Review

A decision-support system perspective of machine learning in agriculture: A review

Ashok Kumar[1], Amit Kumar[2]

[1]Department of Information Technology, GBPUAT, Pantnagar UK, India
[2]ICAR-VPKAS, Almora, Uttarakhand
Corresponding Author Email: ashu.gbpec@gmail.com

Abstract: This article covers the essential concepts and differentiating elements that are shared by the various types of DSSs. The focus is on the concept rather than the technology, which allows for a more in-depth analysis. Decision Support Systems are computer-based systems that are intended to assist users in selecting an acceptable plan of action. These systems are frequently referred to by their abbreviation, "DSSs." The purpose of developing decision support systems (DSSs) is to make it easier for people to make better decisions, whether those decisions are being made by an individual or by a group. Frequently, the end goal of developing DSSs is to arrive at the most optimal conclusion that is possible given the data that is available. To this purpose, a decision support system (DSS) may offer assistance in identifying and assessing options, forecasting the impacts of each choice, benefiting from data visualization and optimization tools, and so on. This study is going to focus mainly on issues relevant to agricultural science. Although decision support systems can be helpful in a variety of contexts, agricultural research is one area in which they are highly helpful.

Keywords: Decision support systems, agriculture, machine learning, technology.

1. Introduction

The development of decision support systems, sometimes known as DSSs, has the overarching goal of making it simpler for people to make better decisions, regardless of whether those decisions are being made by a single person or by a group of people. When building DSSs, the end objective is frequently to arrive at the most optimal conclusion that is feasible given the data that is provided. This is the case a lot of the time. As more farmers have grown to rely on technology to assist them in making decisions regarding the management of their farms, the creation of decision support systems in the agricultural industry has become an increasingly essential endeavor over the past several years. The development of DSSs has as its ultimate goal the achievement of the best possible conclusion given the available data. As more farmers have grown to rely on technology to assist them in making decisions regarding the management of their farms, the creation of decision support systems in the agricultural industry has become an increasingly essential endeavour over the past several years. DSSs have emerged as vital tools in the agriculture industry for a variety of reasons. First and foremost, decision support systems (DSSs) assist farmers in swiftly and correctly making choices by giving them access to real-time data on the soil, climate, crops, pests, and other aspects on an individual basis or in groups. This data may be seen indi-

vidually or collectively. When building DSSs, the end objective is frequently to arrive at the most optimal conclusion that is feasible given the data that is provided. This is the case a lot of the time. As more farmers have grown to rely on technology to assist them in making decisions regarding the management of their farms, the creation of decision support systems in the agricultural industry has become an increasingly essential endeavor over the past several years. The development of DSSs has as its ultimate goal the achievement of the best possible conclusion given the available data. As more farmers have grown to rely on technology to assist them in making decisions regarding the management of their farms, the creation of decision support systems in the agricultural industry has become an increasingly essential endeavour over the past several years. DSSs have emerged as vital tools in the agriculture industry for a variety of reasons. First and foremost, decision support systems (DSSs) assist farmers in swiftly and correctly making choices by supplying them with real-time data on the soil, climate, crops, pests, and other elements. This information is essential for agriculture. These statistics provide farmers with the information they need to make educated decisions regarding the ideal quantity of water, fertilizer, and other inputs to use so that they may maximize crop output while minimizing expenditures. In addition, DSSs assist farmers to save time by automating many of the mundane chores that are connected with farming, such as planting and harvesting the crops. This enables the farmers to work more efficiently. Last but not least, DSSs provide farmers with a variety of analytical and forecasting capabilities that assist them in planning ahead and becoming ready for potential changes in the weather, pests, or crop prices. This can be of assistance to farmers in reducing risk and ensuring the farms' continued viability over the long run. There are five distinct classifications of decision-supporting systems. Document Driven DSS, Data Driven DSS, Communications-Driven DSS, Model Driven DSS, and Knowledge Driven DSS are the names given to these five different types of DSS.

2. Literature review

The DSS is able to assist farmers in protecting their businesses from potential dangers, which will help them ensure the continued prosperity of their farms over the long term. There are five distinct varieties of DSS, and these are the ones that make use of documents, data, communications, models, and knowledge, respectively. Document-driven decision-making support systems, which are also known as document-based systems, provide farmers with simple access to information that they can apply to their businesses in order to make informed decisions. The data-driven decision support system (DSS) provides farmers with large data sets that can be analyzed and used to make predictions regarding their business operations. These can be broken down into five distinct categories: those that make use of documents, data, communications, models, and knowledge, respectively. Document-driven decision-making support systems, which are also known as document-based systems, provide farmers with simple access to information that they can apply to their businesses in order to make informed decisions. The data-driven decision support system (DSS) provides farmers with large data sets that can be analysed and used to make predictions regarding their business operations. Farmers can use communication-driven decision support systems to communicate with experts and other farmers for advice; use knowledge-driven decision support systems, which provide a repository of expert knowledge and experience that farmers can use; use models to help make decisions more effectively; and use model-driven decision support systems. Because of all of these systems, farmers are now able to make decisions in a manner that is both more efficient and effective, which has led to increased yields and improved profitability.

The world's growing population's food demands are straining agricultural productivity. Agriculture 4.0 emphasizes productivity, resource allocation, climate change adaptation, and food waste reduction. This paper examines Agriculture 4.0's agricultural decision support system challenges [1]. Agro technical decision support was developed by an international team of scientists. Weather, soil, and crop data are in the DSSAT's crop-soil simulation models. It has a simple interface for microcomputers [2]. AgroDSS bridges agricultural systems and modern decision support methodologies. Integrating the described system into farm management information systems is the goal. It lets farmers upload, analyze, and retrieve their data [3]. Agricultural droughts depend on crops, reservoir water supplies, rainfall, and soil. A risk-based agricultural drought management methodology includes drought evaluation and monitoring, water stress forecasting and outlook, drought defensive measures, and crop failure records management [4]. Geospatial data and advanced IT can improve agricultural decision-making. This paper summarizes simulation-based decision support systems (DBS) in Indian agriculture. Agricultural research has produced much data. [5]. This paper describes Sardinia's prototype agricultural DSS LANDS for monitoring main crop production. The DSS organizes, integrates, and analyses data using various mathematical models. Predicting potato late blight is a case study [6]. Precision agriculture stakeholders receive feedback from DSSs. End-users need visualization to understand and interpret data. Most DSSs display maps and satellite imagery [7]. GIS and multi-criterial analysis are recommended in this paper. This integration is explained and supported by a conceptual framework. To demonstrate a spatial DSS, a prototype will be shown [8]. Wireless sensor networks (WSN) are a major 21st century technology. This paper demonstrates WSN-based greenhouse management. The proposed system monitors greenhouse environments, controls greenhouse equipment, and offers consumers convenient services [9]. Conservation tillage is crucial to agricultural production's environmental impact. Conservation tillage's impact on pesticide and fertilizer use is unknown [10]. Crop and soil process models should not be used to communicate with farmers. Other, sometimes more efficient and elegant, models are available. DSS design issues include deconstructing professional models in the analytical phase [11]. Farm planning is essential to the design of complex farm advisory decision support systems (DSS). A new approach for medium-to-large farms is integrated into a more general framework to construct DSSs in agriculture. For Albacete Provincial Advanced Agricultural Institute technicians, the system has been validated [12]. A paper discusses how to build a decision support system (DSS) with critical success factors. Pigs2win, a DSS for Flemish pig farms, uses frontier analysis for relative farm analysis and is participatory [13]. To make agricultural science more accessible to farmers and extension officers, scientists create decision support systems (DSSs). However, little attention has been paid to the "doing" and "problem of implementation" when farmers and advisors don't use DSSs [14]. Farmers must adapt to commercial decision support systems (DSSs) on the farm. To understand precision farming data-decision-making issues, six Australian dairy farms were studied [15]. Digital technologies generate massive amounts of data. Farmers and companies could increase productivity by analyzing this data. This practice is still developing, so many barriers must be overcome [16].

3. Machine Learning DSS in Agriculture

The Internet of Things, wireless sensor networks, data analytics, and machine learning in agriculture are showcased in the paper. Data analysis and machine learning in an IoT system were used to predict apple disease in Kashmir Valley apple orchards [17]. Leaf characteristics diagnose most plant diseases. The system segments a

single plant leaf after background removal. Farmers can easily get agricultural expert advice with 96.6% accuracy using the proposed approach [18]. Engineering and science use data mining, but finance and marketing also do. This study proposed a data-mining decision support system. A decision tree and artificial neural network estimate marketing strategies for an organization [19]. To manage agricultural irrigation, SIDSS is proposed. Based on soil measurements and climatic variables, our system estimates plantation irrigation needs weekly. Performance is compared to expert decisions [20]. ML dominates agriculture in this age of automation. 103 ML approach documents are reviewed in this systematic literature review. Associative classifiers and association rule mining were rarely used to solve agricultural problems, according to the survey [21]. The tomato is the second most-produced and-consumed vegetable. Technology has simplified and expanded decision support systems. Farmers need this technology to know when tomatoes are at their best [22].

To maximize output, modern agriculture needs technology. Researchers can now use machine learning (ML) and the Internet of Things (IoT) in agriculture. This paper discusses agricultural ML and IoT work [23]. Crop protection involves controlling pests, diseases, and weeds. Herbicide resistance complicates weed control for farmers. Markov random fields (MRF) may model ryegrass herbicide resistance [24]. Big Data and Machine Learning (ML) are high-performance computing technologies that enable data-driven agricultural process understanding. This paper discusses big agricultural data and machine learning challenges, adaptations, and architecture [25]. Over 59,000 farmers have committed suicide in the last 30 years. Most agricultural departments have historical crop yield data. Considering climate, season, PH level, soil type, and more, these data can reveal potential crops [26]. This paper examines how machine learning can predict plant states and prevent stress-related problems. This paper proposes an iterative, inductive machine-learning application model [27]. Jojoba products are made in Israel. To track plant needs, its orchards have soil moisture sensors. Weather, irrigation, and yield data are from other sources (e.g., meteorological station records and irrigation-plan records) [28]. To benefit from parallel computing and large dataset storage management, the Agro science community must develop its own architectural model. Machine learning and its agricultural applications are explained in this study. It also discusses machine learning algorithms that can be used to model agricultural issues [29]. FCM combines fuzzy logic and cognitive mapping. It handles uncertain descriptions like humans. FCMs may help predict cotton yield and manage crops [30]. Table 1 shows the reference numbered against various attributes; machine learning uses with decision support system concepts in agriculture.

Table 1. Machine learning perspective in Agriculture table.

References	Attribute	Machine Learning used	Agriculture Field
[17]	Internet of things, Data analytics	Yes	Yes
[18]	Diseases, Feature extraction, Decision support systems	Yes	Yes
[19]	Data Mining, Marketing decision support system, Decision Tree	Yes	Yes
[20]	Irrigation Decision support system, Water optimization	Yes	Yes
[21]	Decision support system	Yes	Yes
[22]	Decision support systems	Yes	Yes
[23]	IoT	Yes	Yes
[24]	Big data, Markov random field model	Yes	Yes
[25]	big data	Yes	Yes

[26]	Decision tree, Season, Soil	Yes	Yes
[27]	data mining, decision rules	Yes	Yes
[28]	Data mining, Internet of things (IoT)	Yes	Yes
[29]	Big data, Decision making	Yes	Yes
[30]	Decision making	Fuzzy cognitive, Fuzzy sets	Yes

4. Conclusions

Table 1 compiles references to academic articles that discuss decision support systems (DSS) that employ machine learning. The application of machine learning to agricultural decision-making has the potential to completely transform the industry. The agricultural sector has been revolutionized by machine learning and decision support systems. This means that machine learning algorithms have contributed to better agricultural decisions. The use of decision support systems with machine learning capabilities has enabled farmers to make more accurate decisions.

References

[1] Zhai, Z., Martínez, J. F., Beltran, V., & Martínez, N. L. (2020). Decision support systems for agriculture 4.0: Survey and challenges. Computers and Electronics in Agriculture, 170, 105256. https://doi.org/10.1016/j.compag.2020.105256

[2] Jones, J.W. (1993). Decision support systems for agricultural development. In: Penning de Vries, F., Teng, P., Metselaar, K. (eds) Systems approaches for agricultural development. Systems Approaches for Sustainable Agricultural Development, vol 2. Springer, Dordrecht. https://doi.org/10.1007/978-94-011-2840-7_28

[3] Rupnik, R., Kukar, M., Vračar, P., Košir, D., Pevec, D., & Bosnić, Z. (2018). AgroDSS: A decision support system for agriculture and farming. Computers and Electronics in Agriculture, 161, 260–271. https://doi.org/10.1016/j.compag.2018.04.001

[4] Nam, WH., Choi, JY., Yoo, SH. et al. A decision support system for agricultural drought management using risk assessment. Paddy Water Environ 10, 197–207 (2012). https://doi.org/10.1007/s10333-012-0329-z

[5] Kumbhar V and Singh T P 2013 A Comprehensive Study of Application of Decision Support System in Agriculture in Indian Context International Journal of Computer Applications 63 6-11

[6] Fenu, G., & Malloci, F. M. (2020). DSS LANDS: a decision support system for agriculture in Sardinia. HighTech and Innovation Journal, 1(3), 129–135. https://doi.org/10.28991/hij-2020-01-03-05

[7] Gutiérrez, F., Htun, N. N., Schlenz, F., Kasimati, A., & Verbert, K. (2019). A review of visualisations in agricultural decision support systems: An HCI perspective. Computers and Electronics in Agriculture, 163, 104844. https://doi.org/10.1016/j.compag.2019.05.053

[8] Laaribi, A., Chevallier, J., & Martel, J. (1996). A spatial decision aid: A multicriterion evaluation approach. Computers Environment and Urban Systems, 20(6), 351–366. https://doi.org/10.1016/s0198-9715(97)00002-1

[9] Xuemei Li, Yuyan Deng and Lixing Ding, "Study on precision agriculture monitoring framework based on WSN," 2008 2nd International Conference on Anti-counterfeiting, Security and Identification,

Guiyang, 2008, pp. 182-185, doi: 10.1109/IWASID.2008.4688381.

[10] Uri, N.D. The Environmental Consequences of the Conservation Tillage Adoption Decision in Agriculture in the United States. Water, Air, & Soil Pollution 103, 9–34 (1998). https://doi.org/10.1023/A:1004968616527

[11] Cox, P. (1996). Some issues in the design of agricultural decision support systems. Agricultural Systems, 52(2–3), 355–381. https://doi.org/10.1016/0308-521x(96)00063-7

[12] Recio, B., Rubio, F., & Criado, J. (2002). A decision support system for farm planning using AgriSupport II. Decision Support Systems, 36(2), 189–203. https://doi.org/10.1016/s0167-9236(02)00134-3

[13] Van Meensel, J., Lauwers, L., Kempen, I., Dessein, J., & Van Huylenbroeck, G. (2012). Effect of a participatory approach on the successful development of agricultural decision support systems: The case of Pigs2win. Decision Support Systems, 54(1), 164–172. https://doi.org/10.1016/j.dss.2012.05.002

[14] Jakku, E., & Thorburn, P. (2010). A conceptual framework for guiding the participatory development of agricultural decision support systems. Agricultural Systems, 103(9), 675–682. https://doi.org/10.1016/j.agsy.2010.08.007

[15] Eastwood, C., Chapman, D., & Paine. (2012). Networks of practice for co-construction of agricultural decision support systems: Case studies of precision dairy farms in Australia. Agricultural Systems, 108, 10–18. https://doi.org/10.1016/j.agsy.2011.12.005

[16] Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2017). A review on the practice of big data analysis in agriculture. Computers and Electronics in Agriculture, 143, 23–37. https://doi.org/10.1016/j.compag.2017.09.037

[17] Akhter, R., & Sofi, S. A. (2021). Precision agriculture using IoT data analytics and machine learning. Journal of King Saud University - Computer and Information Sciences, 34(8), 5602–5618. https://doi.org/10.1016/j.jksuci.2021.05.013

[18] H. Waghmare, R. Kokare and Y. Dandawate, "Detection and classification of diseases of Grape plant using opposite colour Local Binary Pattern feature and machine learning for automated Decision Support System," 2016 3rd International Conference on Signal Processing and Integrated Networks (SPIN), Noida, India, 2016, pp. 513-518, doi: 10.1109/SPIN.2016.7566749.

[19] P, K. (2020). Analysis of neural network based language modeling. Journal of Artificial Intelligence and Capsule Networks, 2(1), 53–63. https://doi.org/10.36548/jaicn.2020.3.006

[20] Navarro-Hellín, H., Martínez-Del-Rincon, J., Domingo-Miguel, R., Soto-Valles, F., & Torres-Sánchez, R. (2016). A decision support system for managing irrigation in agriculture. Computers and Electronics in Agriculture, 124, 121–131. https://doi.org/10.1016/j.compag.2016.04.003

[21] P. Bhosale, W. Kastner and T. Sauter, "Automating Safety and Security Risk Assessment in Industrial Control Systems: Challenges and Constraints," 2022 IEEE 27th International Conference on Emerging Technologies and Factory Automation (ETFA), Stuttgart, Germany, 2022, pp. 1-4, doi: 10.1109/ETFA52439.2022.9921517.

[22] Kasimatis, C., Psomakelis, E., Katsenios, N., Katsenios, G., Papatheodorou, M., Vlachakis, D.,

Apostolou, D., & Efthimiadou, A. (2022). Implementation of a decision support system for prediction of the total soluble solids of industrial tomato using machine learning models. Computers and Electronics in Agriculture, 193, 106688. https://doi.org/10.1016/j.compag.2022.106688

[23]　uhi Reshma, S.R., Pillai, A.S. (2018). Impact of Machine Learning and Internet of Things in Agriculture: State of the Art. In: Abraham, A., Cherukuri, A., Madureira, A., Muda, A. (eds) Proceedings of the Eighth International Conference on Soft Computing and Pattern Recognition (SoCPaR 2016). SoCPaR 2016. Advances in Intelligent Systems and Computing, vol 614. Springer, Cham. https://doi.org/10.1007/978-3-319-60618-7_59

[24]　Ip, R. H., Ang, L., Seng, K. P., Broster, J., & Pratley, J. (2018). Big data and machine learning for crop protection. Computers and Electronics in Agriculture, 151, 376–383. https://doi.org/10.1016/j.compag.2018.06.008

[25]　Cravero, A.; Sepúlveda, S. Use and Adaptations of Machine Learning in Big Data—Applications in Real Cases in Agriculture. Electronics 2021, 10, 552. https://doi.org/10.3390/electronics10050552

[26]　Senapaty, M.K.; Ray, A.; Padhy, N. A Decision Support System for Crop Recommendation Using Machine Learning Classification Algorithms. Agriculture 2024, 14, 1256. https://doi.org/10.3390/agriculture14081256

[27]　S. Dimitriadis and C. Goumopoulos, "Applying Machine Learning to Extract New Knowledge in Precision Agriculture Applications," 2008 Panhellenic Conference on Informatics, Samos, Greece, 2008, pp. 100-104, doi: 10.1109/PCI.2008.30.

[28]　Goldstein, A., Fink, L., Meitin, A. et al. Applying machine learning on sensor data for irrigation recommendations: revealing the agronomist's tacit knowledge. Precision Agric 19, 421–444 (2018). https://doi.org/10.1007/s11119-017-9527-4

[29]　Priya, R., & Ramesh, D. (2020). ML based sustainable precision agriculture: A future generation perspective. Sustainable Computing Informatics and Systems, 28, 100439. https://doi.org/10.1016/j.suscom.2020.100439

[30]　Papageorgiou, E., Markinos, A., & Gemtos, T. (2011). Fuzzy cognitive map based approach for predicting yield in cotton crop production as a basis for decision support system in precision agriculture application. Applied Soft Computing, 11(4), 3643–3657. https://doi.org/10.1016/j.asoc.2011.01.036