven decision-making, however, is a major challenge in transforming

	Cloud, and Big Data [12]	environmental data measurement.	facilitating irrigation management and data-driven decision making.	data into accurate and understandable information.
5	IoT-based smart irrigation management system to enhance agricultural water security using embedded systems, telemetry data, and cloud computing [13]	Use of embedded systems, IoT, telemetry data, cloud computing (ThingsBoard), and sensors to manage smart irrigation.	Cloud (ThingsBoard) facilitates real-time data collection and analysis for efficient water use and sustainable agriculture.	Increasing water efficiency and agricultural sustainability. However, there are challenges in calibrating sensor data and the need for reliable systems.
6	Renewable Energy Integration Into Cloud & IoT-Based Smart Agriculture [14]	IoT devices in the form of sensors and actuators for data collection and control, as well as Cloud Computing for data processing, visualization, and storage.	The proposed smart farming system has been shown to reduce water consumption by up to 71.8% compared to conventional irrigation systems.	This system is suitable for use in remote or sub-Saharan regions without electricity. The only drawback mentioned is the cost of permanent monitoring.
7	Efficient IoT-Based Control for a Smart Subsurface Irrigation System to Enhance Irrigation Management of Date Palm [15]	IoT-based underground irrigation system with an autonomous sensor network and the ThingSpeak cloud platform for real-time monitoring and control	The system successfully automates irrigation based on real-time sensor data, improving water use efficiency in date palms in dry areas.	Increasing water efficiency, automatic and real-time, is suitable for dry areas, but the specific research focus is only on date palm plants, so generalization to other plants is necessary.
8	Empowering power distribution: Unleashing the synergy of IoT and cloud computing for sustainable and efficient energy systems [16]	Conduct an in-depth analysis of Cloud of Things (CoT) integration in energy systems to evaluate security architecture, data management, and energy optimization.	Shows that the synergy between IoT and Cloud (CloudIoT) is able to create a Smart Grid that increases the efficiency of energy distribution and optimizes resource use.	Able to combine IoT sensor capabilities with Cloud computing capacity. However, implementing cloud infrastructure and IoT hardware requires a high initial investment.
9	Fuzzy logic-based IoT system for optimizing irrigation with cloud computing: Enhancing water sustainability in smart agriculture[17]	Internet of Things (IoT) based smart agriculture approach with fuzzy logic and cloud computing integration	Smart irrigation systems have been proven to improve water sustainability in modern agriculture.	Water efficiency is higher compared to manual irrigation, but data transmission depends on the internet connection and technological infrastructure.

3.1 Utilization of Cloud Computing in IoT-Based Smart Irrigation Systems

From the results of the analysis of journals discussing the use of Cloud Computing technology in IoT-based smart irrigation systems, it can be concluded that all systems analyzed integrate IoT and Cloud Computing to monitor and manage irrigation in real-time. By using this technology, smart irrigation systems can perform data-based monitoring, such as temperature, soil moisture, and weather, that can directly inform irrigation conditions and irrigation decisions accurately. The main benefit of this technology is the efficiency of water use, where this technology significantly reduces water waste by optimizing the amount of irrigation based on sensor data collected and analyzed in the cloud, which also

increases irrigation precision and supports agricultural sustainability. In addition, Cloud Computing facilitates big data analysis and weather prediction, which allows irrigation management to be more responsive and efficient.

3.2 Challenges in Integrating Cloud Computing and IoT in Smart Irrigation Systems

Cloud Computing technology in smart irrigation offers various benefits, but some challenges need to be considered, especially in terms of integration with IoT and overall system implementation. One of the main challenges is the dependence on reliable cloud infrastructure and hardware. Cloud-based smart irrigation systems are highly dependent on the availability of adequate hardware infrastructure and relatively high maintenance costs, which can be a constraint for farmers or institutions with limited budgets for system implementation and maintenance.

Another challenge is sensor calibration and accurate data processing. Sensors used to monitor environmental conditions must be properly calibrated so that the resulting data can be interpreted correctly. Inaccurate data can lead to suboptimal decision-making in irrigation management. In addition, the cost and need for stable infrastructure are also problems. This system requires a stable internet connection and supporting hardware, which requires high costs, both in the implementation and maintenance stages. Network instability or system failure can affect the effectiveness of irrigation management, making it a major challenge in the integration of this technology.

3.3 Impact of Cloud Computing Technology on Water Efficiency and Agricultural Sustainability

The use of Cloud Computing in IoT-based smart irrigation systems has been proven to have a positive impact on the efficiency of water use and agricultural productivity. The use of the cloud allows for real-time data collection and analysis, which provides a better understanding of irrigation needs based on environmental and crop conditions. This more precise system can reduce water consumption by up to 70%, increase energy efficiency, and support sustainable agriculture. Cloud-based data management facilitates data-driven decision-making, enabling smarter farming and saving costs in the long run. In addition, with the help of this technology, farmers can carry out better irrigation management without having to rely on a large manual workforce.

From the results of the analysis of journals discussing the use of Cloud Computing in IoT-based smart irrigation systems, it can be concluded that the use of this technology provides various significant benefits, especially in terms of water use efficiency and better irrigation management. All systems analyzed integrate IoT and Cloud Computing to enable real-time monitoring and management of irrigation, which helps improve irrigation precision and supports sustainable agriculture.

However, challenges related to maintenance costs, reliable infrastructure, and sensor calibration still need to be considered in further implementation. However, with the right solution, this technology has the potential to have a major impact on the sustainability of the agricultural sector in the future. Overall, Cloud Computing technology integrated with IoT offers a promising solution to improve water use efficiency and support agricultural sustainability, although there are still challenges related to costs and the need for a more stable and reliable system.

4. Conclusions

The use of Cloud Computing in IoT-based smart irrigation systems has a significant impact on water efficiency and agricultural sustainability. This technology enables real-time monitoring and management of irrigation, thereby minimizing water waste and increasing irrigation precision. In addition, the integration of Cloud Computing enables more effective data processing and analysis, providing more accurate insights for more precise data-based decision making. This can increase agricultural productivity and support more efficient natural resource management, as well as help in achieving better agricultural sustainability.

With its ability to optimize irrigation management, Cloud Computing technology plays an important role in supporting smarter and more environmentally friendly agriculture. This system not only enables efficient use of water but also increases food security by improving crop yields and maintaining ecosystem balance. The implementation of this technology in the agricultural sector has the potential to have a positive impact in the long term, supporting the transformation of agriculture towards a more modern, efficient, and sustainable system.

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