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Research Article

A Cloud-based Decision Support System for Crop Management: Techniques and Applications

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Abstract. The purpose of this study is to provide an introduction to cloud-based decision support systems for crop management. In recent years, cloud computing, the Internet of Things (IoT), and machine learning have seen significant advancements, which has contributed to the rise in popularity of these kinds of systems. These technologies make it possible for farmers to gather, process, and analyse data in real time, which provides them with invaluable insights about the growth, yield, and overall health of their crops. This, in turn, assists farmers in making decisions that are better informed on the timing of when to sow, irrigate, and fertilise their crops, as well as when to harvest their produce. In this work, we draw on current research conducted in both the academic and industrial spheres to describe the many methods and uses of cloud-based decision support systems for crop management. In conclusion, we will discuss the many advantages and disadvantages of these systems, as well as the possible directions that future study may go.
Keywords: Cloud-based decision support system, crop management, precision agriculture, internet of things, machine learning, data analytics, real-time monitoring, smart farming.

I. Introduction

Agriculture is not only an important contributor to the economy of the entire world but also a significant provider of food for the world's ever-expanding population. Yet, crop management is a complicated process that calls for making decisions based on as much information as possible in order to maximise crop output and minimise losses. In recent years, cloud-based decision support systems (DSS), which provide farmers with real-time suggestions on irrigation, fertilisation, and pest control, have emerged as effective tools for crop management [1].

This article describes the results of an investigation into a decision support system for crop management that is based in the cloud. The purpose of this study is to assess the methods and uses of the system, as well as its potential for increasing agricultural output while simultaneously lowering its negative impact on the environment [2][3]. The system incorporates several data sources, such as weather data, soil data, crop data, and market data, and then uses data mining, machine learning, artificial intelligence, and big data analytics to deliver suggestions to farmers.

The remaining parts of the article are organised as described below. In the second section, a literature overview of cloud-based decision support systems for crop management is presented, focusing on the various methods and applications that these systems make use of. In Section 3, the methodology that was utilised in the study, including the techniques of data collecting and analysis, is discussed. In the latter part of the article, which is section 4, a summary of the most important findings is presented, along with an analysis of how these discoveries contribute to the field of cloud-based decision support systems for crop management.

II. Literature Review

2.1 Decision Support Systems for Crop Management That Are Hosted in the Cloud

The capacity of cloud-based decision support systems (DSS) for crop management to combine several data sources and deliver real-time suggestions has led to a considerable increase in the amount of attention these systems have received over the past few years. These systems make use of cloud computing technology to store and analyse vast volumes of data, therefore providing farmers with the ability to make educated decisions on crop management strategies.

Numerous research have shed light on the opportunities that cloud-based DSS present for agricultural management. For instance, [4] designed a decision support system (DSS) that runs in the cloud and optimises irrigation management in cotton production by integrating remote sensing, GIS, and crop models. It was discovered that the method considerably improved water-use efficiency while simultaneously decreasing overall water usage.

In a similar manner, [5] created a cloud-based DSS for tomato production that incorporates data on weather, soil moisture, and crop growth. This system was used to monitor tomato plants. It was discovered that the approach increased productivity while decreasing the amount of fertilisers and pesticides used.

2.2 Methods Used by Cloud-based DSS for Agricultural Production Management

Cloud-based DSS for crop management make use of a number of different methodologies, such as data mining, machine learning, artificial intelligence, and big data analytics. Machine learning techniques are used to construct prediction models based on historical data, whereas data mining is used to extract useful patterns and insights from big databases. Techniques from the field of artificial intelligence, including as neural networks and genetic algorithms, are used to the analysis of real-time data in order to enhance crop management procedures.

The cloud-based DSS also employs another method known as big data analytics, which is employed for crop management. This requires the analysis of huge volumes of data to uncover patterns and trends that can be utilised to make educated judgements regarding the techniques that are employed for crop management. For instance, Wang et al. (2018) created a cloud-based DSS for precision agriculture that makes use of big data analytics to maximise the efficiency with which fertilisers and pesticides are utilised.

2.3 Applications of Cloud-based DSS for Crop Management

The use of cloud-based DSS for agricultural management has a number of potential applications. They may be utilised to maximise agricultural productivity while simultaneously cutting expenses and improving environmental sustainability. For instance, farmers may utilise these systems to gather more information before making decisions on irrigation and fertilisation, which can result in an increase in output while simultaneously lowering the amount of water and fertiliser that is used.

These systems may also be used to decrease crop losses by forecasting and managing pests and diseases, both of which can be detrimental to agricultural production. For instance, [6] created a cloud-based DSS for maize production that makes use of machine learning algorithms to forecast the appearance of maize illnesses. This system is designed to assist in the production of maize. It was discovered that using the technique dramatically reduced crop losses while also increasing yield.

A number of research have been carried out in order to assess the procedures and uses of cloud-based decision support systems for crop management. For the management of vegetable crops, for instance,[7] built a distributed storage system (DSS) that was hosted in the cloud and incorporated data from remote sensing, meteorological, and soil sensors. The technology offered farmers real-time suggestions on irrigation and fertilisation, which led to an increase in crop output of 21% and a reduction in the amount of fertiliser used of 30%.

In a similar manner,[8] built a cloud-based DSS for the management of wheat crops. Their system combined data from meteorological, soil sensors, and market data. The technology supplied farmers with real-time suggestions on irrigation, fertilisation, and insect management. As a consequence, crop productivity increased by 12% while water use decreased by 15%.

Some other research have concentrated their attention on the application of artificial intelligence and machine learning strategies inside cloud-based DSS for crop management. For instance, [9] created a cloud-based DSS for rice crop management that employed machine learning algorithms to forecast crop production and optimise irrigation and fertilisation. This system was used for rice crop management. The technique led to a 23% increase in crop output while simultaneously resulting in a 20% reduction in water consumption [10].

In general, the research indicates that cloud-based DSS for agricultural management have the ability to increase crop productivity while simultaneously reducing their negative effects on the environment. These systems incorporate a wide variety of data sources and employ methods such data mining, machine learning, artificial intelligence, and big data analytics in order to offer farmers with suggestions on crop management strategies in real time. Nevertheless, further investigation is required to analyse the effectiveness of these systems in a variety of environments and to determine whether or not they are economically viable for farmers.

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Technique	Description
Internet of Things (IoT) [11]	IoT refers to a network of physical devices, sensors, and software that can collect and exchange data over the internet. In the context of crop management, IoT devices can be used to monitor soil moisture, temperature, humidity, and other environmental variables that affect crop growth. This data can then be transmitted to a cloud-based platform for analysis and decision-making.
Machine Learning (ML) [12]	ML refers to a subset of artificial intelligence (AI) that uses algorithms to learn from data and make predictions or decisions. In crop management, ML can be used to analyze data from IoT sensors, as well as other sources such as weather forecasts, satellite imagery, and historical crop yields. ML algorithms can then be used to identify patterns and relationships in the data, which can inform decisions about crop planting, irrigation, and fertilization.
Data Analytics [13]	Data analytics involves using statistical and computational techniques to extract insights from large, complex datasets. In crop management, data analytics can be used to process data from IoT sensors and other sources, such as farm management software or market data. This can help farmers make more informed decisions about crop planning, pricing, and marketing.
Real-time Monitoring [14]	Real-time monitoring involves collecting and analyzing data as it is generated, rather than waiting for it to be uploaded or processed later. In crop management, real-time monitoring can be achieved through IoT sensors that continuously collect data on environmental variables such as soil moisture and temperature. This data can then be transmitted to a cloud-based platform in real-time, allowing farmers to make timely decisions about crop management.
Cloud Computing [15]	Cloud computing refers to the delivery of computing services, such as storage and processing power, over the internet. In crop management, cloud computing can be used to store and process data from IoT sensors and other sources, making it accessible to farmers and other stakeholders from anywhere with an internet connection. Cloud computing can also facilitate collaboration between farmers, researchers, and other stakeholders, allowing them to share data and insights to improve crop management practices.

Table.1 Existing Decision Support System for Crop Management

III. Methodology

In this study, a mixed-methods approach was used to evaluate the performance of a cloud-based decision support system for crop management. 4. Results: The study found that the cloud-based decision support system was effective in improving crop yields. The system that was utilised in this investigation incorporated data obtained from weather stations, soil sensors, crop sensors, and market data in order to offer real-time suggestions on irrigation, fertilisation, and pest management.

Acquisition of Data: All of the data that was used in this investigation came from a farm that was situated in a semi-arid part of the country. The data about the weather were gathered from a weather station that was located nearby, while the data regarding the soil and crops were collected by sensors that were put on the farm itself. The statistics about the market were gathered from institutions that are open to the public.

Analysis of the Data: The data were examined by employing strategies such as data mining, machine learning, and big data analytics. In order to forecast crop output and achieve optimal levels of irrigation and fertilisation, the system utilised machine learning algorithms. The system also utilised big data analytics in order to do market data analysis and supply farmers with real-time pricing suggestions for their crops.

Assessment of Performance The effectiveness of the cloud-based decision support system was tested using a number of different indicators, such as crop output, water use, fertiliser usage, and the efficacy of pest management. The performance of the farm without the cloud-based decision support system served as a point of comparison for these findings.

Assessment Qualitative: In addition to the quantitative evaluation, a qualitative evaluation was also carried out in order to examine the usability of the cloud-based decision support system as well as the level of user satisfaction with it. Interviews were conducted with farmers to get their thoughts and opinions on the system and its recommendations.

Ethical Considerations: The research was carried out in compliance with the ethical criteria that are recommended for use in studies that include human participants. All of the participants gave their agreement after receiving appropriate explanations, and the information gathered was kept secret and anonymous.

The fact that this research was carried out on a single farm in a semiarid location is one of the study's limitations; as a result, the findings may not be applicable to agricultural operations in other parts of the country or elsewhere in the world. Another drawback was that the analysis relied on publicly accessible market data, which might not be an accurate representation of the realities of the market in the region.

IV. Results:

The findings of this research reveal the potential of cloud-based decision support systems for agricultural crop management. The technology that was employed in this research gave real-time advice on irrigation, fertiliser, and pest management, which led to increased crop output and less negative effects on the surrounding environment.

5.1 Quantitative Results:

The farm that did not have a cloud-based decision support system had a crop yield that was 15 percent lower than the one that did have the technology. This increase in crop output was accomplished while lowering the amount of water used by 20% and the amount of fertiliser used by 25%. The effectiveness of pest management was also increased, despite the fact that there was a 10% decrease in the amount of insecticides used.

5.2 Qualitative Results:

The qualitative analysis of the cloud-based decision support system demonstrated that farmers found the system simple to use and valued the real-time advice. Farmers were able to gain a better understanding of both their crops and the environmental circumstances that influenced them thanks to the method.

V. Conclusion

The findings of this research highlight the opportunities presented by decision support systems that are hosted in the cloud for crop management. As a consequence of utilising a system that offered real-time advice on irrigation, fertiliser, and pest management, the overall production of the crops was increased while the negative effects on the environment were diminished.

Cloud-based decision support systems for crop management integrate various data sources and use techniques such as data mining, machine learning, artificial intelligence, and big data analytics to provide farmers with real-time recommendations on crop management practises. These systems are designed to help farmers increase their yields and reduce their costs. Farmers found the cloud-based decision support system straightforward to use, and they valued the system's ability to provide them with real-time advice, according to the qualitative evaluation of the system. Also, the method assisted farmers in better understanding their crops as well as the environmental circumstances that had an impact on those crops.

Nevertheless, further study is required to evaluate the effectiveness of these systems in a variety of environmental circumstances and methods of farming. Research in the future might potentially concentrate on the scalability of cloud-based decision support systems for crop management as well as the economic feasibility of using such systems for farmers.

In conclusion, cloud-based decision support systems for crop management have the potential to maximise crop productivity while simultaneously minimising their negative effects on the surrounding environment. These systems are able to give farmers with real-time suggestions on crop management strategies, which assists farmers in gaining a deeper understanding of their crops and in making improvements to their methods of farming.

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