SMART FARMING USING THE BIG DATA-DRIVEN APPROACH FOR SUSTAINABLE AGRICULTURE WITH IOT-DEEP LEARNING TECHNIQUES

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Abstract. The study showcases the process of deep learning operated in agriculture, including Deep IoT, which makes the procedure easier using the deep neural system. The use of the IoT in the agrarian sectors makes the evolution of firms more effective. The application of the IoT detector supports the making of grade derivatives in the husbandry department. Marketing of crop finance is two other operations of smart agriculture that help for better harvest farming. Through the IoT technology in the farming industry, agriculturalists can get notifications about the temperature and climate. The method needs professional and qualified employees in the division to properly monitor the system and the methods.

The submission of the proper nourishment for the proper crop increases the life duration of the harvest and makes the crop free from menace. The velocity of the manufacture of undeveloped items can also be improved by using the IoT. The function of the BDA and IoT has enlarged for the healthier construction of farming items. The foreword of elegant farming in the rural industry requires more capable and qualified trainers to give the personnel proper teaching. The urbanization of the farming process and the use of elegant and modern technology are well-designed in the time of "Agriculture 3.0."

Key words: Big-data-driven approach, IoT, smart farming, Sensor technologies, deep learning, Agriculture etc.

1. Introduction. The big-data-driven approach or BDA is a process by which a decision is taken with the help of the observation of the data by the complex data. With the help of the IoT, the improvement in agriculture has increased [22]. The algorithm process in deep learning used in agriculture includes DeepIoT, which makes the process more accessible using the deep neural system. The IoT helps to connect the devices to the internet, which is helpful for the better performance of the system. UAV used in the IoT technology is one of the most effective for the agricultural department.

The main advantageous of smart farming are as follows,

1. Automation of tasks like planting, harvesting, and irrigation reduces the need for manual labor, resulting in increased efficiency and reduced labor costs.
2. Precision application of fertilizers, pesticides, and water ensures that resources are used more efficiently.
3. Smart farming technologies enable farmers to monitor and control various environmental factors such as soil moisture, temperature, and nutrient levels, leading to better crop management and higher yields.
4. Early disease detection and pest control help protect crops, ensuring a more abundant harvest.
5. Reduced use of resources such as water and chemicals lead to a more sustainable and environmentally friendly farming approach.

Smart farming, also known as precision agriculture, is an innovative approach to farming that leverages technology to enhance productivity, efficiency, and sustainability in agriculture. It involves the use of various technologies such as sensors, automation, data analytics, and connectivity to optimize various aspects of farming.

2. Objectives.
1. To understand the approach of BDA in smart farming
2. To find the feasible techniques of BDA that are helpful for the agricultural department
3. To determine the issues of the use of the IoT process in smart farming
4. To estimate the future effectiveness of deep learning in the agricultural department
5. To assess the effectiveness and impact of the use of modern technology in the farming department

The main motivation behind the research is ,

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1. The primary motivation is to improve the efficiency and effectiveness of agriculture. The use of deep learning and IoT technologies in agriculture is seen as a way to streamline various processes and make them more efficient, leading to better outcomes in terms of crop yield, quality, and resource utilization.
2. The research aims to explore the application of the Internet of Things (IoT) in the agricultural sector. IoT can offer real-time monitoring and data collection capabilities, which are vital for precision agriculture. The motivation is to leverage IoT technology to enhance decision-making and overall farm management.
3. The study seeks to contribute to the evolution of agricultural practices and the agricultural industry as a whole. It recognizes that modern technology, such as IoT and deep learning, can lead to more advanced and effective farming methods and help agricultural firms progress.

3. Methodology. The use of a vast number of data and information used in the study is helpful for the analysis of the impact of the IoT in smart farming. The data and information are collected from various kinds of secondary sources like the internet, journals, and articles. The application of the IoT in the agricultural department makes the growth of firms more convenient [13]. The secondary method used in the study is beneficial for analyzing the impact of deep learning in smart farming.

3.1. The approach of BDA in smart farming. Different approaches and techniques are used in the BDA, which are effective for smart farming in the present day. The application of the water cycles, the rainfall patterns and the fertilizer requirements are the most effective and valuable for smart learning [26]. Smart farming is the process of farming that uses advanced techniques and IoT technologies for the better growth and development of agricultural items. Applying artificial intelligence techniques is also a helpful tool for the smart farming process.

3.1.1. The approach used in the intelligent farming. There are many kinds of factors and techniques that are used in smart farming for the better quality of the products. ***Sensor technologies*** are crucial techniques for managing the temperature and other natural factors used in intelligent farming [12]. The ordinance of the IoT sensor helps the making of quality products in the agriculture department.

The process of integration of the smart technique is the main factors of the implementation of the new and innovative technique in the smart farming. The upgradation of the traditional methods and enhancement of the quality and production of agricultural products is another factor of the smart farming technology. The communication process and use of innovative technology is the one of the most helpful approaches for the development of the process of smart farming [11]. There are various kinds of methods and techniques of the smart farming like precession farming, aquaponics, hydroponics and the vertical farming.

The use of the different kinds of techniques is different and the application of this techniques increase the efficiency of the methods and also reduce the workload of the farmers. The popularity of the above techniques and methods gaining increasingly day by day among the farmers. The application of this techniques in the farming sector also reduces the effort of the workers which leads to the increment of the rate of requirement of the employees in the business.

From the figure 3.1, it can be said that the core process of the smart operation of smart farming is the storage of the data in the data cloud and the proper analysis of the data and information [28]. The constellation of the process and the planning of the farming of the crop have to be done by the proper verification by the IoT technologies [10]. Marketing and the insurance of crop finance are two other operations of smart farming that help for better farming of the crop [17]. Therefore, the proper implementation of the techniques and avoidance of the traditional practices and processes become helpful for the enhancement of smart farming in the present day.

The figure 3.2 shows that the yield prediction and the prediction of the weather affect the growth of the farming of agricultural items. The processing of the data and the analysis of the information help to increase the production of farming items [23]. The analysis of the data related to the quality of soil and the weather are two effectives for better farming. The improvement of the communication process is smart farming and the recruitment of skilled workers helps to implement the process in the growth of the agricultural items in the farming industries [2]. Therefore, the techniques and approaches that are used in the BDA for smart farming are useful for enhancing sustainability in the agricultural department.
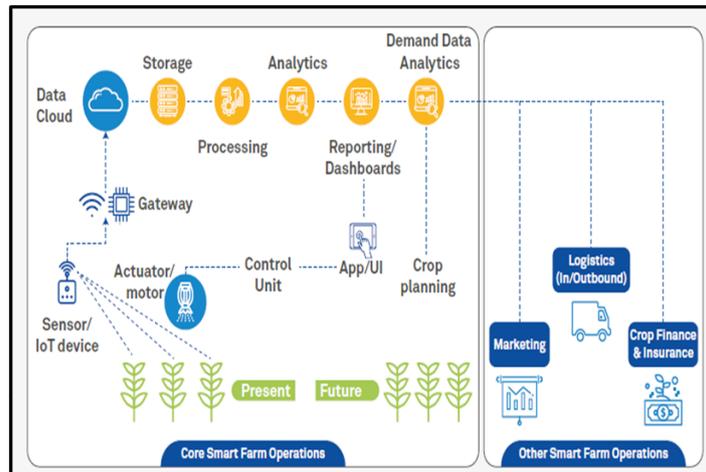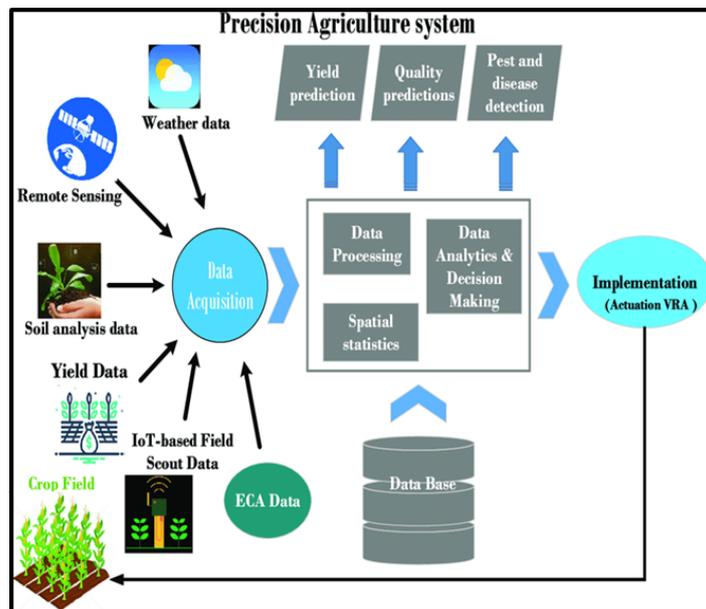
Fig. 3.1: The process of smart farming

Fig. 3.2: Representation of the big data in smart farming

3.2. Techniques of BDA for the agricultural department. Different kinds of techniques and process are used in the agricultural industries for making a revolution in the industry. From the year 1890 to the year 2020, the agricultural department faced various kinds of revolution in the department. The implementation of the machine in the agricultural department was shown from the year 1890 to the year 1940 [24]. For farming, the proper knowledge of the climate and weather is very important to increase the rate of farming in a particular area [1]. With the help of IoT technology in the farming industry, farmers can be able to get information about the weather and climate. The use of the smart farming sensor becomes beneficial for knowing the condition of the weather.
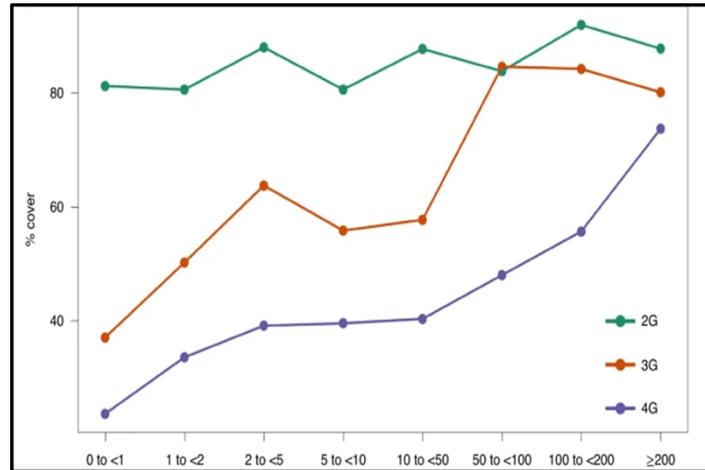
Fig. 3.3: Data-driven farming in the world

3.2.1. Livestock monitoring. Enabling the livestock monitoring process by using the tag or collar on the animals, the health condition, location and blood pressure and many other things of the animal can be detected. This device and the process is helpful in the agriculture sector and helps the farmers to understand the unhealthy things that is out of the range of normal factors. With the help of the livestock monitoring process the farmers can be able to understand the viral illness of the animal and after the detection they can be able to take the proper step according to the level. Other than the detection of the health of the animal, the monitoring system is also affective for the tracking of the GPS for collecting the historic data and information about the grazing place.

The main benefits and effectiveness of the livestock monitoring process are:

1. The analysing of the time to give birth of the animals and determining the breeding
2. Tracking of the patterns of grazing and the appropriate place for grazing
3. Determining the condition of health of the animals
4. Analysing the data and information that are historic

With the help of smart technologies like IoT technologies and the BDA, the process of smart farming becomes easier. Through the process of livestock monitoring, the health of the animals can be determined [21]. The detention of the diseases of the animals and the process of recovery of the animal from the diseases can be easily estimated by the above process.

3.2.2. Greenhouse automation. One of the most impactful and effective technologies in smart farming is the process of the greenhouse automation. With the use of the BDA and IoT technologies, the detection of the level of greenhouse gases becomes easier for farmers [5]. The future detection of the condition of the soil and the level of humidity can be estimated with the help of this process. In the process of BDA, the detection of the weather using the smart weather station is also useful to understand the condition of the weather for better farming.

The figure 3.3 shows the range of the usage of the data-driven process globally. Most of the countries in the world use the 2G data for smart farming and the range of 80% of the cover of the data is from 100 to 200. The usage of the 4G data is in the range below 40% and for the range greater than 200, 60% of the 4G data is used. The use of the various new and innovative technologies in the agricultural sector helps to errs the effect of the greenhouse gases in the present days. The data and information that are used in this sector are collected from the internet and the authentic sources helps to emission the effect of the greenhouse and harmful gases. The technique of the data-driven in the agricultural sector helps to automate the harmful impact of the harmful emission. The installation of the software technologies and the automated actions helps to decrease the temperature in the environment with the opening of the process of ventilation. Thus, the controlling of the

temperature under the greenhouse automation is useful for the improvement of the works in the agriculture department.

4. Issue of the IoT process in smart farming. The use of the IoT in smart farming also includes some issues and problems in agriculture. The common issue with the use of the IoT in smart farming is the lack of skilled and knowledgeable workers in the IoT [14]. The scarcity of skilled workers in this sector made a negative impact on the application of various kinds of methods and technologies for better work in the process of smart farming [25]. The IoT system in smart farming is mainly used for the monitoring of the use of the sensor and the analysis of the automotive irrigation system [20]. Thus, the process needs more experienced and skilled employees in the department for the proper monitoring of the system and the technologies.

Among the all issues, the most vital and effective issues of the use of the IoT farming in the agricultural sector is the problems in the assess in the internet process. The lack of the internet connection in the rural sector makes the process of the agriculture less effective. In the year 2022, the value of the IoT in the agricultural sector is 13.7 US dollars and the value will be increased to 28.56 US dollars in the year 2030. The excessive use of the IoT things in the agricultural sector required the high skilled employees in the agricultural firm. Therefore, the lack in the number of the workers in the agricultural sector is a big issue of this department.

One of the most vital issues of the use of the IoT in smart farming is the location of the firms. Most of the agricultural firms are located in remote areas and rural areas. For rural areas, the ***scarcity of the internet*** and the issues of the network convention become the main problems for the agricultural department [3]. Also, the tools and the equipment of the IoT are of ***high cost*** and this is one of the most vital problems for smart farming [11]. The need for the proper resources of money makes the use and the process of the IoT less effective for the implementation of smart farming in the present day [7]. Another challenge that is faced by the agricultural sector is the lack of security for the employees and farmers in the industries. The increment of insecurity among the farmers is one of the big issues for smart farming. The implementation of the technology and modern internet process requires more security for the agricultural department and this helps in the growth and development of smart farming in the recent era.

5. The future effectiveness of deep learning in agriculture. There are both positive and negative effects of the use of the BDA and IoT in the smart farming. The application of the IoT in the farming industry becomes helpful and effective if the techniques can be used wisely [29]. With the help of the deep learning process, the workers in the agricultural department can be estimated the crop diseases and also estimate the benefits of the fertilizer [4]. The application of the appropriate fertilizer for the appropriate crop increases the life span of the crop and makes the crop free from danger [15]. The reduction of the cost can be happened by the use of deep learning in the agricultural department. Therefore, by using the process of deep learning, the cost and the price of the crops and other agricultural items can be minimized.

The IoT has a great future in the agricultural department and the use of this technology will be helpful for the better benefit of the farmers. The use of the IoT in the agricultural department helps to optimize the resources of the crops [30]. The rate of the production of agricultural items also can be enhanced by the use of the IoT. Monitoring the climate and the farming of the greenhouse become easier with the use of technology in the farming industries.

The figure 5.1 shows that in the year 2021, the rate of precession farming is the highest among all other techniques. In the year 2030, the use of techniques that are effective for smart farming becomes increased [27]. Therefore, it is clear that in the future, the application of the BDA and IoT become increased for the better production of agricultural items.

6. Results. It is clear from the above discussion that the application of the various kinds of technologies and methods in smart farming makes the process of farming more interesting and easier. Deep learning is one of the most impactful and effective ways to increase the rate of the production of agricultural items [16]. As a result, the introduction of smart farming in the agricultural industry requires more skilled and experienced trainers for giving the workers proper training [8]. The implementation of IoT technologies and the BDA in the agricultural department needs more money and resources [9]. The scarcity of money and resources become one of the most common issues in the agricultural department.

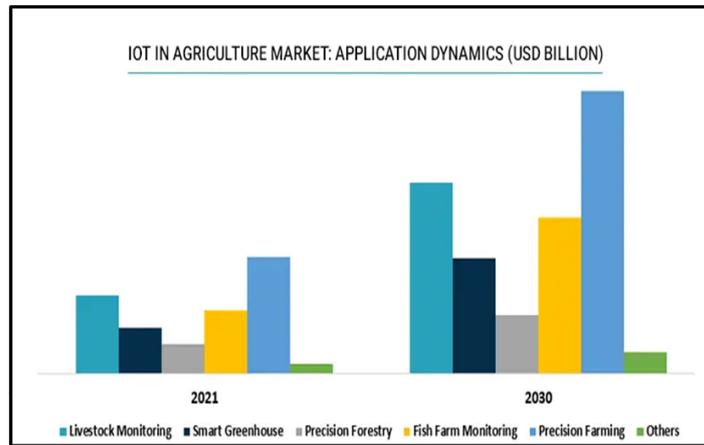The figure 6.1 shows the aspects of the IoT in the Department of Agriculture. The strategic feature of

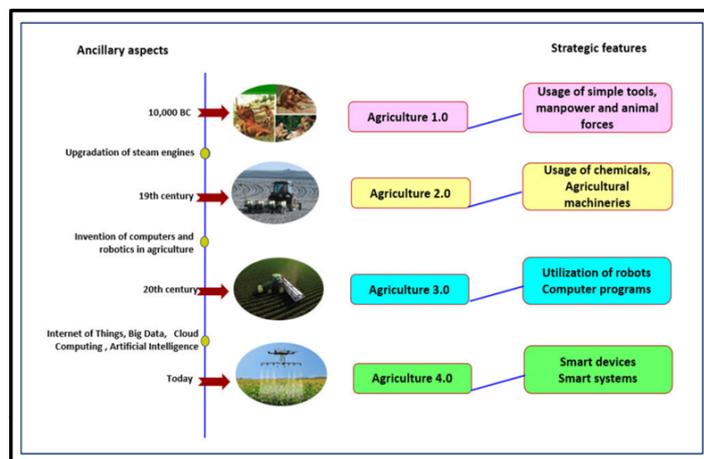Fig. 5.1: Future of IoT in the agricultural department

Fig. 6.1: Smart Farming and the IoT

"**Agriculture 1.0**" is the application of tools that are simple and easy to use [18]. The manpower and the use of animals are the main processes of this kind of agriculture. In the part of **"Agriculture 2.0**", there was used various kinds of machines and chemicals. This upgradation process increases the rate of productivity of the agricultural department in the past years [19].

The figure 6.2 shows ways smart farming is shaping the growth of farming style through the usage of technology. The urbanization of the agricultural process and the use of smart and modern technologies are applied in the time of "**Agriculture 3.0"** The last stage of the agricultural process, the process of **"Agriculture 4.0"** makes the smart devices and the smart process for the growth and development of the sector [6]. From the above research it can be conclude that the innovative technologies in the data science gives a new revolution for the development and growth of the agricultural sector. The skilled based agriculture in the present days is the important factor that driven the technology and information sector to a high level. The emerging of the countries by the revolution of the agriculture department through the world improve the entire cycle of the agricultural sector. Thus, the use of the BDA and IoT technologies in smart farming is useful for the increment of the rate of production and the quality of the crops.

The initiatives of the government and NGO helps to driven the agricultural department to a next level. As
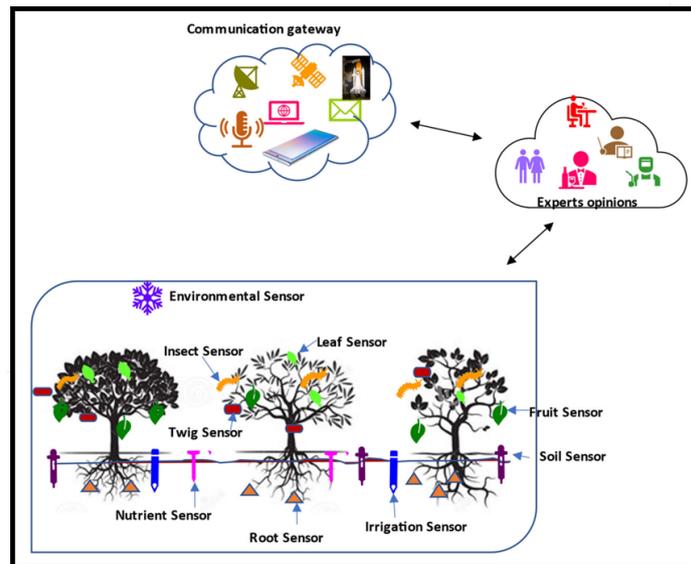
Fig. 6.2: Smart Farming

a result, it can be said that the changing of the weather is the one of the most effective for the development of the agricultural department and the growth in the production rate. The growth of the plants and crops can be detected properly with the help of the detection of the temperature of soil and weather. The implementation of the new technologies and methods in the agricultural sectors is the most useful and valuable process in the present days.

7. Conclusion. In conclusion, the study underscores the substantial influence of Internet of Things (IoT) and Big Data Analytics (BDA) on the field of agriculture. It demonstrates that the adoption of IoT and BDA technologies has brought about a profound transformation in agriculture, marking a shift from the traditional "Agriculture 1.0" to the more advanced and data-driven "Agriculture 4.0." This transition reflects the effective application of innovative methods and technologies, resulting in increased efficiency, sustainability, and productivity within the agricultural sector. Nevertheless, the conclusion also acknowledges that the integration of modern technologies is not without its challenges. One such challenge is the need for careful planning and the recruitment of skilled and capable workers in the agricultural industry to effectively harness the potential of IoT and BDA. Looking forward, the conclusion anticipates further advancements in agricultural production and crop quality, as the continued utilization of IoT in smart farming promises to bring about noticeable positive changes in the agricultural landscape. This future-oriented perspective highlights the ongoing opportunities for growth and development in agriculture through the incorporation of IoT technology.

REFERENCES

[1] M. S. Ali, A. M. M. Raafee, and A. S. M. Mia, *Smart farming using ai towards bangladeshi agriculture*, Journal of FST, 1 (2022), p. 189.
[2] M. Amiri-Zarandi, R. A. Dara, E. Duncan, and E. D. Fraser, *Big data privacy in smart farming: a review*, Sustainability, 14 (2022), p. 9120.
[3] M. Amiri-Zarandi, M. Hazrati Fard, S. Yousefinaghani, M. Kaviani, and R. Dara, *A platform approach to smart farm information processing*, Agriculture, 12 (2022), p. 838.
[4] M. Andronie, G. Lăzăroiu, M. Iatagan, I. Hurloiu, and I. Dijmărescu, *Sustainable cyber-physical production systems in big data-driven smart urban economy: a systematic literature review*, Sustainability, 13 (2021), p. 751.
[5] S. A. Bhat and N.-F. Huang, *Big data and ai revolution in precision agriculture: Survey and challenges*, IEEE Access, 9 (2021), pp. 110209–110222.
[6] N. Chandra, *Significant advancements in agriculture science*, Dr. Ajay B. Jadhao, (2023), p. 72.

[7]   J. A. Delgado, N. M. Short Jr, D. P. Roberts, and B. Vandenberg, *Big data analysis for sustainable agriculture on a geospatial cloud framework*, Frontiers in Sustainable Food Systems, 3 (2019), p. 54.

[8]   K. Dineva and T. Atanasova, *Cloud data-driven intelligent monitoring system for interactive smart farming*, Sensors, 22 (2022), p. 6566.

[9]   F. N. Fote, S. Mahmoudi, A. Roukh, and S. A. Mahmoudi, *Big data storage and analysis for smart farming*, in 2020 5th International Conference on Cloud Computing and Artificial Intelligence: Technologies and Applications (CloudTech), IEEE, 2020, pp. 1–8.

[10] P. Fraga-Lamas, L. Ramos, V. Mondéjar-Guerra, and T. M. Fernández-Caramés, *A review on iot deep learning uav systems for autonomous obstacle detection and collision avoidance*, Remote Sensing, 11 (2019), p. 2144.

[11] M. Gupta, M. Abdelsalam, S. Khorsandroo, and S. Mittal, *Security and privacy in smart farming: Challenges and opportunities*, IEEE access, 8 (2020), pp. 34564–34584.

[12] B. Güven, İ. Baz, B. Kocaoğlu, E. Toprak, D. Erol Barkana, and B. Soğutmaz Özdemir, *Smart farming technologies for sustainable agriculture: From food to energy*, in A Sustainable Green Future: Perspectives on Energy, Economy, Industry, Cities and Environment, Springer, 2023, pp. 481–506.

[13] M. Javaid, A. Haleem, R. P. Singh, and R. Suman, *Enhancing smart farming through the applications of agriculture 4.0 technologies*, International Journal of Intelligent Networks, 3 (2022), pp. 150–164.

[14] E. Karunathilake, A. T. Le, S. Heo, Y. S. Chung, and S. Mansoor, *The path to smart farming: Innovations and opportunities in precision agriculture*, Agriculture, 13 (2023), p. 1593.

[15] A. Lytos, T. Lagkas, P. Sarigiannidis, M. Zervakis, and G. Livanos, *Towards smart farming: Systems, frameworks and exploitation of multiple sources*, Computer Networks, 172 (2020), p. 107147.

[16] E. Micheni, J. Machii, and J. Murumba, *Internet of things, big data analytics, and deep learning for sustainable precision agriculture*, in 2022 IST-Africa Conference (IST-Africa), IEEE, 2022, pp. 1–12.

[17] G. Obi Reddy, B. Dwivedi, and G. Ravindra Chary, *Applications of geospatial and big data technologies in smart farming*, in Smart Agriculture for Developing Nations: Status, Perspectives and Challenges, Springer, 2023, pp. 15–31.

[18] K. Paul, S. S. Chatterjee, P. Pai, A. Varshney, S. Juikar, V. Prasad, B. Bhadra, and S. Dasgupta, *Viable smart sensors and their application in data driven agriculture*, Computers and Electronics in Agriculture, 198 (2022), p. 107096.

[19] A. Rejeb, K. Rejeb, and S. Zailani, *Big data for sustainable agri-food supply chains: a review and future research perspectives*, Journal of Data, Information and Management, 3 (2021), pp. 167–182.

[20] S. Rogotis and N. Marianos, *Smart farming for sustainable agricultural production*, Big Data in Bioeconomy: Results from the European DataBio Project, (2021), pp. 191–205.

[21] A. Roukh, F. N. Fote, S. A. Mahmoudi, and S. Mahmoudi, *Big data processing architecture for smart farming*, Procedia Computer Science, 177 (2020), pp. 78–85.

[22] R. Saadane, A. Chehri, S. Jeon, et al., *Ai-based modeling and data-driven evaluation for smart farming-oriented big data architecture using iot with energy harvesting capabilities*, Sustainable Energy Technologies and Assessments, 52 (2022), p. 102093.

[23] M. N. Sadiku, T. J. Ashaolu, and S. M. Musa, *Big data in agriculture*, Int. J. Sci. Adv, 1 (2020), pp. 44–48.

[24] V. Saiz-Rubio and F. Rovira-Más, *From smart farming towards agriculture 5.0: A review on crop data management*, Agronomy, 10 (2020), p. 207.

[25] M. N. I. Sarker, M. S. Islam, H. Murmu, and E. Rozario, *Role of big data on digital farming*, Int. J. Sci. Technol. Res, 9 (2020), pp. 1222–1225.

[26] M. N. I. Sarker, M. Wu, B. Chanthamith, S. Yusufzada, D. Li, and J. Zhang, *Big data driven smart agriculture: Pathway for sustainable development*, in 2019 2nd international conference on artificial intelligence and big data (ICAIBD), IEEE, 2019, pp. 60–65.

[27] T. A. Shaikh, W. A. Mir, T. Rasool, and S. Sofi, *Machine learning for smart agriculture and precision farming: towards making the fields talk*, Archives of Computational Methods in Engineering, 29 (2022), pp. 4557–4597.

[28] A. Singh, R. Mehrotra, V. D. Rajput, P. Dmitriev, A. K. Singh, R. S. Tomar, O. Singh, and A. K. Singh, *Geoinformatics, artificial intelligence, sensor technology, big data: emerging modern tools for sustainable agriculture*, Sustainable Agriculture Systems and Technologies, (2022), pp. 295–313.

[29] H. Singh, N. Halder, B. Singh, J. Singh, S. Sharma, and Y. Shacham-Diamand, *Smart farming revolution: portable and real-time soil nitrogen and phosphorus monitoring for sustainable agriculture*, Sensors, 23 (2023), p. 5914.

[30] S. Yadav, A. Kaushik, M. Sharma, and S. Sharma, *Disruptive technologies in smart farming: an expanded view with sentiment analysis*, AgriEngineering, 4 (2022), pp. 424–460.