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Artificial Intelligence Supported Agricultural Decision Support Systems: The Farming of the Future

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Abstract

This study proposes an artificial intelligence (AI) based Agricultural Decision Support System (ADSS) that addresses the lack of data, uncertainties caused by climate change, and the inadequate transfer of scientific knowledge to the field in agricultural production in Turkiye. While digital agriculture technologies generate large volumes of data, most of these data are used solely for monitoring and visualization and fail to deliver actionable, personalized recommendations to farmers. The proposed system compares sensor data and farmer declarations with optimum agronomic parameters defined in the literature to generate meaningful and applicable recommendations on irrigation scheduling, fertilizer management, disease risk, and planting time. Machine learning algorithms support crop recommendation, yield prediction, and risk forecasting, enabling more accurate strategic, tactical, and operational decisions. Reference data are managed exclusively by experts, safeguarding scientific accuracy; regional climatic averages, kc coefficients (crop coefficient), and phenological stage information are consolidated in a centralized database. The system also supports sensorless usage scenarios, making it accessible to small-scale enterprises with limited technology. Image processing and deep learning achieve 97–99% accuracy in disease diagnosis, while IoT sensors detect water stress to enable more efficient autonomous irrigation. The applicability of the system depends on regular and accurate data entry by farmers and on the transparency and explainability of the AI-based decision engine. Data privacy and ethical use are critical for the system's sustainability. Overall, the proposed AI supported agricultural decision support system represents an innovative digital transformation model that aggregates Turkiye's agricultural data on an integrated platform and provides farmers with personalized, applicable guidance shifting agriculture from experience-driven to data-driven, predictable, and sustainable management.

Keywords: *Artificial Intelligence, Agricultural Decision Support System, Digital Agriculture*

Introduction

Global-scale issues such as global population growth and climate change have propelled the agricultural sector to a critical tipping point in terms of productivity (Ahmad & Nabi, 2021). The success of agricultural production depends on the correct management of environmental factors such as temperature, humidity, soil properties, and plant growth parameters (Yaşar & Yurtaslan, 2025). Although the optimum ranges of these parameters are defined in the literature, their inability to apply them effectively in the field brings efficiency losses. With Agriculture 4.0, the integration of IoT, artificial intelligence, and big data technologies into agricultural processes significantly increases precision and decision-making accuracy in production (Şahin, 2022).

Today, sensors and digital farming applications make it possible to collect copious amounts of data from fields (Güman & Günay, 2024). However, most current systems only process this data at the monitoring or visualization level; It cannot provide the farmer with feasible and timely guidance suitable for the current field conditions. The small-scale nature of agricultural enterprises in Türkiye complicates the adoption of advanced technologies and further complicates farmers' access to scientific references (Çakır & İşlek, 2021). Since most of the manufacturers do not have the necessary measurement equipment, they often make their decisions based on their intuition, observations and experiences (Gürbüz et al., 2023). In this context, it is not only a data provider; the need for decision support mechanisms that can interpret data and transform it into meaningful, applicable, and personalized recommendations is increasing (Ayberkin, 2025).

This study proposes an artificial intelligence-based Agricultural Decision Support System (ADSS) that interprets the optimum plant cultivation parameters defined in the literature by comparing them with the field data obtained from the farmer. The proposed system integrates the data received from the field with scientific references and provides action-oriented recommendations to the farmer, including the correct use of inputs, the right timing and the right application method. The system offers an adaptable structure for different user profiles based not only on sensor data but also on basic field information declared by the farmer. Updating agronomic parameters is done only by expert managers; Thus, the accuracy and up-to-dateness of the scientific information in the system are preserved. In addition, crop type recommendations and yield predictions are made with machine learning models, and data-supported predictions are brought to farmers' decision-making processes (Sevli, 2025; Karadeniz, 2024).

Yield and quality in agricultural production depend on providing environmental and agronomic requirements at the right amount and at the right time. Although these requirements are defined in detail in the literature, the transfer of scientific information to the field is often insufficient. Despite the abundance of data provided by digital agricultural technologies, the inability to present this data as applicable decisions to farmers creates a significant disconnect between academic knowledge and field practice. Given the difficulties farmers face in accessing scientific references and advanced analysis opportunities, there is a need for flexible decision support systems that can work with not only high-tech based solutions but also basic data.

In this context, the proposed artificial intelligence-supported decision support system reveals a structure that not only collects data, but also transforms it into information, interprets it and offers directly applicable suggestions to the farmer. Thus, scientific knowledge is adapted to the daily activities of the farmer through modern digital technologies; Agricultural consultancy processes are moved to the digital environment. This approach aims to transform agricultural decision support systems from data-driven structures to an information-driven, intelligent, and dynamic structure, aiming to achieve a sustainable increase in productivity in agricultural production.

Material and Method

Decision Support Systems (DSS) are interactive computer-based systems developed to help decision-makers solve complex problems, processing raw data and expert information into meaningful action plans (Ahmad & Nabi, 2021). In the agricultural sector, these systems are called Agricultural Decision Support Systems (ADSS) and aim to guide producers with the approach of "right input, right time and right method". Given the dynamic nature of agricultural production and the important level of uncertainty, the importance of such systems is increasing.

The functioning of an effective decision support system relies on the harmonious operation of databases, analytical models, and user interfaces. Data and knowledge base; real-time measurements obtained from sensors, historical production records and agronomic reference values defined in the literature are brought together (Ayberkin, 2025). Building on this foundation, the model layer is the section where data is analyzed and transformed into meaningful results. In this layer, prediction models are created using Artificial Intelligence and Machine Learning algorithms; for example, yield estimation and crop recommendation can be made according to changes in temperature, humidity or soil moisture (Karadeniz, 2024; Yaşar & Yurtaslan, 2025). System outputs are transmitted to farmers or experts via the user interface; graphical representations, maps or direct-action suggestions (Öztürk et al., 2023; Güman & Günay, 2024).

Decisions taken in agricultural production are evaluated at three levels in terms of duration and scope: strategic, tactical and operational. Strategic decisions include long-term choices such as product pattern planning and have annual or longer-lasting effects (Demir, 2021). Tactical decisions include shorter-term production processes such as irrigation timing during the season, fertilizer dosing or disease management. Operational decisions, on the other hand, include practices that require rapid intervention in unexpected situations such as sudden weather changes (Bayrakçı et al., 2021; Şahin, 2024; Ahmad & Nabi, 2021).

DSSs are divided into distinct categories according to the nature of the inputs they process. Data-driven decision support systems focus on analyzing large data sets and real-time data streams (Özer et al., 2022), while model-driven systems provide optimization through mathematical and statistical models (Sevli, 2025). While knowledge-oriented systems attract attention with their structures that include expert knowledge and rules in a specific field, communication-oriented decision support systems allow teams to make joint decisions by focusing on interaction between users (Ahmad & Nabi, 2021).

Today, modern agricultural decision support systems are transforming into smart structures that work integrated with advanced technology components, transcending traditional data processing approaches. IoT-based sensors monitor the conditions in the field in real-time, blockchain technology guarantees data security, and artificial intelligence algorithms can interpret the data obtained with high accuracy (Ayberkin, 2025; Güman & Günay, 2024). This transformation moves agriculture to a knowledge-based smart management ecosystem and transforms the traditional experience-oriented production approach into a data-driven strategic model (Yaşar & Yurtaslan, 2025; Anonymous, 2024).

Research articles reporting large data sets stored in a public database should indicate which database the data was uploaded to and provide relevant access numbers. If access numbers have not yet been obtained at the time of submission, they must be provided during the peer review process. These numbers must be submitted before publication.

Interventional studies on animals or humans, as well as other studies requiring ethical approval, must indicate the authoritative institution granting the approval and the relevant ethical approval code.

Results

The use of artificial intelligence (AI) in digital agriculture; It has become one of the most critical technologies developed to optimize production processes, rationalize resource use, and provide data-driven strategic guidance to farmers (Karadeniz, 2024; Yaşar & Yurtaslan, 2025; Ahmad & Nabi, 2021). Artificial intelligence works by adapting cognitive abilities specific to human intelligence, such as learning, recognition, decision-making, and problem-solving, to computer systems, and is at the center of Agriculture 4.0 and 5.0 processes, transforming complex agricultural data into meaningful action plans (Wolfert et al., 2017; Şahin, 2022; Karadeniz, 2024).

One of the most important application areas of artificial intelligence in digital agriculture is precision agriculture and input management. AI-based systems enable the realization of variable rate applications (VRA) by analyzing the needs at each point of the field, thus optimizing the use of inputs (Özer et al., 2022). In water management, moisture, temperature and soil water data obtained from IoT sensors are processed by artificial intelligence algorithms to detect the water stress of the plant; thus, autonomous irrigation systems work more efficiently and water consumption is significantly reduced (Öztürk et al., 2023; Liakos et al., 2018; Şahin, 2024). Similarly, fertilizer management is improved by evaluating soil analysis data by AI models, and the necessary nutrients are applied to the plant in the right doses, resulting in savings in chemical usage (Güman & Günay, 2024; Ahmad & Nabi, 2021). In this context, artificial intelligence increases the applicability of the 5R approach, which is based on the principles of "right input, right time, right amount, right place and right method" in agriculture (Ahmad & Nabi, 2021).

Artificial intelligence also provides a significant transformation in the detection of diseases, pests and weeds. In particular, image processing and deep learning methods go beyond the human eye and achieve high accuracy rates in disease and pest diagnosis (Karadeniz, 2024; Yaşar & Yurtaslan, 2025). CNN-based models that detect diseases from leaf images can make rapid assessments with accuracy ranging from 97–99% (Karadeniz, 2024; Sachdeva et al., 2021) and offers early intervention to producers. Digital pheromone traps used in the monitoring of pest populations reduce losses by creating early warning mechanisms with artificial intelligence-supported analysis (Anonymous, 2022). In weed management, autonomous robots significantly reduce the use of chemicals by performing targeted spraying (Blue River Technology, 2021; Şahin, 2022).

Another important use case of artificial intelligence is forecasting and yield analysis. AI models working on large datasets can predict yields by leveraging historical production data, satellite images, and meteorological information, making significant contributions to production planning (Özer et al., 2022; Karadeniz, 2024). In addition, estimating market prices offers a significant advantage in terms of optimizing farmers' economic decisions; artificial intelligence-based price projections can increase the revenues of producers (Demir, 2021). Weather forecasting models, on the other hand, identify risks such as frost, drought, or extreme heat in advance, enabling producers to take necessary measures in a timely manner (Bukhari & Pandit, 2024; Şahin, 2024).

Autonomous machines and robotic systems in agriculture are one of the most visible applications of artificial intelligence technologies. AI-supported tractors can operate without an operator thanks to GPS and sensor systems, while robotic harvesting systems can perform automatic picking by analyzing the maturity level of fruits (Şahin, 2022; Arvas & Çınar, 2023). Unmanned aerial vehicles (drones), on the other hand, accelerate production processes by performing many functions such as spraying, seed planting, and phytosanitary monitoring with artificial intelligence-supported image analysis (Gürbüz et al., 2023; Şahin, 2022).

Artificial intelligence applications are also increasingly used in animal husbandry and aquaculture. In sensitive livestock systems, movement, temperature, and behavior data obtained from wearable sensors can be processed by AI models, allowing for early detection of animal diseases and preventing yield losses (Yaşar & Yurtaslan, 2025). In aquaculture, underwater imaging systems and artificial intelligence optimize feed use by monitoring fish behavior and contribute to the protection of water quality.

The artificial intelligence-supported agricultural decision support system proposed in this study aims to provide solutions to the main problems encountered in agricultural production in Türkiye such as data access, lack of information and lack of practical suggestions. The system is designed in a structure that aims to close the data-information gap emphasized in the literature. Despite the abundance of data generated by digital agricultural technologies, the majority of farmers do not have the expertise to interpret this data, existing systems remain solely focused on monitoring, and scientific references cannot be transferred to the field, demonstrating the necessity of such a decision support mechanism (Ahmad & Nabi, 2021). In addition, the fact that most of the enterprises in Türkiye are small-scale makes it difficult for every farmer to use high-tech platforms effectively (Çakır & İşlek, 2021). The proposed system aims to overcome this limitation by allowing for both simple data entry and support for sensorless use cases.

One of the system's strengths is the preservation of scientific accuracy, thanks to which reference data is managed exclusively by experts. Gathering climatic averages, product-based KC coefficients, and phenological stage information from different regions of Türkiye under a central structure enhances the reliability of the recommendations presented to farmers (Ministry of Agriculture and Forestry, 2024). In addition, this structure allows seasonal changes and regional differences to be reflected in decision processes. In addition, the multi-layered data structure of the system increases the circulation of agricultural knowledge by allowing not only farmers but also academics to use the database for research purposes (Karadeniz, 2024).

On the other hand, the applicability of the system also points to some limitations. Firstly, farmers' accurate and regular data entry into the system is a factor that directly affects the accuracy of recommendations. Especially in sensorless usage scenarios, the fact that the data is based on declarations may create uncertainty in the system's recommendations in some cases. Additionally, the sustainability of the system is highly dependent on the data update processes of experts, as regional climate data and crop parameters need to be updated over time (Ayberkin, 2025). Therefore, the role of expert administrator can be considered a critical component for the success of the system.

Another critical point of contention is the explainability requirement of the AI-based decision engine. Farmers' ability to understand the reason for the proposal will increase their trust in the system. In this context, it is thought that mechanisms should be developed to explain the decisions of the model transparently. In addition, it should not be ignored that the recommendations of artificial intelligence are not a final decision on their own, but a guide that should be evaluated together with the conditions applicable to the farmer (Özer et al., 2022).

When evaluated from an academic point of view, data combinations to be produced by the system; It will also make significant contributions to research areas such as the effects of climate change on agriculture, shifts in crop growing patterns and modeling regional production risks. Opening farmer data to scientific research in an anonymized form can significantly reduce the lack of agricultural data in Türkiye (Yaşar & Yurtaslan, 2025). However, data privacy and ethical use issues are aspects that need to be carefully regulated in the later stages of the system.

When evaluated in general, the proposed decision support system offers an innovative digital transformation approach that can respond to the instant needs of producers, make regional climatic and agronomic data effectively available, and facilitate the transfer of scientific knowledge to the field. If the system is successfully implemented, it is predicted that both production efficiency and access to agricultural information will increase. However, the effectiveness of the system may vary depending on user training, regular data updates, and the level of explainability of the AI. For this reason, it is recommended that future studies include improvements to increase the user experience of the system and make the decision-making mechanism more comprehensive.

The discussion section should not be content with just repeating the new findings; should consider the author's conclusions within the broader context of other studies on the subject and interpret them with minimal speculation.

Conclusion

This study proposes an artificial intelligence-supported agricultural decision support system that aims to provide solutions to basic problems such as the lack of data in agricultural production in Türkiye, the uncertainties caused by climate change, and the inability to adequately transfer scientific knowledge to the field. In the literature, it is stated that digital agricultural technologies generate a large amount of data, but this data is mostly used only for monitoring and visualization purposes and cannot provide feasible decisions to the farmer (Ahmad & Nabi, 2021). The proposed model fills this gap and offers an integrated structure that compares field data with scientific references.

One of the important contributions of the system is the maintenance of the accuracy of agronomic information thanks to the management of reference data by experts. Collecting parameters such as temperature, humidity, precipitation, and kc coefficients from different regions of Türkiye in a central database enhances the reliability of recommendations presented to farmers (Anonymous, 2024). In addition to this structure, the integration of field data provided by the farmer into the system ensures that both low-tech small enterprises and professional users can benefit from the system (Çakır & İşlek, 2021).

This decision support structure compares the basic data provided by the farmer with the optimum values defined in the literature and offers personalized recommendations on issues such as irrigation timing, fertilizer management, disease risk and planting time. These recommendations, based on 5R principles, contribute to the efficient and sustainable management of agricultural resource use (Ahmad & Nabi, 2021). In addition, the system's artificial intelligence-based forecasting models support production planning by creating future yield projections (Sevli, 2025; Karadeniz, 2024).

In line with the discussions, some limitations arise in terms of the sustainability of the system. User training and ease of use are critical, as farmers' regular and accurate data entry into the system directly impacts recommendation accuracy (Gürbüz et al., 2023). Additionally, regular expert updates are imperative due to the time-dependent change in reference values (Ayberkin, 2025). The transparency and explainability of the outputs of artificial intelligence models is another crucial factor that will increase farmers' trust in the system (Özer et al., 2022).

Within the scope of future studies, it is recommended to expand the system to a wider geographical database, integrate sensor and remote sensing technologies, develop regional early warning mechanisms, and enrich the academic panel with advanced analysis tools. In addition, an artificial intelligence chat assistant that can continuously learn with the data provided by the farmer and the manager can transform agricultural consultancy into a digital structure by accelerating access to information.

As a result, the proposed agricultural decision support system; It is an important digital transformation model in terms of collecting Türkiye's agricultural data accumulation on a holistic platform, facilitating access to information and offering personal recommendations to farmers. The implementation of this system will contribute to both increasing production efficiency and reducing agricultural risks, providing strategic support to the sustainability of the country's agriculture (Anonymous, 2024).

Declarations

Ethical Approval Certificate

This study is a review article and does not involve any experiments on humans or animals; therefore, ethics committee approval is not required.

Author Contribution Statement

Firdevs Bahşi: Data collection, investigation, formal analysis, and drafting of the initial manuscript.

M. Cüneyt Bağdatlı: Manuscript administration, supervision, conceptualization, methodology, review and editing.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding this study.

References

Ahmad, L., & Nabi, F. (2021). Agriculture 5.0: Artificial Intelligence, Iot and Machine Learning. CRC Press.

Arvas, M. M., & Çınar, A. (2023). Topraksız Tarımda Çilek Olgunluğunun Yapay Zekâ Teknikleri Kullanılarak Tespiti. All Sciences Proceedings, 350–353.

Ayberkin, D. (2025). Tarbiot KDS: Akıllı Tarım Uygulamaları Için Blokzincir Ve Iot Teknolojileri Ile Gerçek Zamanlı Karar Destek Sistemi Tasarımı. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 15(1), 12–24.

Anonymous, (2022). Tarım Brifingi, İzmir İl Tarım ve Orman Müdürlüğü. İzmir Valiliği.

Anonymous, (2024). Tarımda Dijital Dönüşüm, Veri Tabanlı Tarım, Teknolojik Gelişim Çalışma Belgesi. IV. Tarım Orman Şûrası. Tarım ve Orman Bakanlığı

Bayrakçı, H. C., Çiçekdemir, R. S., & Özkahraman, M. (2021). Tarım Arazilerinde Harcanan Su Miktarının Yapay Zekâ Teknikleri Kullanılarak Belirlenmesi. Düzce Üniversitesi Bilim Ve Teknoloji Dergisi, 9(6), 237–250.

Bukhari, S. N. H., & Pandit, S. F. (2024). Short-term Weather Forecasting For Precision Agriculture In Jammu And Kashmir: A Deep-learning Approach. In Data-Driven Farming: Harnessing the Power of AI and Machine Learning in Agriculture (pp. 243–258). CRC Press.

Blue River Technology. (2021). See & Spray: Computer Vision and Machine Learning for Precision Weed Control. Available date: 1 March 2026, https://Bluerivertechnology.com

Çakır, A., & İşlek, F. (2021). Türkiye'nin Akıllı Tarım (Tarım 4.0) Potansiyeli. In K. Kökten & H. İnci (Eds.), Türkiye'de Organik Tarım Ve Agro-Ekolojik Gelişmeler (Pp. 155–174). İksad Yayınevi.

Demir, K. (2021). Cultivation Planning Across Europe Using Machine Learning Techniques. European Journal of Science and Technology, (21), 697–707.

Güman, Z., & Günay, F. B. (2024). Nesnelerin Interneti Yardımıyla Akıllı Tarımda Yapay Zekâ Tabanlı Gübre Ve Mahsul Tahmini. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 14(3), 958–973.

Gürbüz, M. B., Erbaş, Y., Ada, S., Karaşahin, E., Güven, E., & Eren, T. (2023). Tarımda Drone Seçimi Ve Çizelgelemesi: Kırıkkale Ili Örneği. All Sciences Proceedings, 838–869.

Karadeniz, A. T. (2024). Tarımda AI Kullanımı. AgriTR Science, 6(2), 145–152.

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine Learning in Agriculture: A Review. Sensors, 18(8), 2674. https://doi.org/10.3390/S18082674

Özer, B., Kuş, S., & Yıldız, O. (2022). Veri Madenciliği Yöntemleri Ile Tarımsal Veri Analizi: Bir Akıllı Tarım Sistemi Önerisi. Mühendislik Bilimleri Ve Tasarım Dergisi, 10(4), 1417–1429.

Öztürk, S., Ülküsoy, S. İ., & Atmaca, S. (2023). Tarım 4.0 Nesnelerin İnterneti Ve Veri Analitiği Modellemeli Otonom Sulama Sistemi. International Journal of Advanced Natural Sciences and Engineering Research, 7(2), 134–139.

Sachdeva, G., Singh, P., & Kaur, P. (2021). Plant Leaf Disease Classification Using Deep Convolutional Neural Network with Bayesian Learning. Materials Today: Proceedings, 45, 5584–5590.

Sevli, O. (2025). Tarımsal Verimliliği Artırmak Için Agro-Klimatik Koşullara Bağlı Olarak Makine Öğrenmesi Temelli Mahsul Tavsiye Sistemi. Uluslararası Sürdürülebilir Mühendislik Ve Teknoloji Dergisi, 9(1), 70–79.

Şahin, H. (2022). Dijital Tarım, Tarım 4.0, Akıllı Tarım, Robotik Uygulamalar Ve Otonom Sistemler. Tarım Makinaları Bilimi Dergisi, 18(2), 68–83.

Şahin, H. (2024). Tarımsal Akıllı Sulama Sistemlerinde Yapay Zekâ, Derin Öğrenme Ve Nesnelerin Interneti Uygulamaları. Tarım Makinaları Bilimi Dergisi, 20(1), 41–60.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big Data in Smart Farming – A Review. Agricultural Systems, 153, 69–80. https://doi.org/10.1016/J.Agsy.2017.01.023

Yaşar, M., & Yurtaslan, N. (2025). Tarımda Yapay Zekâ Çağı: Çok Katmanlı Dijital Dönüşümün Ekosistemsel Ve Operasyonel Boyutları. AgriTR Science, 7(2), 91–100.