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Implementation and adoption of smart technologies in agri-allied sectors

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Abstract

Together with livestock, horticulture and fishing, India's agriculture industry has successfully met government production targets and broken records in nearly every commodity category. Unfortunately, these industries have accomplished the targets at the expense of the deterioration of natural resources and adverse impact on the environment. Besides, being a cornerstone of global sustenance, these industries face multifaceted challenges ranging from resource scarcity to climate variability. The inclusion of smart farming combined with drones, artificial intelligence, robotics, robotic agricultural bots, cloud computing, wireless sensor networks, expert systems and the Internet of Things (IoT) to bring an effective change can be a better alternative. Integrating these technologies into farming facilitates improved managerial decision-making for all the stakeholders, resulting in increased yield. The benefits of AI adoption are multifaceted, encompassing heightened efficiency, reduced environmental impact and improved crop quality. Furthermore, the burgeoning agriculture-tech sector has the potential to stimulate economic growth and job creation. Looking ahead, emerging trends in robotics, machine learning and the IoT signify a dynamic future for AI in agriculture, heralding a transformative era for the industry. The study utilizes Systematic Literature Review (SLR) method, guided by the PRISMA technique, to develop a conceptual framework. A total of 28 documents published between 2010 and 2024 are included in the analysis. This paper aims to explore the various AI trends in these sectors, while thoroughly analysing the role of these techniques, as well as their challenges and prospects.

Keywords

artificial intelligence; digital; internet of things; precision agriculture; smart farming; sustainable management

Introduction

A revolutionary period in how we live, work and interact is being ushered in by the world's unprecedented rapid transition to smart technologies. Hi-tech technologies are revolutionising existing systems in a variety of industries through the integration of cutting-edge advancements like artificial intelligence (AI), data analytics and the Internet of Things (IoT). Industry 4.0 is transforming manufacturing through data-driven decision-making and automation of production processes. Precision agriculture uses sensors and drones to achieve sustainable farming methods, while the educational environment is embracing virtual classrooms and personalised learning experiences. This worldwide change is not just technological, rather, it is a paradigmatic progression towards intelligent, linked and efficient systems that promise increased productivity, better use of resources and an overall higher standard of living (1).

For agriculture to maximise resource utilisation and boost productivity, intelligent technology is crucial. Farmers can track crop health, soil conditions and weather patterns in real-time with the use of sensors, drones and Internet of Things devices (2). Precision farming is made possible by this data-driven strategy, which permits focused fertilisation, irrigation and pest management. Artificial intelligence and automated equipment further automate processes, saving labour and operating expenses. Precision farming, smart greenhouses, livestock management, agriculture drones and farm management systems are just a few of the uses for smart farming approaches (3).

Aquafarming sector has undergone a revolutionary change with the introduction of automated feeding systems for offshore aquaculture units that leverages technology to optimize feeding practices and minimize environmental impact (4). These systems use artificial intelligence, environmental sensors and real-time data analytics to precisely manage the operations like water quality management, feed management, disease management to increase sustainability, efficiency and precision of the aquaculture sector (5). These systems incorporate software platforms, automatic feeding machines, fish-feeding activity sensors, water quality monitoring systems, feeding management models and Internet of Things (IoT) technology (6).

Smart technology has also created a great impact on the livestock and horticulture industry. In horticulture, farmers can optimise resource utilisation by monitoring crop health, irrigation and soil conditions in real-time through the use of sensors and precision agriculture technologies (7). Data analytics and automated systems make better decisions by cutting down on waste and raising productivity. Smart technology makes it easier to remotely monitor the health, behaviour and environmental factors of livestock. Real-time data from wearable technology and smart tags facilitates early disease identification and productive breeding initiatives. All things considered, the incorporation of intelligent technology into horticultural and livestock operations results in more profitable, resource-efficient methods.

Materials and Methods

A Systematic Literature Review (SLR) methodology is used in the study to examine the studies on the adoption and use of smart technologies in agri-allied industries. This methodology was used because it takes a methodical approach to finding, assessing and synthesizing pertinent research. The literature is chosen and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) format, which ensures accuracy and transparency.

Table 1. Criteria for document selection

Criteria	Description
Research Question	• What are the smart technologies implemented in agri-allied sectors and how are they applied? • What aspects of agri-allied industries encourage or impede the use of smart technologies?
Inclusion Criteria	• Peer-reviewed articles • Research articles in English language • Between January 2010 to August 2024 • Articles focusing on smart technologies, AI, agriculture and allied sectors and livestock.
Exclusion Criteria	• Articles not meeting all the inclusion criteria • Book Chapters, review articles, etc. • Articles published initially in other language • Articles not available in full-text • Articles irrelevant to key thematic areas
Search Strategy	• Keywords: "Smart Technologies", "Artificial Intelligence", "Precision Agriculture", "Agri-allied Sectors", "Automation", "Internet of Things" • Boolean Operators: "AND" and "OR"

Data were collected from three sources, i.e., SCOPUS, IEEE Explorer and Google Scholar, using a search strategy (Table 1). Proper Inclusion and Exclusion criteria were followed. The documents were selected in four phases (PRISMA Format). A total of 1034 documents were identified in 1st phase of Identification, from which 63 duplicate articles were removed and 971 articles were selected for the screening phase. At this phase, 541 documents were removed after Title and Abstract screening. There are 430 documents left for the eligibility check. After full-text evaluation, 402 articles were excluded based on the availability of full-text documents and their relevance to the key thematic area. A total of 28 documents were included in the qualitative study, as represented in Fig. 1.

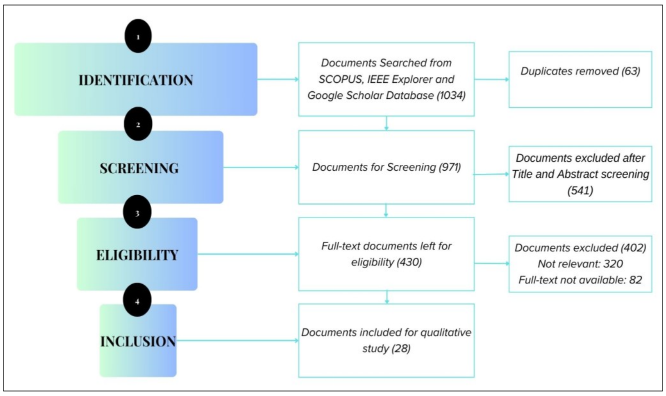

Fig. 1. PRISMA Flow diagram.

Application of AI in agriculture sector

Integration of AI and automated equipment with automated processes saves labour and operating expenses in the farming process. Smart agriculture promotes sustainability by reducing its negative effects on the environment, saving resources and increasing yields. In a world that is changing quickly, farmers may increase productivity, make well-informed decisions and contribute to global food security by leveraging technology. An attempt to investigate how automation, linked devices and IoT will revolutionize agriculture and greatly enhance almost every aspect of it (8). Modern precision agriculture solutions, presented in Table 2 are made possible by the application of cutting-edge technology like the Internet of Things, which revolutionizes conventional agricultural methods like irrigation. The ARETHOU5A IoT platform stands as the premier intelligent irrigation system for precision agriculture, delivering unparalleled efficiency and maximizing crop productivity (2).

Table 2. Different AI technologies in agriculture

Technique	Strength	Limitation	Reference
•Global navigation satellite system (GNSS) •Geographic information systems (GIS)	•Precision agriculture uses technologies to collect and analyze spatial variability data. •It enables farmers to make site-specific management decisions for soils and crops.	-NA-	(10)
Wireless Sensor Networks (WSN) and Internet of Everything (IoE)	•The system provides real-time data on soil parameters for informed decision-making. •The system is built incrementally using Agile and Waterfall methods.	•Time-consuming and costly soil sample analysis. •Difficulty in replicating sampling due to funding constraints.	(11)
•Bibliometric review using Scopus database •Analysis conducted with VOSviewer software	•Smart farming increases efficiency, quality, speed and reduces costs and waste. •The use of information technologies and sensors optimize productivity and reduce resource waste.	-NA-	(25)
Innovative soil-crop management systems	Millions of practitioners, scientists and interested parties actively experimenting and collaborating.	•No template or set of procedures for climate smart sustainable agriculture. •Success depends on location, scale, types of production and farmer's objectives.	(26)
Digital imaging-based Artificial Intelligence (ML and DL)	Smart intelligent techniques in crop and soil monitoring.	Need for integrating hybrid AI and reinforcement learning techniques for agricultural monitoring and management	(12)
•Convolutional Neural Network model •Image augmentation approaches to eliminate overfitting problem	Achieved a testing accuracy of 94 % for disease classification.	Limited to wheat crop only.	(27)
Convolutional Neural Networks (ResNet50, MobileNetV2 and InceptionV3)	Better classification of weed with better accuracy.	Requires a fast internet connection.	(28)
Utilization of YOLO v5 model for weed detection and mapping	•YOLO v5 model enables detection, recognition and mapping of weeds. •AI technology assists farmers in the process of weed management.	-NA-	(29)

Smart technologies are being used in agriculture to improve soil management. These technologies include of sensors, the Internet of Things (IoT) and wireless sensor networks (WSN) (9). Data on the composition of the soil, including its organic matter, moisture content and nutrient content, are gathered using sensors (10). After that, this data is sent to cloud-based systems for analysis and visual aids (11). Intelligent agricultural and soil monitoring systems based on digital images are also being employed, such as machine learning and deep learning (12). Crop diseases are being detected and predicted by smart farming systems using Artificial Intelligence (AI) and Internet of Things (IoT) sensors based on visual indications.

Applications of AI in horticulture sector

India's diverse soil, temperature and agroecological zones offer the provision to cultivate many horticultural crops. Horticultural crops benefit a balanced diet and possess some aesthetic benefits (13). With the development of modern society, horticulture crops serve a social and economic purpose by influencing human lifestyles, enhancing the beauty of surrounding landscapes and forming human culture (14). Horticultural researchers must focus on new technologies to meet the constant demands and obstacles, improve orchard management decisions and transform horticultural productivity. Thus, the main objective of artificial intelligence-infused horticulture is to produce high-quality fruits, vegetables and decorative crops while utilizing cutting-edge technology, tools and systems to minimize the need for human labour and increase its effectiveness (15). Artificial intelligence technologies aid in the production of healthier crops, organize data for farmers, reduce the workload and improve the food supply chain and different technologies are represented in Table 3. They also provide information on current weather conditions, including temperature, rain, wind speed, wind direction, solar radiation, pest control and soil and growing conditions (6).

The creation of intelligent systems based on modern computer technologies and data analysis techniques has opened up fantastic prospects to enhance horticultural crop management and production. Modern methods have been widely used to gather various types of digital information from horticultural crops, such as remote sensing, which is carried out by unmanned aerial vehicles (UAVs) and satellites, the Internet of Things (IoT), thermal and near-infrared cameras, artificial neural network, fuzzy logics and X-ray imaging technology (16). Some recent development includes the application of some advanced models which enable the researchers to track crop growth and also implement the best possible management practices to maximize the growth process (13).

Application of AI in aquaculture sector

Artificial intelligence and fish farming together have led to a significant surge in this sector. Automated feeding systems, a widely used AI technique in fisheries helped to increase sustainability and efficiency and the discussion of other technologies is thoroughly covered in Table 4. Smart feeding systems minimise waste and environmental effects by optimising feed distribution through continuous monitoring

Table 3. Different AI technologies in horticulture

Technique	Strength	Limitation	Reference
Real-time Kinematic-Global Positioning System (RTK-GPS) based vegetable transplanter	The system can generate extremely precise maps of crop plant locations for use in subsequent centimetre-scale precision plant care procedures.	It depends on a stable data link between the mobile device and the base station, which might be hampered by inadequate cellular coverage.	(13)
Variable Rate Irrigation (VRI)	•It optimizes crop performance and input use by matching application rates to crop requirements and soil type. •The effective use of a finite resource and good crop output in vegetable cropping systems depend on the exact water control.	Technical expertise and initial investment.	(30)
Precision Mechanical Weeder	By chopping off the weed's stem and wiping, the direct chemical application end effector is utilized to provide chemical via the vascular tissue of the plant directly.	High computational capacity for inference in real time and training.	(13)
Two-row tractor operated laser sensor based site-specific herbicide applicator	It was first created at ICAR-CIAE, Bhopal. The designed herbicide applicator consists of two parts: the applicator part, which has a controller, solenoid valve and nozzles for applying herbicide and a laser sensor for detecting interrow weeds. The laser sensor has been trained to detect green colour at a +10 % threshold.	The sensor's training and calibration is necessary for colour recognition and differences in the same colour's hues had an impact on identification.	(31)
Microcontroller based contact type variable rate herbicide applicator	IIT Kharagpur developed it. Using real-time image processing, the system calculates automatically how much herbicide should be administered to the weeds that are there. The amount of herbicide provided is based on weed density approach.	NA	(32)
Automated Harvesting System	A machine vision control system for identifying the fruits on the tree is part of an automated harvesting system. A colour camera is fixed in the vision control system, which gives the control system information on the position and separation of the fruits.	Poor intelligence, high initial cost and low efficiency prevent it from reaching the commercialization level.	(33)
Automated Yield Monitoring System	Colour cameras, a laptop computer, a real-time kinematics global positioning system and customized software make up an automated yield monitoring system that is installed on a Specialized Farm Motorized Vehicle (SFMV) to enable real-time mapping of fruit production.	More study is needed to make it extensively commercialized.	(34)

of variables like fish behaviour, water quality and nutritional needs. Fish diet optimisation and adaptive feeding are made possible by the combination of image processing and fish behaviour monitoring, which reduces food waste (4). Fish producers can make well-informed decisions quickly thanks to the incorporation of IoT technology, which enables remote control and monitoring of critical parameters like water temperature, pH levels, dissolved oxygen and fish health. Reducing overfeeding and fostering the general well-being and development of aquatic animals not only improves operational efficiency but also advances sustainable practices. Furthermore, to manage and keep an eye on fish tanks, researchers have developed aquaponic monitoring systems with smart automation (17). These systems may give users messages and regulate parameters like temperature, humidity and water level (17).

Smart technology is also revolutionising traditional processes in fishery farming by improving water quality monitoring. Real-time data collection is made possible by sophisticated sensors and Internet of Things (IoT) devices, providing instantaneous insights into critical factors including pH levels, dissolved oxygen, temperature and nutrient concentrations. Additionally, they offer remote access to the data via computer or smartphone graphical user interfaces, or GUIs. Besides, convolutional neural networks (CNN), a type of deep learning technology, are being used to reliably classify fish behaviour into distinct categories, such as normal and starving (18).

Application of AI in livestock sector

The livestock industry is not an exception to the way artificial intelligence is transforming every aspect of modern life. It is highly anticipated that the integration of biological knowledge and technological innovation in contemporary technology will lead to a significant breakthrough in the livestock industry (19). In fact, over the past decades, precision farming in the livestock industry has advanced which incorporates remote monitoring, contemporary sensor -based data collection, fast data transfer and massive data storage via the Internet of Things (IoT) and details are outlined in Table 5. Modern farms using AI techniques are expanding remarkably because they have reduced labour costs and increased animal production efficiency while also minimizing physical effort (20).

AI is applied to numerous livestock production domains, such as the quantity and quality of pasture forage measured by air and satellite, physiological evaluations and body weight and composition, on-animal devices that track movements, locations and activities in grazing and foraging environments, swift detection of lameness and other diseases, yield and composition of milk, assessments of calving illnesses and reproductive health, feed intake and greenhouse gas emissions (21).

Impact of utilizing AI in livestock farming

Aerial management: Using computer vision-equipped drones to manage livestock is one of the most amazing uses of AI in

Table 4. Different AI technologies in aquaculture

Technique	Strength	Limitation	Reference
Multi-factor feeding system based on IoT technology Evaluation of fish growth, feed conversion rate and waste discharge	The web-based multi-factor intelligent precision feeding system improves fish growth. The system reduces feed consumption and discharge of nitrogen and phosphorus wastes.	Complications while using	(6)
Adaptive smart fish feeding with image processing based on fish behaviors Smart software algorithm proposed for fish feeding and development	Smart fish feeding system aims to minimize food waste and increase food conversion ratio. The system reduces feed wastage, user involvement and operational costs.	Use of antibiotics and risk of feed poisoning, Competition among the fish	(5)
WIFI wireless transmission network	The system uses WIFI wireless transmission network and various monitoring sensors.	-NA-	(35)
Smart automation aquaponic monitoring system using sensors and microcontroller Data stored in the cloud and retrieved via smartphone application (Blynk)	The smart automation aquaponics monitoring system helps reduce manpower and operation costs. The system allows users to monitor and control parameters through a smartphone application.	-NA-	(17)
Deep Convolutional Neural Network (DCNN) algorithm	Computer vision and DCNN algorithm successfully detect fish diseases. Achieved a satisfying mean average precision (mAP) of 0.237.	Manual process of detecting fish diseases prone to human error.	(36)
Biosensor technology combining biocatalytics and electronics to measure fish health indicators.	Biosensors can rapidly and easily measure indicators of fish health. Biosensors can provide real-time data on fish stress and physiological state.	Sampling errors, uncontrollable aquaculture conditions and unsound methodological approaches.	(37)

Table 5. Different AI technologies in livestock

Technique	Strength	Limitation	Reference
Structured light illumination	To monitor animal feed intake, structured light illumination (SLI) and time of flight techniques are utilized which comprised of a camera and a light projector. Images of the light patterns in the scene under observation are projected using the projector.	At present, SLI systems can only operate indoors, away from direct sunlight.	(38)
Calibrated stereo cameras	By using triangulation and analysing the difference between corresponding points, several cameras set up in a calibrated stereo arrangement can be utilized to derive depth information about the objects.	Using multiple cameras can be impractical.	(39)
Artificial neural networks	The method makes use of marker-based genomic prediction of complicated traits. Without specifically defining a genetic model, it can capture enigmatic correlations between single nucleotide polymorphisms (SNPs) and phenotypic values.	As whole genome marker sets are used, computational costs gradually become higher.	(40)
Decision Support Tools for early detection of lameness	Data-driven decision support tools assist farmers in taking action to promote animal health and higher product yield by identifying diseases and the approach is based not just on real-time data but also on expert knowledge.	Relatively costly.	(41)
Radiofrequency identification device (RFID)	Animals are identified electronically if they carry a device tag called radio frequency identification, which records a unique number allocated to the device. By continuously transmitting radio waves, it uses electromagnetic fields to automatically identify the tag.	This approach has a complex working mechanism.	(19)
Infrared temperature measurement	The technique combines real-time, long-range, non-invasive body temperature monitoring.	This contact temperature measurement technique may cause stress in the animal.	(42)
Biometric method	It is a non-invasive approach that utilizes AI and computer vision-based technologies to identify animals since it finds any physical, anatomical, molecular, or quantitative characteristic that can be used to uniquely identify and confirm an animal.	The output can be variant.	(43)

this field. These drones fly over vast fields and farms, surveying animal populations on their own. Their ability to reach far-off places and cover wide areas makes them significant. Drones that are integrated with AI systems can quickly notify herd management when an animal goes missing, enhancing the herd's security and safety (22).

Monitoring health and well-being: AI models are essential for keeping an eye on livestock health and spotting symptoms of disease or damage. These models are made in a way to identify abnormal movements, which are frequently the first signs of animal health issues. The ability to spot problems early allows herd managers to take quick action to stop the spread of disease (23).

Feeding rates: Herd managers use this technology to evaluate the feeding habits of each animal and keep a careful eye on its health. Reduced feeding rates may indicate ill health and allow for early intervention.

SWOT analysis of inclusion of AI in agriculture and allied sectors

The terms artificial intelligence (AI) and agriculture may have appeared like a strange mix until recently. The farming process has undergone a revolution due to the swift progress in agricultural technology with AI in recent times. The sustainability of our food system is being threatened by global issues like population increase, climate change and resource scarcity, thus these technologies are becoming more and more important. By introducing AI, many problems are resolved and the negative aspects of traditional farming are lessened. With so many advantages (strengths) these technologies possess some internal challenges (weaknesses) and some external challenges (threats) too. However, the opportunities that AI-infused techniques can bring are undeniable. A precise analysis of the strengths, weaknesses, opportunities and threats of these technologies is described in Fig. 2.

Future aspects

Autonomous farm machinery: Automated farming equipment using AI and robotics along with other intelligent technologies will reduce manpower requirements and increase operational efficiency. Robotic harvesters and autonomous tractors boost productivity by mechanizing tasks including planting, harvesting and sorting (23).

***Blockchain for supply chain transparency*:** The implementation of blockchain technology in the agricultural supply chain will improve traceability and transparency, guaranteeing product authenticity and giving consumers comprehensive information about the food's origins (7).

***Augmented Reality (AR) for training and maintenance*:** Through the provision of virtual overlays for equipment operation and repair, step-by-step instructions and troubleshooting advice, augmented reality applications will help farmers with training and maintenance activities (24).

***Collaborative platforms for knowledge sharing*:** Digital platforms will make it easier for farmers, academics and business leaders to collaborate, building a worldwide network for the exchange of agricultural knowledge, innovations and best practices.

***Customized farming solution*:** With AI, farming operations can be tailored to particular farm needs, crop varieties and unique regional conditions, maximizing resource efficiency and minimizing environmental effects.

Conclusion

Artificial intelligence is becoming an intrinsic part of our everyday lives as it is a dynamic, important technology that is developing more quickly than anticipated and the farming industry is not an exception. Agriculture and allied industries have completely changed as a result of the inclusion of artificial intelligence, which offers massive advantages. AI coupled with big data analysis, the Internet of Things (IoT), expert systems and neural networks leads to precision farming, which integrates fewer resources to produce higher-quality and better yield while also helping producers with automated farming and culture. AI adoption in agricultural management is essential for a robust and sustainable future, it is not merely a technological trend. The agrarian community will become more productive, knowledgeable and connected as a result of the use of AI infrastructure in farming. They will also be able to provide analysts with enormous volumes of data about crop yields, soil maps, fertilizer applications, weather information, machinery and animal health. Further, a few initiatives have been started to investigate the application of AI at the edge of Internet of Things networks and the preliminary findings are quite

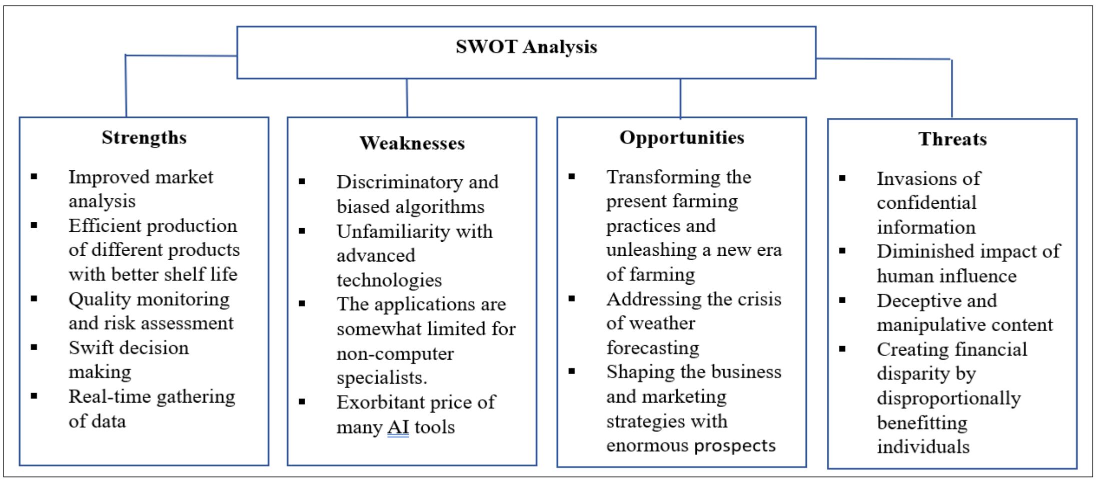

Fig. 2. SWOT analysis of inclusion of AI in agriculture and allied sectors.

encouraging. More advanced sensor and data analytics algorithms, the use of AI and machine learning to automate decision-making and the incorporation of blockchain technology to enhance supply chain transparency and traceability are some of the future developments in smart agriculture technologies that are expected to occur. Nevertheless, the constraints of data accuracy, reluctance to adopt technologies, funding and computational expertise need to be addressed with effective planning and research.

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Authors' contributions

AKP and PS conceptualized the study, while AKP and SS developed the methodology. All authors validated the work, with PS and ND carrying out the analysis. All the authors contributed to writing the original manuscript and data curation, while AKP and SS reviewed and edited the final version. All the authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors of this paper declare that they have no conflicts of interest associated with this paper.

Ethical issues: None

References

1. Bandhana D, Sharma NA. IoT and its significance on smart technologies in the health sector-An extensive review. In: 2022 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE). 2022. pp. 1–8. IEEE. https://doi.org/10.1109/CSDE56538.2022.10089253
2. Boursianis AD, Papadopoulou MS, Gotsis A, Wan S, Sarigiannidis P, Nikolaidis S, et al. Smart irrigation system for precision agriculture-The AREThOU5A IoT platform. IEEE Sensors J. 2020;21(16):17539–47. https://doi.org/10.1109/JSEN.2020.3033526
3. Sivakumar R, Prabadevi B, Velvizhi G, Muthuraja S, Kathiravan S, Biswajita M, et al. Internet of things and machine learning applications for smart precision agriculture. IoT Appl Computer; 2022. p. 135–65. https://doi.org/10.5772/intechopen.97679
4. Karningsih PD, Kusumawardani R, Syahroni N, Mulyadi Y, Saad MSBM. Automated fish feeding system for an offshore aquaculture unit. In: IOP Conference Series: Materials Science and Engineering. 2021;1072(1):012073. https://doi.org/10.1088/1757-899X/1072/1/012073
5. Jeyabharathi D, Divyadharshini M, Haripriya SP. Smart fish feeding system based on fish feeding intensity. In: 2022 7th International Conference on Communication and Electronics Systems (ICCES). 2022. pp. 1491–96. IEEE. https://doi.org/10.1109/ICCES54183.2022.9835981
6. Liu X, Zhang C, Du K, Sha Z, Luo Y, Wang CF. Application of a web -based multi-factor intelligent precision feeding system for fish. Energy Environ Sci. 2023. p. 1–15. https://doi.org/10.1039/C8EE02656D
7. Boogaard FP, Rongen KSAH, Kootstra GW. Robust node detection and tracking in fruit-vegetable crops using deep learning and multi-view imaging. Biosys Eng. 2020;192:117–32. https://doi.org/10.1016/j.biosystemseng.2020.01.023
8. Khanna A, Kaur S. Evolution of Internet of Things (IoT) and its significant impact in the field of precision agriculture. Comp Electr Agri. 2019;157:218–31. https://doi.org/10.1016/j.compag.2018.12.039
9. Rani R, Kaur G, Singh P. Smart soil monitoring system for smart agriculture. In: Artificial Intelligence and IoT-Based Technologies for Sustainable Farming and Smart Agriculture. 2021. pp. 213–29. IGI Global. https://doi.org/10.4018/978-1-7998-1722-2.ch013
10. Shaheb MR, Sarker A, Shearer SA. Precision agriculture for sustainable soil and crop management. In: Soil Science-Emerging Technologies, Global Perspectives and Applications. Intech Open. 2022.
11. Mbandi J. Soil data collection using wireless sensor networks and offsite visualization: case study of the innovative solutions for digital agriculture project in Kenya [Doctoral dissertation]. NM-AIST; 2021. https://doi.org/10.21227/v2m5-qs54
12. Kumar SV, Parvathi SU. Computational intelligent systems for crop and soil monitoring through digital imaging: A survey. In: Gupta R, Jain A, Wang J, Bharti S, Patel S, editors. Artificial Intelligence Tools and Technologies for Smart Farming and Agriculture Practices; 2023. p. 1–21. https://doi.org/10.4018/978-1-6684-8516-3.ch001
13. Tiwari PS, Sahni RK, Kumar SP, Kumar V, Chandel NS. Precision agriculture applications in horticulture. Pantnagar J Res. 2019;17(1):1–10.
14. Kondratieva OV, Fedorov AD, Slinko OV, Voytyuk VA, Alekseeva SA. New solutions in the horticultural industry. In: IOP Conference Series: Earth and Environmental Science. 2022;1010(1):012103. https://doi.org/10.1088/1755-1315/1010/1/012103
15. Kumar V, Jakhwal R, Chaudhary N, Singh S. Artificial intelligence in horticulture crops. Annals of Horti. 2023;16(1):72–79. https://doi.org/10.5958/0976-4623.2023.00014.2
16. Haokip SW. Advanced horticulture with Artificial intelligence (AHAI). 2020;2(2):365–69.
17. Abdullah MST, Mazalan L. Smart automation aquaponics monitoring system. JOIV: Int J Info Visual. 2016;6(1-2):256–63. http://doi.org/10.30630/joiv.6.1-2.925
18. Iqbal U, Li D, Akhter M. Intelligent diagnosis of fish behaviour using deep learning method. Fishes. 2022;7(4):201. https://doi.org/10.3390/fishes7040201
19. Aharwal B, Roy B, Meshram S, Yadav A. Worth of artificial intelligence in the epoch of modern livestock farming: A review. Agri Sci Digest-A Res J. 2023;43(1):1–9. https://doi.org/10.18805/ag.D-5355
20. Chimakurthi VNSS. Implementation of artificial intelligence policy in the field of livestock and dairy farm. Ameri J Trade Policy. 2019;6(3):113–18. https://doi.org/10.18034/ajtp.v6i3.591
21. Niloofar P, Francis DP, Lazarova-Molnar S, Vulpe A, Vochin MC, Suciu G, et al. Data-driven decision support in livestock farming for improved animal health, welfare and greenhouse gas emissions: Overview and challenges. Comp Electr Agri. 2021;190:106406. https://doi.org/10.1016/j.compag.2021.106406
22. Kumari P. 6 Smart animal livestock management using vision AI. Labelling Made Easy; 2023.

23. Prabha C, Pathak A. Enabling technologies in smart agriculture: A way forward towards future fields. International Conference on Advancement in Computation and Computer Technologies; 2023. p. 821–26. https://doi.org/10.1109/InCACCT57535.2023.10141722

24. Eli-Chukwu NC. Applications of artificial intelligence in agriculture: A review. Eng Technol Appl Sci Res. 2019;9(4). https://doi.org/10.48084/etasr.2756

25. de Souza JS, dos Reis JGM, da Cruz Correia PF, Rodrigues GS. A bibliometric overview over smart farming. Chem Proceed. 2022;10(1):28. https://doi.org/10.3390/IOCAG2022-12327

26. Swami S. Innovative soil-crop management systems for climate-smart sustainable agriculture. J Environ Bio. 2023;44(3):I-II.https://doi.org/10.22438/jeb/44/3/Editorial

27. Jouini O, Sethom K, Bouallegue R. Wheat leaf disease detection using CNN in smart agriculture. International Wireless Communications and Mobile Computing; 2023. p. 1660–65. https://doi.org/10.1109/IWCMC58020.2023.10183348

28. Suriya DS, Latha AH. Weeds classification using convolutional neural network architectures. J Soft Comp Parad. 2023;5(2):116–33. https://doi.org/10.36548/jscp.2023.2.003

29. Doddamani PK, Revathi GP. Detection of weed and crop using YOLO v5 algorithm. In: 2022 IEEE 2nd Mysore Sub Section International Conference (MysuruCon). 2022. pp. 1–5. IEEE. https://doi.org/10.1109/MysuruCon55714.2022.9972386

30. Osroosh Y, Peters RT, Campbell CS, Zhang Q. Comparison of irrigation automation algorithms for drip-irrigated apple trees. Computers and Electronics in Agriculture. 2026;128:87–99. https://doi.org/10.1016/j.compag.2016.08.013

31. Agrawal KN, Singh K, Tiwari PS, Chandra MP. Laser sensor-based tractor mounted herbicide applicator. In: Proceedings 2012 national conference on agro-informatics and precision agriculture (AIPA). 2012. pp. 183–85.

32. Tewari VK, Kumar AA, Nare B, Prakash S, Tyagi A. Microcontroller-based roller contact type herbicide applicator for weed control under row crops. Computers and Electronics in Agriculture. 2014;104:40–45. https://doi.org/10.1016/j.compag.2014.03.005

33. Zhao Y, Gong L, Huang Y, Liu C. A review of key techniques of vision-based control for harvesting robot. Computers and Electronics in Agriculture. 2016;127:311–23. https://doi.org/10.1016/j.compag.2016.06.022

34. Das J, Cross G, Qu C, Makineni A, Tokekar P, Mulgaonkar Y, Kumar V. Devices, systems and methods for automated monitoring enabling precision agriculture. In: IEEE International Conference on Automation Science and Engineering. 2015. p. 462–69. https://doi.org/10.1109/CoASE.2015.7294123

35. Ya'acob N, Dzulkefli NNSN, Yusof AL, Kassim M, Naim NF, Aris SSM. Water quality monitoring system for fisheries using Internet of Things (IoT). Conference Series: Materials Sci Eng. 2021;1176(1):012016. https://doi.org/10.1088/1757-899X/1176/1/012016

36. Yasruddin ML, Ismail MAH, Husin Z, Tan WK. Feasibility study of fish disease detection using computer vision and deep convolutional neural network (dcnn) algorithm. In: IEEE 18th International Colloquium on Signal Processing and Applications. 2022. p. 272–76. https://doi.org/10.1109/CSPA55076.2022.9782020

37. Endo H, Wu H. Biosensors for the assessment of fish health: a review. Fisheries Sci. 2019;85:641–54. https://doi.org/10.1007/s12562-019-01318-y

38. Tedeschi LO, Greenwood PL, Halachmi I. Advancements in sensor technology and decision support intelligent tools to assist smart livestock farming. J Animal Sci. 2021;99(2):1–11. https://doi.org/10.1093/jas/skab038

39. Bloch V, Levit H, Halachmi I. Assessing the potential of photogrammetry to monitor feed intake of dairy cows. J Dairy Res. 2019;86(1):34–39. https://doi.org/10.1017/S0022029918000882

40. Khanikar D, Phookan A, Gogoi A. Artificial neural networks- An introduction and application in animal breeding and production: A review. Agricultural Reviews. 2022. p. 1–8. https://doi.org/10.18805/ag.R-2421

41. Alsaaod M, Fadul M, Steiner A. Automatic lameness detection in cattle. The Vet J. 2019;246:35–44. https://doi.org/10.1016/j.tvjl.2019.01.005

42. Murugeswari S, Murugan K, Rajathi S, Kumar MS. Monitoring body temperature of cattle using an innovative infrared photodiode thermometer. Computers and Electronics in Agriculture. 2022;198:107120. https://doi.org/10.1016/j.compag.2022.107120

43. Singh A. Role of biometric identification in cattle management. Mantra Innovation That Counts; 2020.