International Journal of Applied Science and Engineering
Citation: *IJASE*: **12**(01): 17-27, June 2024
DOI: 10.30954/2322-0465.1.2024.3

IJASE
INTERNATIONAL JOURNAL OF APPLIED SCIENCE AND ENGINEERING

REVIEW PAPER

INFORMATICS

Agricultural Information Networks and Systems: Necessity, Components— *A Scientific Review*

P.K. Paul[1*], Abhijit Bandyopadhyay[2], Mahabubul Hoque[1] and Sudhir Kumar Jena[3]

[1]*Raiganj University (A State Govt. University), Raiganj, West Bengal, India*
[2]*Raniganj Institute of Computer and Information Science (RICIS), Raniganj, West Bengal, India*
[3]*Rajiv Gandhi University, Doimukh, Arunachal Pradesh, India*

**Corresponding author: pkpaul.infotech@gmail.com*

Received: 12 Mar., 2024 **Revised:** 22 May., 2024 **Accepted:** 05 Jun., 2024

ABSTRACT

Agricultural Informatics is a field of practice and education. This is also known as Agricultural Information Technologies and Agricultural Information Science. Applications of IT and Computing in Agriculture and other allied domains dedicated in incorporating better and healthy Agricultural practice supported by various technologies. Agricultural activities is effectively started in worldwide operation of Agricultural Systems for effective and progressive situation. Though there are critical issues and challenges in Agricultural Informatics which include social, technological, finance and economical concern. Agricultural Information Networks is an advanced gift of Agricultural Informatics dedicated in information storage and sharing of information dedicated to the agricultural development. Many countries have their Agricultural Information Networks and Centres and there are international Information Networks too. This chapter described about the impact, role and significance of Agricultural Informatics and highlights the values in developing agro segments which include pre and post agricultural systems.

Keywords: Agro Informatics, Digital Agriculture, Development Studies, Smart Agriculture, Sustainability, Information Networks

Agricultural Information Networks is dedicated in agricultural development using proper techniques and technologies. Agricultural in modern days supported by various techniques and technologies and among these Agricultural Networks are worthy as it is dedicated in information and documentation related progress[2],[3],[4]. 'Agricultural Informatics' in certain cases also known as 'Agricultural Information Technology'. ICT Applications in Agriculture is highly required in agro-product development including pre and post production. Various tools, technologies and systems are highly useful in Agricultural Systems management and some of the emerging[24],[28],[29] —

How to cite this article: Paul, P.K., Bandyopadhyay, A., Hoque, M. and Jena, S.K. (2024). Agricultural Information Networks and Systems: Necessity, Components— *A Scientific Review*. *IJASE.*, **12**(01): 17-27.

Source of Support: None; **Conflict of Interest:** None

- Software Development, Systems and Technologies
- Network Systems, Management and Technologies
- Database Systems, Management and Technologies
- Web Systems, Management and Technologies
- Multimedia Systems, Management and Technologies and so on.

Internationally many developed nations are focused on Agricultural Information Networks for better survive of the human being[5],[7],[10]. Ministries including institutions, associations and firms are engaged in use of Agricultural Informatics practice even there are several issues and concerns. Implementation of the Agricultural Information Networks is responsible in advancing sustainable agro system. Here Fig. 1 is showing several nomenclature related to the Agro Informatics; whereas supported fields are depicted in Fig. 2 [30],[32],[33].

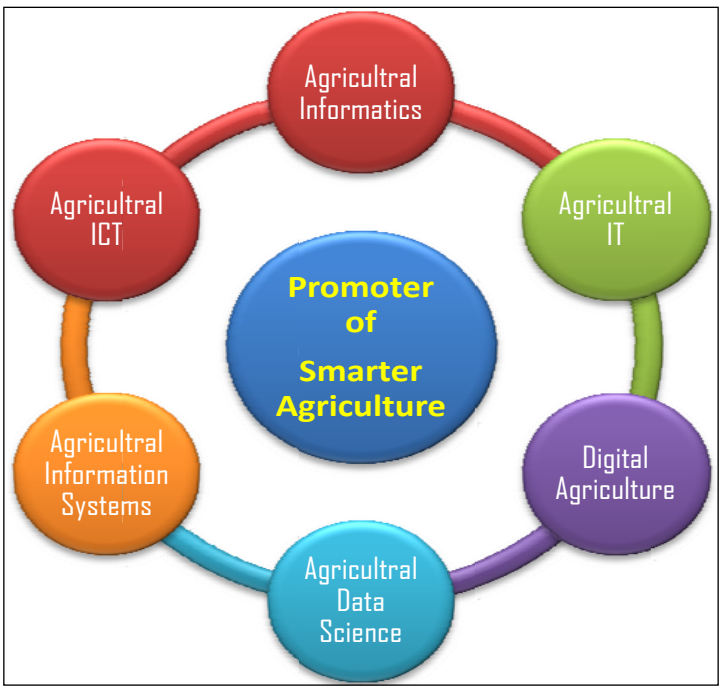

Fig. 1: Allied areas Agricultural Informatics for the creation of smarter agricultural systems

OBJECTIVE

The present work titled 'Agricultural Information Networks and Systems: Necessity, Components—*A Scientific Review'* is a theoretical and conceptual work which is dedicated with following aim and objectives—

- To know about the basic of Agricultural Informatics with basic features as well as attributes.

- ❒ To know about the functions and emergence of Agricultural Information Networks dedicated in smart agricultural systems development.
- ❒ To gather about the components of Agricultural Information Networks specially for the proper and sustainable impact in Agricultural Sector.
- ❒ To know about the impact and role of Agricultural Information Networks in advancing modern digital societies which is supported by various technologies.

METHODOLOGY ADOPTED

As far as the work 'Agricultural Information Networks and Systems: Necessity, Components— *A Scientific Review'* is concerned, this is theoretical in nature and depends on existing sources of knowledge. Various books, journals, periodicals, and magazines related to Agricultural Information Networks, Agricultural, Agricultural Information Management are studied, analyzed and reported in this work.

EXISTING WORKS

There are various works related to the Agricultural Information Networks among the notable works, few important are stated as follows —

Chisita, C.T. (2010)[8] in this paper the author examines the provision of agricultural information in Zimbabwe to small scale farmers. It looks into the best ways to reach small-scale farmers in Harare, Zimbabwe, with agricultural information. This study explained the effect of ICT (Information and Communication Technology) on the spread of agricultural information among small scale farmers in Zimbabwe. Described how much information supply is used to encourage small-scale farmers to get agricultural information. Draws attention to the problems of farmers have in obtaining agricultural information. It also stated the latest ICT driven projects aimed at facilitating access to agricultural information to farmers. In this study, in order to provide agricultural knowledge for maintaining agriculture, the responsibilities of libraries, schools, and agricultural research extension services are discussed. The limitations of the use of alternative media to transmit agricultural information to small-scale farmers are discussed, along with the use of radio, television, and podcasts to spread agricultural information.

Duhan, A. and Singh, S. (2017)[11] in their work tried to determine which sources farmers used to obtain vital information regarding weather forecasts and agricultural related operations. This study also identifies a number of socioeconomic factors, including age, education, and farm size, that influence farmers' decisions on how to evaluate information sources. According to authors, the most widely used source of up-to-date information relating agricultural activity is newspaper. And other sources of information regarding agriculture are state agriculture department, television, agricultural universities, and radio. Various kinds of information are provided to the farmers from time to time by agriculture development officer, horticulture development officer and other agriculture officers from various agriculture offices. Dealers in agricultural inputs were in regular contact with the farmers. Additionally, they provided farmers with timely information on new types of seed, pesticides, etc. Maximum farmers got up-to-date information from the input dealers followed by private organizations and fellow farmers. A very few farmers got latest information from internet. It demonstrates how farmers were still isolated from the quickly advancing technology of this modern age. Farmers may carry out appropriate farming activities

at the appropriate times and in right ways with the use of weather forecasting information. This study shows that maximum number of farmers got up-to-date weather information from newspaper followed by television, radio and SMS services on the mobile. Farmers considered that newspaper was the most reliable and authentic source of information.

Khan, G.A. *et al.* (2010)[19] have mentioned that as a source of agricultural information for the farmers, Television is regarded to be one of the effective media. In context of agricultural, many TV channels are telecasting information and report on agriculture. Developing an understanding of the accessibility of agricultural information via electronic media appears to be the first step in utilizing electronic media for agricultural activities. Ensuring farmers are aware of the availability of agricultural information through various electronic media is crucial because it puts them in a better position to use and absorb the knowledge. In this study the authors stated that the awareness in respect of agricultural broadcasts and contacts was very weak. Moreover, there was little to usage of electronic media to obtain agricultural information. However, all things considered, it can be said that electronic media do not play a vital role in the farming community's ability to receive agricultural information.

Mtega, W.P. and Msungu, A.C. (2013)[25] in this study the authors evaluated the ways in which ICTs can improve the availability of agricultural information necessary to support agribusiness and agricultural output in Tanzania. This study perticularly identified the function of particular ICTs in agribusiness and agricultural production and evaluated the efficiency of frequently used ICTs in the production and dissemination of agricultural knowledge and information services. The factors that restrict ICTs' power to support Tanzanian agribusiness and agricultural productivity were also assessed. The findings show that if utilized with ability, mobile phones, radio, computers, television, and the internet have the ability to completely change the industry. According to the authors, farmers preferred radio and mobile phones for communication, whereas researchers and extension workers preferred computers and the internet. Additionally, it was reported that different ICT applications, like calls, short message services, and sim-banking, are often used. They also stated that from these findings, it is advised that internet and mobile service providers expand their infrastructure and minimize the tariffs related with using their services in order to attract more customers. This may facilitate more information sharing among agricultural stakeholders, leading to enhance in agribusiness and agricultural output. The foundation of Tanzania's economy is agriculture. It employs over 70% of the country's workforce. It creates over 45% of the country's GDP. It provides roughly 66% of its foreign exchange, and supplies raw materials for regional industries.

Nakasone, E. *et al.* (2014)[26] in their work stated that mobile phones in rural areas has brought vital changes in the agricultural field. They mentioned that generally access to mobile phones has developed agricultural market performance at the macro level but affects at the micro level are mixed. Mobile phones may have a great impact on agricultural markets. Mobile phones can provide more effective communication between different market agents, improving information flows and perhaps boosting effectiveness. These findings may be particularly important for developing country rural areas, where a lack of infrastructure often leads to a less integrated market. Nevertheless, very few studies examine the mobile phone usage patterns of farmers and dealers for agricultural marketing purposes. A survey shows that farmers use mobile phone for marketing transactions in main commercial potato and rice producing areas.

Paul , P.K. *et al.* (2014)[31] in their work stated that ISN (Information Systems and Networks) is a type of consortium which is dedicated to information activities. It includes activities like information collection,

selection, organization and dissemination. For Information Transfer Cycle chain, Information Systems and Networks are regarded as vital pillar. It may be set up on a particular subject or discipline. In this paper the authors stated related to information systems, its role, values and characteristics. They have also discussed about AGRIS. Its characteristics, functions, and morals in the modern agricultural and environmental world. The authors have also mentioned various types of ISN. In the field of Agriculture and Environment and Animal Husbandry, AGRIS is a vital name. In the field of Agricultural Science and Technology, it is the public domain database with around 2.6 Million structured bibliographic records. Nearly 150 information networks are devoted to Agriculture, Horticulture, Fisheries, Environmental data, Information, full text data, and book collections. AGRIS is connected to National Information Networks of related fields situated in 65 Countries. Through the FAO Website (http://www.afris.fao.org), AGRIS is available online. Nowadays AGRIS has a crucial role as an International indexing and Digital Repositories with the bibliographic and full text database. The authors have stated some challenges of AGRIS also.

Voutos, Y. *et al.* (2019)[41] in their work the authors stated that the phrase intelligent agriculture, sometimes known as smart farming, often refers to the incorporation of IT (Information Technology) and computer science with the conventional understanding of farming. More precisely, the affordability of relatively sophisticated sensors and small-scale devices—which are now even linked to the Internet of Things (IoT)—made it possible for them to be incorporated into and utilized within agricultural production systems. It is anticipated that new and developing models and technology, such as the use of inexpensive network storage, will further this advancement. The basic objectives of this paper are as (i) about intelligent agriculture methods, to identify, group, and acknowledge the current state-of-the-art research knowledge, (ii) according to meaningful data sources, categorize them, and (iii) from the perspective of the main trends in the field, to describe current efficient data processing and utilization aspects. The authors identified the active utilization of Machine Learning procedures for a multitude of agricultural tasks.

Zhang, Y. *et al.* (2016)[45] in their work mentioned that more than the last three decades, by the useful deployment of ICTs (Information and Communication Technologies), agriculture sector of China has been converted from the conventional to modern practice. In this conversion process, Information processing and dissemination have played a vital role. The objectives of this paper to review and recognize the ICT based information dissemination models in China. And to improve productivity and economic, social and environmental sustainability share the knowledge and experience in applying emerging ICTs in disseminating agriculture information to farmers and farm communities. The improvement stages of China's agricultural information dissemination systems and many methods for the creation and operation of agricultural information services are reviewed and analyzed in this study. There is a discussion and identification of seven ICT-based information distribution models. In this study success cases are presented. Researchers and practitioners might utilize the findings as a helpful guide for creating ICT-based information dissemination systems in the future. In this paper, the authors aims to help other developing countries in gaining insights from China's experience and best practices when using emerging ICTs for agriculture information transmission and knowledge transfer.

DATA & INFORMATION SEGMENTS IN AGRICULTURAL INFORMATION SYSTEMS

An Agricultural Information System encompasses several key components that work together to manage agricultural data effectively:

Data collection: This entails compiling information from a range of sources, including surveys, weather stations, satellites, drones, and sensors. Real-time data collection on soil conditions, weather patterns, crop health, and insect infestations is greatly aided by technologies such as the Internet of Things (IoT) and Geographic Information Systems[44],[46].

Data Processing and Analysis: In order to derive valuable insights from data, it must first be acquired and then processed and evaluated. Pattern recognition, outcome prediction, and suggestion generation are achieved by the application of artificial intelligence (AI), machine learning, and advanced analytics algorithms[1],[9],[14]. This aids in increasing crop yields, minimizing environmental effects, and optimizing resource utilization.

Data Storage: Efficient storage solutions are essential for managing the vast amounts of data generated. Cloud computing offers scalable and secure storage options, enabling easy access and sharing of information among stakeholders[12],[13].

Information Dissemination: Effective communication channels are crucial for disseminating information to farmers and other stakeholders. This includes mobile apps, websites, social media, and traditional media like radio and television. Extension services also play a vital role in providing personalized advice and training to farmers[34],[38],[39].

ROOT AND FUNDAMENTAL NEED OF THE INFORMATION NETWORKS ON AGRICULTURE

Since agriculture is the main source of food, fiber, and fuel, it has always been a fundamental component of human society. The growing number of people on the planet is driving up demand for agricultural products at a never-before-seen pace. In this regard, networks and agricultural information systems (AIS) have emerged as essential instruments for raising farmer incomes, guaranteeing sustainability, and increasing productivity[18],[22],[23]. For modern agriculture, AIS and networks are essential for the following main reasons:

Enhancing Decision-making

Farmers can receive precise and fast information from agricultural information systems on crop management techniques, market pricing, pest and disease outbreaks, soil health, and weather. Making decisions with knowledge that maximizes crop yields and minimizes losses requires this information[15],[16],[17]. To lower the risk of crop failure, farmers should schedule planting and harvesting dates to avoid unfavourable weather conditions, for example, with the aid of weather forecasts and early warning systems.

Facilitating Knowledge Sharing

AIS and Networks enable the dissemination of agricultural research and best practices from experts and research institutions to farmers. Through online platforms, mobile applications, and social media, farmers can access a wealth of information and training materials on various aspects of farming[20],[21],[27]. The dissemination of knowledge is especially helpful to smallholder farmers who might not have access to conventional extension services. Farmers can implement more productive and sustainable agricultural practices by keeping up with the newest advancements in technology and farming methods.

Encouraging Market Entry

For farmers to make profitable decisions about what to plant and when to sell their produce, they need to have access to market information. Farmers can bargain for higher prices and lower post-harvest losses thanks to AIS and Networks' real-time data on market prices, demand trends, and supply chain logistics[35],[36]. Digital platforms can also link farmers and buyers directly, eliminating the need for middlemen and boosting the farmers' portion of the sale price.

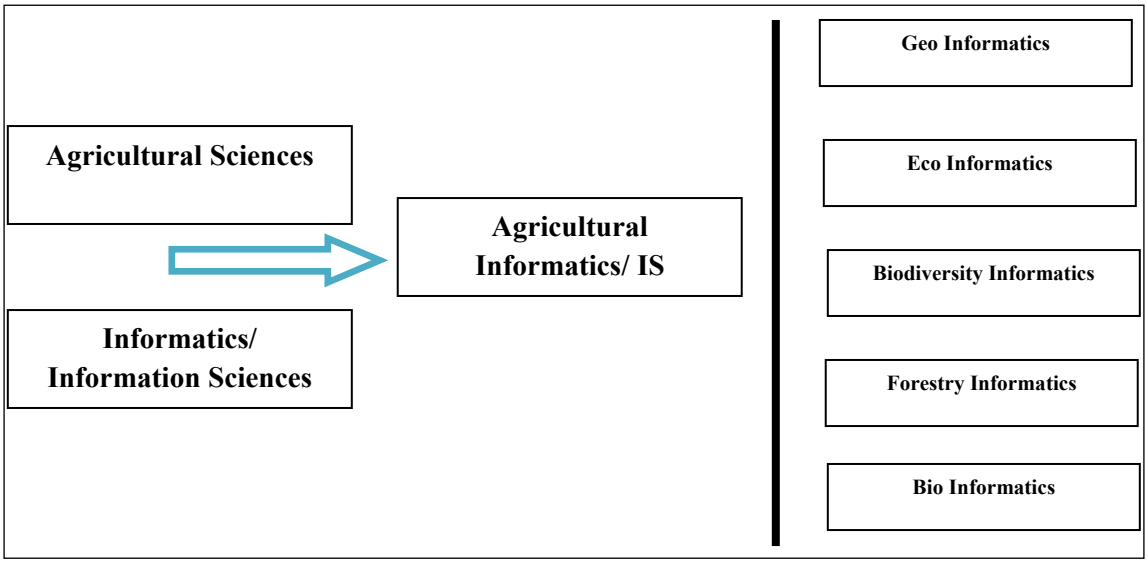

Fig. 2: Allied fields of Agricultural Informatics

Endorsing Sustainable Farming

Given the necessity to strike a balance between environmental conservation and productivity, sustainability is a big challenge in agriculture. By offering knowledge on integrated pest control, soil health management, and water conservation strategies, AIS and Networks are essential in advancing sustainable farming practices. Farmers may optimize the use of inputs like fertilizers, herbicides, and water by utilizing precision agricultural technologies, which will lessen their impact on the environment and increase resource efficiency.

Addressing Climate Change

Changes in growing seasons, a rise in the frequency of extreme weather events, and the spread of diseases and pests are just a few of the major issues that climate change presents to agriculture. For the agriculture sector attempts to adapt to and mitigate the effects of climate change, AIS and networks are crucial. Farmers may lower greenhouse gas emissions and increase their resilience to climate change by implementing climate-smart agricultural practices. For instance, knowledge of water-saving irrigation methods and crop types resistant to drought can help farmers adapt to changing weather patterns and water constraints[6],[36].

Encouraging Smallholder Farmers

The bulk of agricultural laborers in many developing nations are smallholder farmers, who frequently confront a variety of difficulties, such as restricted access to markets, resources, and information[18],[23]. By giving these farmers the resources and knowledge they need to increase their revenue and production, AIS and Networks can give them more influence. Some technologies that can improve the lives of smallholder farmers are digital financial services, online markets, and mobile-based advice services.

Enabling Data-Driven Agriculture

The abundance of data coming from several sources—such as sensors, drones, and satellite imagery—has created new opportunities for data-driven agriculture. Farmers can gain useful insights from the integration and analysis of this data by using AIS and Networks. For instance, precision farming methods maximize input application and enhance crop management by utilizing data on soil moisture levels, crop growth phases, and insect activity[37],[40]. The productivity and sustainability of agriculture can be greatly increased with this data-driven strategy[42],[43].

CONCLUSION

The increasing adoption rates of Agricultural Information Systems by farmers and technological improvements are driving their rise. The advancement of artificial intelligence, big data analytics, and Internet of Things (IoT) devices has greatly influenced the development of AIS. Large-scale agricultural data can be collected and analyzed thanks to these technologies, producing insights that are more precise and useful. Moreover, the proliferation of mobile technology and internet connectivity has facilitated the widespread adoption of AIS, particularly in developing countries. Mobile applications and online platforms have made it easier for farmers to access information and services that were previously unavailable. The future of Agricultural Information Systems is promising, with ongoing research focused on enhancing system capabilities and integration. Innovations such as blockchain for traceability, advanced data analytics, and autonomous systems are expected to further revolutionize agriculture.

REFERENCES

1. Aker, J.C. 2011. Dial "A" for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries. *Agricultural Economics,* **42**(6): 631-647.

2. Barakabitze, Alcardo Alex, Kadeghe G. Fue, and Camilius Aloyce Sanga. 2017. "The use of participatory approaches in developing ICT-based systems for disseminating agricultural knowledge and information for farmers in developing countries: The case of Tanzania." *The Electronic Journal of Information Systems in Developing Countries* **78**(1): 1-23.

3. Bauckhage, C. and Kersting, K. 2013. Data mining and pattern recognition in agriculture. *KI-Künstliche Intelligenz*, **27**(4): 313-324.

4. Behera, B.S., Das, T.K., Jishnu, K.J., Behera, R.A., Behera, A.C. and Jena, S. 2015. E-governance mediated agriculture for sustainable life in India. *Procedia Computer Science*, **48**: 623-629.

5. Behera, B.S., Panda, B., Behera, R.A., Nayak, N., Behera, A.C. and Jena, S. 2015. Information communication technology promoting retail marketing in agriculture sector in India as a study. *Procedia Computer Science*, **48**: 652-659.

6. Channe, H., Kothari, S. and Kadam, D. 2015. Multidisciplinary model for smart agriculture using internet-of-things (IoT), sensors, cloud-computing, mobile-computing & big-data analysis. *Int. J. Computer Technology & Applications*, **6**(3): 374-382.

7. Chauhan, N.B. 2010. Information technology for agricultural development in India. *Dipak De and Basavaprabhu Jirli, Ganga Kaveri Publishing House, Jangamawadi Math Varanasi*, pp. 1-24.

8. Chisita, C.T. 2010 . An investigation into the use of ICT in the provision of agricultural information to small scale farmers in Harare. In *World Library and Information Congress: 76th IFLA General Conference and Assembly* (pp. 10-15).

9. Dando, T., Koutsou, S. and Wright, S. 2019. Managing risk in agriculture: The role of information systems. *Journal of Agricultural Economics,* **70**(2): 256-274.

10. Demiryurek, K., Erdem, H., Ceyhan, V., Atasever, S. and Uysal, O. 2008. Agricultural information systems and communication networks: the case of dairy farmers in Samsun province of Turkey. *Information Research*, **13**(2): 13-2.

11. Duhan, A. and Singh, S. 2017. Sources of agricultural information accessed by farmers in Haryana, India. *International Journal of Current Microbiology and Applied Sciences*, **6**(12): 1559-1565.

12. Fritz, S., See, L., Bayas, J.C.L., Waldner, F., Jacques, D., Becker-Reshef, I. ... and McCallum, I. 2019. A comparison of global agricultural monitoring systems and current gaps. *Agricultural Systems*, **168**: 258-272.

13. Gómez-Chabla, R., Real-Avilés, K., Morán, C., Grijalva, P. and Recalde, T. 2019. IoT Applications in Agriculture: A Systematic Literature Review. In *2nd International* Conference on ICTs in Agronomy and Environment (pp. 68-76). Springer, Cham.

14. Hussain, M. and Al-Mudimigh, A. 2021. Challenges and opportunities in agricultural information systems. *Computers and Electronics in Agriculture,* **185**: 106175.

15. Kajol, R. and Akshay, K.K. 2018. Automated Agricultural Field Analysis and Monitoring System Using IOT. *International Journal of Information Engineering and Electronic Business*, **11**(2): 17.

16. Kamble, S.S., Gunasekaran, A. and Gawankar, S.A. 2020. Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications. *International Journal of Production Economics*, **219**: 179-194.

17. Kaniki, A.M. 1988. Agricultural information services in less developed countries. *International library review*, **20**(3): 321-336.

18. Khan, A., Lee, H. and Lee, J. 2023. Blockchain and IoT in agriculture: A comprehensive review. *Computers and Electronics in Agriculture,* **202**: 107459.

19. Khan, G.A., Muhammad, S., Chaudhry, K.M. and Khan, M.A. 2010. Present status and future preferences of electronic media as agricultural information sources by the farmers. *Pak. J. Agri. Sci.*, **47**(2): 166-172.

20. Khattab, A., Abdelgawad, A. and Yelmarthi, K. 2016. Design and implementation of a cloud-based IoT scheme for precision agriculture. In *2016 28th International Conference on Microelectronics (ICM)* (pp. 201-204). IEEE.

21. Kizilaslan, N. 2006. Agricultural information systems: a national case study. *Library Review*, **55**(8): 497-507.

22. Klerkx, L., Jakku, E. and Labarthe, P. 2019. A Review of Social Science on Digital Agriculture, Smart Farming and Agriculture 4.0: New Contributions and a Future Research Agenda. *NJAS - Wageningen Journal of Life Sciences,* **90-91**: 100315.

23. Kumar, P., Singh, R. and Shukla, S. 2020. Adoption of mobile-based agricultural information systems in developing countries. *Information Technology for Development,* **26**(3): 563-580.

24. Levkina, R.V., Kravchuk, I.I., Sakhno, I.V., Kramarenko, K.M. and Shevchenko, A.A. 2019. The economic-mathematical model of risk analysis in agriculture in conditions of uncertainty. *Financial and Credit Activity Problems of Theory and Practice*, **3**(30): 248-255.

25. Mtega, W.P. and Msungu, A.C. 2013. Using information and communication technologies for enhancing the accessibility of agricultural information for improved agricultural production in Tanzania. *The Electronic Journal of Information Systems in Developing Countries*, **56**(1): 1-14.

26. Nakasone, E., Torero, M. and Minten, B. 2014. The power of information: The ICT revolution in agricultural development. *Annu. Rev. Resour. Econ.*, **6**(1): 533-550.

27. Nandyala, C.S. and Kim, H.K. (2016). Green IoT agriculture and healthcare application (GAHA). *International Journal of Smart Home*, **10**(4): 289-300.

28. Ozdogan, B., Gacar, A. and Aktas, H. 2017. Digital agriculture practices in the context of agriculture 4.0. *Journal of Economics Finance and Accounting*, **4**(2): 186-193.

29. Paul, P.K., Sinha, R.R., Baby, P., Shivraj, K.S., Aremu, B. and Mewada, S. 2020. Usability Engineering, Human Computer Interaction and Allied Sciences: With Reference to its Uses and Potentialities in Agricultural Sectors: A Scientific Report, *Scientific Review*, **6**(7): 71-78.

30. Pau, P.K., Ghosh, M. and Chaterjee, D. 2014. Information Systems & Networks (ISN): Emphasizing Agricultural Information Networks with a case Study of AGRIS. *Scholars Journal of Agriculture and Veterinary Sciences*, **1**(1): 38-41.

31. Paul, P.K., Aithal, P., Sinha, R., Saavedra, R. and Aremu, B. 2019. Agro Informatics with its Various Attributes and Emergence: Emphasizing Potentiality as a Specialization in Agricultural Sciences—A Policy Framework. *IRA-International Journal of Applied Sciences,* **14**(4): 34-44.

32. Paul, P.K. *et al*. 2015. Information and Communication Technology and Information: their role in Tea Cultivation and Marketing in the context of Developing Countries—A Theoretical Approach. *Current Trends in Biotechnology and Chemical Research,* **5**(2): 155-161.

33. Paul, P.K. *et al.* 2016. Cloud Computing and Virtualization in Agricultural Space: A Knowledge Survey. *Palgo Journal of Agriculture*, **4**(2): 202-206.

34. Rao, N.H. 2007. A framework for implementing information and communication technologies in agricultural development in India. *Technological Forecasting and Social Change*, **74**(4): 491-518.

35. Reddy, P.K. and Ankaiah, R. 2005. A framework of information technology-based agriculture information dissemination system to improve crop productivity. *Current Science*, **88**(12): 1905-1913.

36. Svensson, J. and Hartwich, F. 2020. Improving the Role of Information and Communication Technology for Agricultural Value Chains in Developing Countries. *Agricultural Systems,* **181**: 102830.

37. Teye, F., Holster, H., Pesonen, L. and Horakova, S. 2012.*Current Situation on Data Exchange in Agriculture in EU27 and Switzerland*, ICT for Agriculture, Rural Development and Environment, T., Mildorf, C., Charvat, Jr. (Eds), Czech Centre for Science and Society Wirelessinfo, Prague, pp. 37-47.

38. TongKe, F. 2013. Smart agriculture based on cloud computing and IOT. *Journal of Convergence Information Technology*, **8**(2): 210-216.

39. Tsanova, A., Maraseni, T. and Toma, L. 2021. The role of sensor technologies in precision agriculture. *Sensors,* **21**(7): 2352.

40. Voutos, Y., Mylonas, P., Katheniotis, J. and Sofou, A. 2019. A survey on intelligent agricultural information handling methodologies. *Sustainability*, **11**(12): 3278.

41. Wolfert, S., Ge, L., Verdouw, C. and Bogaardt, M.J. 2017. Big Data in Smart Farming – A Review. *Agricultural Systems,* **153**: 69-80.

42. Yadav, P. and Bhardwaj, S. 2022. Market access and value chain integration through agricultural information systems. *Agricultural Systems,* **196**: 103275.

43. Zhang, Y., Li, X. and Xu, Y. 2020. Precision agriculture and its impact on sustainability: A review. *Environmental Science & Policy,* **114**: 24-33.

44. Zhang, Y., Wang, L. and Duan, Y. 2016. Agricultural information dissemination using ICTs: A review and analysis of information dissemination models in China. *Information Processing in Agriculture*, **3**(1): 17-29.

45. Zhou, L., Wang, X. and Zhao, X. 2021. Advancements in IoT and big data for agriculture. *Future Generation Computer Systems,* **119**: 477-489.