Food Science and Engineering
http://ojs.wiserpub.com/index.php/FSE/

Review

Deployment of Industry 4.0 into the Agricultural Food Industry: A Focus on Facet, Insight, Knowledge, and Resilience (FIKR) Personality Traits and AI-Powered Inventory Management

Chee Kong Yap[1*], Chee Seng Leow[2], Wing Sum Vincent Leong[2]

[1]Department of Biology, Faculty of Science, University of Putra Malaysia, Serdang 43400, Malaysia
[2]Humanology Sdn Bhd, Kuala Lumpur 56000, Malaysia
E-mail: yapchee@upm.edu.my

Received: 25 September 2023; **Revised:** 16 August 2024; **Accepted:** 23 August 2024

Abstract: Integrating Artificial Intelligence (AI) in precision agriculture within the framework of Industry 4.0 (I4) is revolutionizing crop disease management and inventory management, offering innovative solutions that enhance both agricultural productivity and environmental sustainability. Combined with I4 technologies, AI-powered systems can predict, detect, and manage crop diseases accurately, reducing reliance on chemical pesticides and improving overall farm efficiency. AI algorithms identify disease patterns and suggest optimal intervention strategies by analyzing real-time data from drones, sensors, and satellite imagery. This approach minimizes crop loss, maximizes yield, and aligns with sustainable farming practices by reducing the environmental footprint. However, the success of these technologies is influenced by the personality traits of farmers. Traits such as openness to innovation, conscientiousness, and analytical thinking are crucial for the effective adoption and utilization of AI-driven solutions. Conscientious farmers follow precise instructions and maintain equipment, while those open to new experiences are more likely to experiment with innovative technologies. Analytical thinkers excel in interpreting complex data, and making informed decisions that improve crop health and yield. The research underscores the need for fostering these traits among farmers to maximize the benefits of AI technologies. Additionally, the study highlights the importance of interdisciplinary collaboration in developing and implementing AI-driven solutions that address both agricultural productivity and environmental sustainability. By integrating technological advancements with human factors, AI has the potential to transform crop disease management, contributing to a more sustainable and resilient agricultural system. The findings call for continued research, policy support, and a holistic approach to fully realize the benefits of AI in agriculture.

Keywords: AI in precision agriculture, sustainable crop disease management, real-time data analysis, farmer personality traits, interdisciplinary collaboration, Industry 4.0

1. Introduction

The Industry 4.0 (I4) worldview deploys the utilization of sensors, machines, workpieces, and information technology frameworks associated with the value chain beyond a single organization. As in different industries, the food processing sector is expected to gradually embrace I4.0 [1]. I4.0 represents a combination of digital and physical

DOI: https://doi.org/10.37256/fse.5220243707

systems. It supports intelligent factories where machines are augmented with internet connectivity and connected to a system that can visualize the entire production chain and make decisions autonomously [2-6]. This context offers new technologies expanding worldwide, specifically in Europe, driving all organizations towards stronger competitiveness in the future. The development prospects are significant for the food industry [7].

The facet, insight, knowledge, and resilience (FIKR) assessment tool consists of 20 personality traits used by Humanology Sdn Bhd [8]. These traits form the backbone of FIKR and include Endurance, Variety, Aggressive, Self-criticism, Intuition, Dependent, Nurturance, Emotional, Extrovert, Achievement, Support, Analytical, Perceivers, Structure, Intellectual, Self-concept, Autonomy, Introvert, Control, and Lie scale. The Arabic word FIKR means "reflection" or "contemplation". It is often used interchangeably with muraqaba, the Sufi word for meditation. Muraqaba means "to watch over" or "to take care of". We watch over our spiritual heart during meditation and centre it with the creator.

Inventory management has become a crucial aspect of the agricultural sector, with AI-powered systems transforming how farms and retailers manage their stock [9-10]. These intelligent systems can analyze market trends, consumer behaviour, and environmental factors to make accurate forecasts, allowing farmers and retailers to adjust their inventory levels accordingly [10]. Effective inventory management enhances profitability and supports sustainability by minimizing excess production and waste [10].

Effective inventory management is crucial for businesses to maintain a steady supply of products and minimize losses. Artificial intelligence (AI) advances have revolutionized this field, providing powerful tools for predicting market trends and optimizing inventory strategies [11]. However, the success of these AI-powered systems is not solely dependent on the technology itself, but also on the personality traits of the individuals responsible for their implementation and management. Individuals with strong foresight and the ability to anticipate market trends and consumer demands can leverage AI predictions to make informed decisions [12]. These visionary leaders can proactively adjust inventory levels and distribution strategies to meet changing market needs, reducing the risk of overstock or stockouts. Meticulous managers, on the other hand, ensure accurate tracking and management of inventory, minimizing waste and improving efficiency [13].

The integration of AI-powered systems and the importance of personality traits in inventory management have become increasingly evident in the agricultural sector [10]. AI's ability to optimize resource use and efficiency, coupled with the crucial role of human traits like foresight, meticulousness, and adaptability, have the potential to revolutionize the way farms and retailers manage their inventory, leading to a more sustainable and profitable food supply chain [10, 14].

This paper aims to review publications with the keywords 'Industry 4.0, AI, and Food Agriculture', to make a synthesis for further discussion, and to recommend future directions in the era of AI.

2. Methodology

Because Scopus is the most widely utilised database for conducting literature searches, Scopus was used for the literature study [15]. The Scopus bibliographic information source was used for this study because of the magnitude and variety of distributions it offers for scholarly distributions. On 7 August 2024, 239 publications were chosen using the keywords 'AI' and 'Agriculture', which had to be in the article titles of the papers in the Scopus database from 1987 to 2024. It is divided into 75 items with 5 major clusters, with at least 5 times repetitions. Similarly, with keywords 'Personality Trait AI, and Agriculture', a total of 15 papers were found. Based on 15 papers on 'Personality', 'AI' and 'Agriculture' on the Scopus database searched on 7 August 2024, from 2022 to 2024. It is divided into 7 items with 2 major clusters, with at least 2 times repetitions. Similarly, with the keywords 'Artificial intelligence' and 'Food industry', a total of 50 papers were found. Based on 50 papers on 'Artificial intelligence' and 'Food industry' on the Scopus database searched on 7 August 2024, from 1995 to 2024. It is divided into 19 items with 3 major clusters, with at least 3 times repetitions.

Bibliometric analyses are an established method to evaluate research literature, particularly in scientific fields benefiting from computational data treatment and witnessing increased scholarly output [16]. VOSviewer is a software that generates a clear graphical representation of bibliometric maps, especially for extensive datasets [17]. To highlight the trends of studies conducted on the topic of 'Personality Trait', from 1921-2024 (on 11,311 papers from the Scopus database), we performed a bibliometric analysis using the VOSviewer software (VOS stands for visualization of similarities-see www.vosviewer.com).

Scopus comprises many significant research papers and offers integrated analysis tools for creating informative visual representations [18]. VOSviewer was employed to analyze each keyword, calculate links, calculate total link strengths, and compare co-occurrences with other keywords.

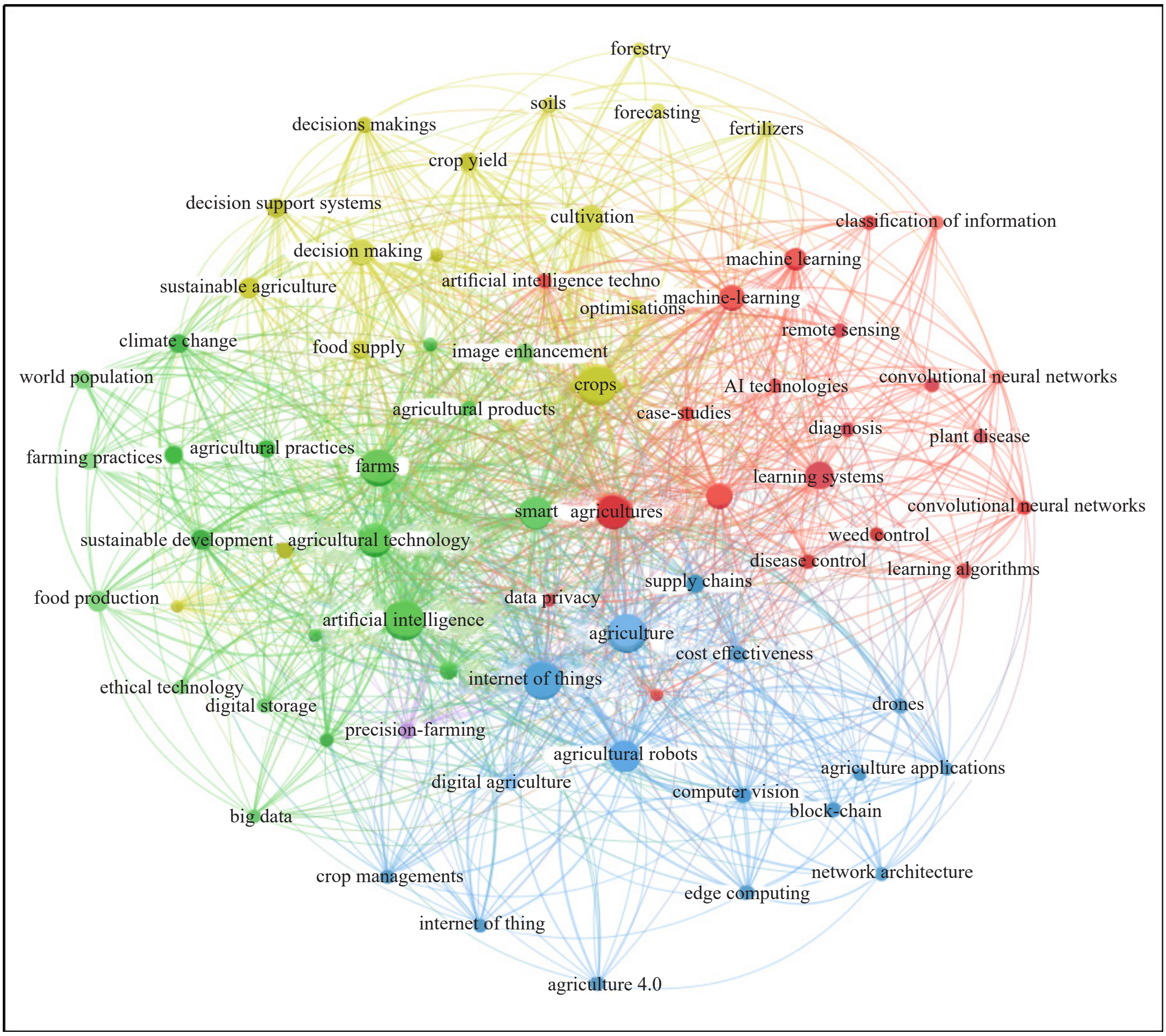

Figure 1. A bibliometric analysis of research themes on using the keywords 'AI' and 'Agriculture'. Visualization of the paper network confirming the main themes of research. Based on 239 papers on 'AI' and 'Agriculture' on the Scopus database searched on 7 August 2024, from 1987 to 2024. It is divided into 75 items with 5 major clusters, with at least 5 times repetitions

3. Results

3.1 *Literature on AI and agriculture*

Figure 1 shows the bibliometric analysis of research themes using the keywords 'AI' and 'Agriculture'. The green cluster in the network graph emphasizes sustainable agriculture, agricultural technology, and decision-making. Central nodes such as “sustainable agriculture” connect with related concepts like sustainable development, food production, and climate change, illustrating the broad scope of efforts to create more sustainable farming practices. “Decision making” is another key node in this cluster, linked to decision support systems and agricultural practices, highlighting the role of informed decision-making in optimizing crop yields and resource use. Additionally, the node “farms” connects with topics such as food supply, farming practices, and the global population, showcasing the interconnected nature of sustainable farming with broader environmental and societal goals.

The yellow cluster focuses on decision-making processes and the support systems that aid in agricultural practices. The central node, “decision making”, is connected to decision support systems and agricultural practices, underlining the importance of these systems in enhancing productivity and efficiency in farming. This cluster also includes nodes like “cultivation”, which is linked with soils, forecasting, and fertilizers, and “crop yield”, which connects with agricultural products and food supply. Together, these nodes depict a detailed picture of how precise and informed decision-making can lead to better cultivation practices and improved crop yields, ultimately contributing to a more reliable food supply.

In the red cluster, the emphasis is on advanced technologies such as machine learning and AI applications in agriculture. The node “machine learning” stands out, connecting with AI technologies, learning systems, and remote sensing, illustrating the use of these advanced methods to enhance agricultural processes. Topics like “plant disease” are linked with convolutional neural networks, weed control, and disease control, indicating the critical role of AI in identifying and managing plant health issues. This cluster also includes nodes like “convolutional neural networks”, which are connected to the classification of information and learning algorithms, showcasing the sophisticated computational methods employed to tackle complex agricultural challenges.

The blue cluster highlights the integration of digital technologies and automation in agriculture. “Internet of Things (IoT)” is a central node, connected to precision farming, big data, and digital agriculture, demonstrating the significant role of IoT in collecting and analyzing data for more precise and efficient farming practices. The node “agricultural robots” is linked with computer vision, blockchain, and supply chains, reflecting the growing use of automation and digital technologies in agriculture. Additionally, “digital agriculture” connects with crop management and data privacy, emphasizing the trend towards leveraging digital tools and data to improve agricultural outcomes and address privacy concerns. This cluster encapsulates the movement towards a more technologically advanced and data-driven approach to farming.

3.2 *Literature on personality traits, AI and agriculture*

Figure 2 shows the bibliometric analysis of research themes on using the keywords ‘AI’ and ‘Agriculture’. The network graph in Figure 2 shows the connections and relationships between concepts related to personality traits, AI, and human factors. It consists of two distinct clusters, each represented by different colours, highlighting the thematic areas and their interconnectedness.

The red cluster focuses on the intersection of personality traits and AI. The central node in this cluster is “personality traits”, which connects to “personality types”, “population statistics”, and “artificial intelligence”. This indicates a strong link between the study of personality traits and the use of AI in analyzing and understanding these traits. The connection to “population statistics” suggests that demographic data plays a role in understanding personality traits, while the link to “personality types” indicates the categorization and differentiation within personality studies. The integration of AI signifies the application of advanced computational methods to analyze and interpret personality-related data.

The green cluster highlights the broader implications of personality traits in relation to humans. The central node “artificial intelligence” connects to “humans”, “personality”, and “human factors”, suggesting that AI is being used to study and understand human personality traits. The node “personality” is connected to “humans”, emphasizing the direct relationship between personality studies and human behavior. This cluster illustrates the importance of AI in enhancing our understanding of human personality and its various aspects, potentially leading to applications in areas such as human resources, psychology, and personal development.

Based on 15 papers on ‘Personality’, ‘AI’ and ‘Agriculture’ on the Scopus database searched on 7 August 2024, from 2022 to 2024. It is divided into 7 items with 2 major clusters, with at least 2 times repetitions.

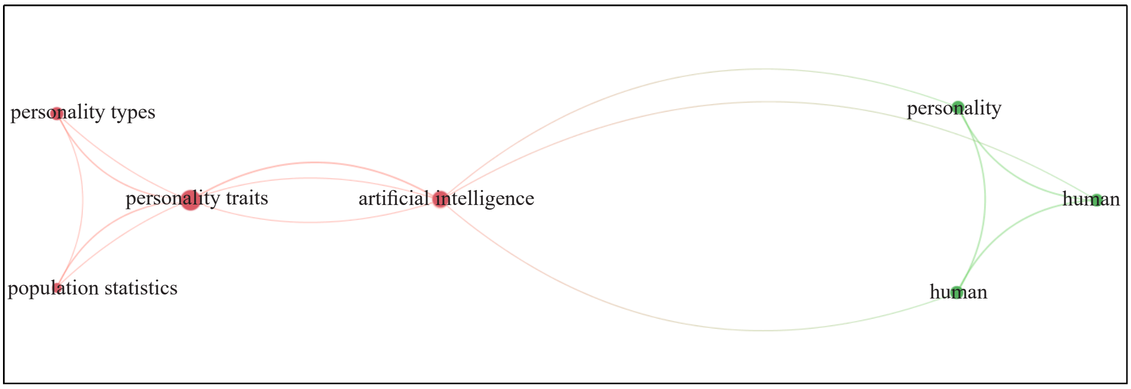

Figure 2. A bibliometric analysis of research themes on using the keywords 'AI' and 'Agriculture'. Visualization of the paper network confirming the main themes of research

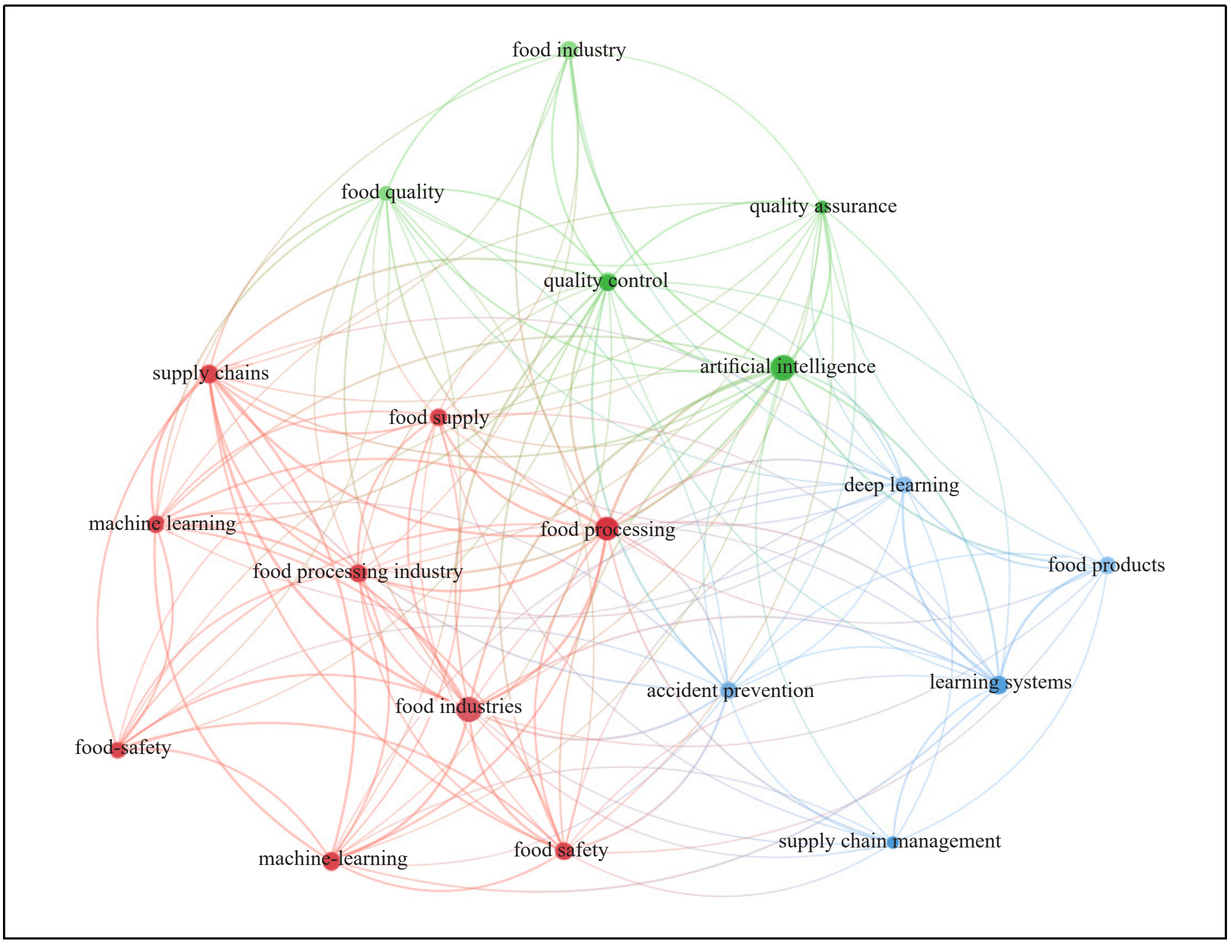

Figure 3. A bibliometric analysis of research themes on using the keywords 'Artificial intelligence' and 'Food industry'. Visualization of the paper network confirming the main themes of research. Based on 50 papers on 'Artificial intelligence' and the 'Food industry', the Scopus database was searched on 7 August 1995, from 1995 to 2024. It is divided into 19 items with 3 major clusters, with at least 3 times repetitions

3.3 *Literature on 'artificial intelligence' and 'food industry'*

Figure 3 shows the bibliometric analysis of research themes on using the keywords 'Artificial intelligence' and 'Food industry'. This network graph in Figure 3 presents the relationships and connections between various topics related to food processing, AI, and supply chain management. It is divided into three main colour clusters, each representing a different thematic area within the broader context of food industry operations and innovations.

The green cluster focuses on quality control within the food industry, emphasizing the role of AI in ensuring quality and safety. The central node "quality control" is linked to "quality assurance", "food quality", and "food industry", indicating the importance of maintaining high standards throughout the food production process. The node "artificial intelligence" connects with these quality-related nodes, highlighting the use of AI technologies to enhance quality control measures. This cluster suggests a strong emphasis on leveraging AI to improve the reliability and efficiency of food quality assurance practices.

The red cluster centers around food processing and the broader food industries, with a significant focus on machine learning. The central node, "food processing", connects to "food processing industry", "food industries", "food safety", and "machine learning". This indicates a comprehensive view of the food processing sector, including industry-specific challenges and the integration of machine learning techniques to address them. "Supply chains" and "food supply" are also connected within this cluster, underscoring the importance of efficient supply chain management in ensuring a steady and safe food supply. This cluster highlights the critical role of advanced machine learning methods in optimizing food processing operations and maintaining food safety standards.

The blue cluster emphasizes the application of learning systems and deep learning in the context of supply chain management. The central node "learning systems" is connected to "deep learning", "supply chain management", "food products", and "accident prevention". This illustrates the use of advanced learning algorithms to enhance various aspects of supply chain management, from predicting demand and optimizing logistics to preventing accidents and ensuring the safety of food products. The connection to "food products" suggests a direct impact on the final output of the supply chain, emphasizing the importance of these technologies in maintaining product quality and safety.

4. Discussion

AI has played a significant role in precision agriculture. The agricultural sector has witnessed a transformative shift with the advent of I4 and the integration of AI technologies [19]. I4 represents a combination of digital and physical systems, utilizing sensors, machines, and information technology to create interconnected and intelligent production environments. These advancements have revolutionized precision agriculture, empowering farmers to enhance crop management and improve predictive analytics.

4.1 *Enhanced crop management through AI and Industry 4.0*

Integrating AI tools, such as machine learning and computer vision, has enabled the analysis of vast amounts of data from drones, satellites, and sensors [19-20]. This data-driven approach allows farmers to precisely monitor crop health, soil conditions, and weather patterns, optimizing water application, fertilizers, and pesticides. By minimizing waste and maximizing yield, AI-powered precision agriculture enhances resource utilization and supports sustainable farming practices. The deployment of I4 technologies into agricultural systems is expected to drive significant productivity gains and support the digital transformation of the food industry. The success of AI integration in precision agriculture is heavily influenced by the personality traits of the farmers [20].

Conscientious farmers are more likely to follow precise instructions and maintain the equipment necessary for AI systems [19, 21]. Those open to new experiences may be more willing to experiment with innovative technologies and integrate them into their farming practices. Analytical thinkers can better understand and interpret complex data, making informed decisions that improve crop health and yield [21].

4.1.1 *Predictive analytics in agriculture within Industry 4.0*

I4 has also transformed predictive analytics in agriculture, leveraging historical data and real-time information to predict crop yields, disease outbreaks, and pest infestations [19]. AI algorithms can anticipate challenges and provide valuable insights, enabling farmers to take proactive measures [20]. This predictive capability helps mitigate risks and optimize production processes, ensuring consistent and high-quality yields. By integrating AI-driven precision agriculture, farmers can improve their resilience to adverse conditions and maintain a sustainable food production system [19]. These advancements in precision agriculture and predictive analytics demonstrate the immense potential of AI in transforming the agricultural sector and meeting the growing global demand for food [17, 22].

4.2 *The influence of personality traits on precision agriculture adoption in the era of Industry 4.0*

In the age of I4, the integration of AI technologies such as machine learning and computer vision has revolutionized precision agriculture [21]. These data-driven tools analyze vast amounts of data from drones, satellites, and sensors to monitor crop health, soil conditions, and weather patterns with remarkable accuracy [9]. This precise approach allows farmers to apply water, fertilizers, and pesticides exactly where and when they are needed, reducing waste [10, 23-25] and maximizing yield [9]. Integrating AI optimises resource usage and supports sustainable farming practices by minimizing environmental impact [9].

Interestingly, the personality traits of farmers play a crucial role in successfully adopting and utilising AI technologies in precision agriculture [21]. Conscientiousness, openness to new experiences, and analytical thinking can enhance a farmer's ability to effectively use data-driven insights for crop management.

In conclusion, the integration of AI in precision agriculture has revolutionized farming practices, optimizing resource usage and supporting sustainable agriculture [9]. However, the success of these technologies is heavily influenced by the personality traits of the farmers adopting them [21]. By understanding the role of personality in precision agriculture, researchers and policymakers can develop strategies to effectively promote the adoption of these transformative technologies [14].

4.2.1 *The impact of personality traits on the adoption of predictive analytics in agriculture*

The advent of I4 has revolutionized the agricultural sector, enabling farmers to leverage predictive analytics to optimize their operations [9]. AI-driven technologies can accurately forecast crop yields, disease outbreaks, and pest infestations, empowering farmers to take proactive measures and mitigate potential risks. Beyond these technological advancements, the adoption and effective utilization of predictive analytics are significantly influenced by the personality traits of the farmers themselves.

Farmers with a higher tolerance for risk are more inclined to trust the predictions made by AI algorithms and implement bold strategies to address the identified challenges [9]. On the other hand, resilient individuals are better equipped to adapt to the changes and challenges highlighted by predictive analytics, maintaining their productivity even in the face of adverse conditions [9]. Proactive farmers, characterized by their forward-thinking and action-oriented nature, are more likely to implement the preventive measures suggested by AI, ensuring their crops' continued health and productivity [9].

However, the adoption of predictive analytics in agriculture is not without its challenges. While AI-powered innovations have immense potential to improve agricultural outcomes, a holistic approach is necessary to address these technologies' complexities and potential risks [14]. Developers must be mindful of data collection, processing, and storage issues, as well as the potential for monopolies over data, seeds, and pesticides [14]. Moreover, the successful implementation of predictive analytics requires an interdisciplinary approach, bringing together experts from various fields to ensure that appropriate, fair, and sensible policies are implemented in the agricultural sector [26].

To build trust in the use of predictive analytics, it is crucial to address the issue of bias in AI algorithms. Bias can arise from the assumptions made during the algorithmic development process, leading to inaccurate predictions and suboptimal decision-making [26]. Overcoming harmful bias and pursuing fairness and inclusiveness in AI solutions are essential for improving human-machine partnerships in agriculture [26].

In conclusion, the adoption and effective utilization of predictive analytics in agriculture are heavily influenced by the personality traits of farmers. While I4 has transformed the agricultural sector, the success of these technologies ultimately depends on the ability of farmers to adapt, trust, and proactively implement the insights provided by AI-driven predictive analytics.

4.3 *The impact of personality traits on the effectiveness of real-time monitoring in agriculture*

The I4 revolution has ushered in a new era of technological advancements that have transformed the agricultural sector. Sensors embedded in fields can now provide farmers with continuous real-time data on critical factors such as soil moisture, nutrient levels, and temperature [27-29]. AI systems can process these insights to generate actionable recommendations, enabling farmers to respond promptly to any issues and optimize their crop management [27-29].

Integrating IoT, AI, and other emerging technologies has given rise to the concept of precision agriculture, which focuses on collecting, storing, and analyzing digital data to enhance farming practices [27, 30] has allowed for precise monitoring of field conditions, enabling farmers to fine-tune their inputs and decision-making [28, 30]. The widespread adoption of I4 technologies in agriculture, often called "Agriculture 4.0", has increased productivity, sustainability, and efficiency [31]. By leveraging these digital solutions, farmers can improve their yield, reduce environmental impact, and alleviate their workload [32].

However, the effectiveness of these real-time monitoring systems is heavily dependent on the personality traits of the farmers [33-34]. Attentive farmers are more likely to promptly notice and act upon the data provided by these systems [27]. Adaptable individuals can quickly adjust their farming practices based on real-time insights, ensuring optimal crop management. Diligent farmers are committed to maintaining the monitoring systems and consistently using the data to improve their farming practices, leading to better overall outcomes [9].

Using sensor technologies and AI-based precision agriculture techniques has improved decision-making, resource efficiency, and crop yields [27]. Unfortunately, these innovative approaches have been hindered by the limited support and advisory services available to farmers [21].

As the agricultural industry continues to embrace the opportunities presented by I4, it is crucial to understand the role of personality traits in effectively implementing real-time monitoring systems [9]. By recognizing the importance of attentiveness, adaptability, and diligence, farmers can maximize the benefits of these transformative technologies and drive sustainable progress in the agricultural sector [4].

4.3.1 *The integration of AI and Industry 4.0 in advancing plant breeding*

The field of plant breeding has experienced a remarkable transformation with the integration of AI and I4.0 technologies. These advancements have enabled the rapid identification and development of crop varieties with desirable traits, addressing the challenges posed by a changing climate and growing population [28].

AI-powered analyses of genetic data and environmental interactions can predict the performance of plant varieties under specific conditions, accelerating the breeding process and enhancing the precision of selecting traits such as drought resistance, pest tolerance, and high yield. This integration ensures that new crop varieties can be developed faster and more efficiently, providing a crucial solution to global food production's pressing issues [31].

However, integrating AI and I4 in plant breeding must be accompanied by a holistic approach that addresses potential negative effects, such as data monopolies and unequal access to technology [14]. Developers must be aware of these issues to ensure that their solutions can be applied effectively and equitably, avoiding widening the gap between rich and poor countries [14]. Ultimately, the convergence of AI and I4 in plant breeding holds immense potential to revolutionize the field, but it must be implemented responsibly and focus on addressing the challenges of a changing climate and growing population [35].

4.4 *The transformative role of AI in optimizing agricultural logistics within Industry 4.0*

The modern agricultural landscape has been transformed by the advent of I4 technologies, with AI emerging as a powerful tool in revolutionizing the efficiency of the agricultural supply chain. AI algorithms can analyse vast logistical data troves, enabling the determination of the most optimal transportation routes, thus reducing delays and minimizing costs.

By enhancing logistics efficiency, AI plays a crucial role in ensuring fresh produce reaches markets quickly and with minimal spoilage, contributing to a more reliable and sustainable food supply chain that benefits producers and consumers [14]. The integration of AI-driven logistics optimization has been a game-changer, as strategic thinkers can effectively plan and implement these technologies, while those with strong organizational skills can manage the complexities of supply chain operations, ensuring seamless integration of AI tools.

The impact of AI on the agricultural sector is multifaceted, as it can optimize the use of resources and improve the efficiency of various processes, from crop management to livestock monitoring [10]. AI-powered precision agriculture, for instance, can enhance decision-making by providing farmers with valuable insights derived from data analytics, leading to improved yields, reduced spending on inputs, and increased productivity. Furthermore, adopting AI in the agricultural sector can also contribute to sustainability by reducing harmful chemicals, improving soil fertility, and mitigating the environmental impact of farming practices [36].

In conclusion, the integration of AI in the agricultural supply chain within the framework of I4 has been transformative. It enhances logistics efficiency, optimizes resource utilization, and contributes to a more sustainable and reliable food system [22, 37].

5. Conclusion

Integrating AI within the framework of I4 into the agricultural food industry marks a significant advancement in sustainable crop disease management and inventory management. By leveraging real-time data and predictive analytics, AI systems provide early detection and targeted interventions, reducing dependency on chemical pesticides and enhancing crop yield. The deployment of I4 technologies, such as sensors, IoT, and advanced data analytics, supports the digital transformation of agriculture, enhancing both productivity and sustainability. The success of these technologies heavily relies on the farmers' willingness to adopt and effectively use AI solutions, which is influenced by their personality traits such as openness to innovation, conscientiousness, and analytical thinking.

Promoting these traits among farmers can lead to the successful implementation of AI-driven solutions, fostering more resilient and sustainable agricultural systems. The study highlights the transformative potential of AI in agriculture and underscores the importance of continued research, policy support, and interdisciplinary collaboration to fully realize the benefits of these technologies. By integrating technological advancements with human factors, AI and I4 have the potential to revolutionize crop management, inventory management, and logistics, contributing to a more sustainable and reliable food system. This holistic approach is essential for addressing global food security and environmental sustainability challenges, ensuring that the agricultural sector can meet the growing demands of the future.

Author contributions

Conceptualization, C.K.Y. and C.S.L.; methodology, C.S.L. and W.S.V.L.; software, C.S.L.; validation, C.K.Y., C.S.L. and W.S.V.L.; formal analysis, C.K.Y.; investigation, C.S.L. and W.S.V.L.; resources, C.S.L. and W.S.V.L.; data curation, C.K.Y. and C.S.L.; writing-original draft preparation, C.K.Y.; writing-review and editing, C.S.L. and W.S.V.L.; visualization, C.K.Y. and C.S.L.; supervision, C.S.L.; project administration, C.S.L.; funding acquisition, C.S.L. and V.S.V.L. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflicts of interest.

References

[1] Noor Hasnan NZ, Yusoff YM. Short review: Application areas of Industry 4.0 technologies in food processing sector. In *2018 IEEE Student Conference on Research and Development (SCOReD)*. Selangor, Malaysia: IEEE; 2018. p.1-6.

[2] Ichsan M, Dachyar M, Farizal. Readiness for implementing Industry 4.0 in food and beverage manufacturer in Indonesia. *IOP Conference Series: Materials Science and Engineering*. 2019; 598(1): 012129.

[3] Kayikci Y, Subramanian N, Dora M, Bhatia MS. Food supply chain in the era of Industry 4.0: Blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology. *Production Planning & Control*. 2022; 33(2-3): 301-321.

[4] Khan PW, Byun YC, Park N. IoT-blockchain enabled optimized provenance system for food Industry 4.0 using advanced deep learning. *Sensors*. 2020; 20(10): 2990.

[5] Köbnick P, Velu C, McFarlane D. Preparing for Industry 4.0: Digital business model innovation in the food and beverage industry. *International Journal of Mechatronics and Manufacturing Systems*. 2020; 13(1): 59-89.

[6] Luque A, Peralta ME, De Las Heras A, Córdoba A. State of the Industry 4.0 in the Andalusian food sector. *Procedia Manufacturing*. 2017; 13: 1199-1205.

[7] Boccia F, Covino D, Di Pietro B. Industry 4.0: Food supply chain, sustainability, and servitization. *Rivista Studi Sostenibilita*. 2019; 1: 77-92.

[8] Humanology Sdn Bhd. 2024. Available from: https://hba.com.my/ [Accessed 2nd August 2024].

[9] Linaza MT, Posada J, Bund J, Eisert P, Quartulli M, Döllner J, et al. Data-driven artificial intelligence applications for sustainable precision agriculture. *Agronomy*. 2021; 11(6): 1227. Available from: https://doi.org/10.3390/agronomy11061227.

[10] Giri A, Saxena RR, Saini P, Rawte S. Role of artificial intelligence in advancement of agriculture. *International Journal of Chemical Studies*. 2020; 8(2): 375-380. Available from: https://doi.org/10.22271/chemi.2020.v8.i2f.8796.

[11] Belhadi A, Mani V, Kamble SS, Khan SAR, Verma S. Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: an empirical investigation. *Annals of Operations Research*. 2024; 333(2): 627-652.

[12] Jain S, Gandhi AV. Impact of artificial intelligence on impulse buying behaviour of Indian shoppers in fashion retail outlets. *International Journal of Innovation Science*. 2021; 13(2): 193-204.

[13] Kaya F, Aydin F, Schepman A, Rodway P, Yetişensoy O, Demir Kaya M. The roles of personality traits, AI anxiety, and demographic factors in attitudes toward artificial intelligence. *International Journal of Human-Computer Interaction*. 2024; 40(2): 497-514.

[14] Gwagwa A, Kazim E, Kachidza P, Hilliard A, Siminyu K, Smith ML, et al. Road map for research on responsible artificial intelligence for development (AI4D) in African countries: The case study of agriculture. *Patterns*. 2021; 2(12): 100381. Available from: https://doi.org/10.1016/j.patter.2021.100381.

[15] Scopus. *What is Scopus preview*? 2020. Available from: https://service.elsevier.com/app/answers/detail/a_id/15534/supporthub/scopus/#tips [Accessed 1st January 2024].

[16] Ellegaard O, Wallin JA. The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*. 2015; 105(3): 1809-1831. Available from: https://doi.org/10.1007/s11192-015-1645-z.

[17] Van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*. 2009; 84(2): 523-538. Available from: https://doi.org/10.1007/s11192-009-0146-3.

[18] Guz AN, Rushchitsky JJ. Scopus: A system for the evaluation of scientific journals. *International Applied Mechanics*. 2009; 45(4): 351-362. Available from: https://doi.org/10.1007/s10778-009-0189-4.

[19] Manaware D. Artificial intelligence: A new way to improve Indian agriculture. *International Journal of Current Microbiology and Applied Sciences*. 2020; 9(3): 1095-1102. Available from: https://doi.org/10.20546/ijcmas.2020.903.128.

[20] Bujang AS, Abu Bakar BH. Agriculture 4.0: Data-driven approach to galvanize Malaysia's agro-food sector development. In *Proceedings of the FFTC-RDA International Symposium on "Developing Innovation Strategies in the Era of Data-driven Agriculture"*. Jeonju, Republic of Korea; 2019. p.1631.

[21] Ali DA, Bowen D, Deininger K. Personality traits, technology adoption, and technical efficiency: Evidence from smallholder rice farms in Ghana. *The Journal of Development Studies*. 2020; 56(7): 1330-1348.

[22] Akyazi T, Goti A, Oyarbide A, Alberdi E, Bayon F. A guide for the food industry to meet the future skills requirements emerging with Industry 4.0. *Foods*. 2020; 9(4): 492.

[23] Chaterji S, DeLay ND, Evans J, Mosier NS, Engel BA, Buckmaster DR, et al. Artificial intelligence for digital agriculture at scale: Techniques, policies, and challenges. *arXiv: 2001.09786*. 2020. Available from: https://doi.org/10.48550/arxiv.2001.09786.

[24] Devitt SK. Cognitive factors that affect the adoption of autonomous agriculture. *arXiv: 2111.14092*. 2021. Available from: https://doi.org/10.48550/arxiv.2111.14092.

[25] Mesías-Ruiz GA, Pérez-Ortiz M, Dorado J, Castro ADD, Peña J. Boosting precision crop protection towards agriculture 5.0 via machine learning and emerging technologies: A contextual review. *Frontiers in Plant Science*.

2023; 14: 1143326. Available from: https://doi.org/10.3389/fpls.2023.1143326.
[26] Gardezi M, Joshi B, Rizzo DM, Mark R, Prutzer E, Brugler S, et al. Artificial intelligence in farming: Challenges and opportunities for building trust. *Agronomy Journal*. 2024; 116(3): 1217-1228. Available from: https://doi.org/10.1002/agj2.21353.
[27] Hrustek L. Sustainability driven by agriculture through digital transformation. *Sustainability*. 2020; 12(20): 8596. Available from: https://doi.org/10.3390/su12208596.
[28] Sung J. The fourth industrial revolution and precision agriculture. In: Hussmann S (ed.) *Automation in Agriculture-Securing Food Supplies for Future Generation*s. London: IntechOpen; 2018. Available from: https://doi.org/10.5772/intechopen.71582.
[29] Kilbas AA, Srivastava HM, Trujillo JJ. Preface. *North-Holland Mathematics Studies*. 2006; 204: vii-x. Available from: https://doi.org/10.1016/s0304-0208(06)80001-0.
[30] Singh RK, Berkvens R, Weyn M. AgriFusion: An architecture for IoT and emerging technologies based on a precision agriculture survey. *IEEE Access*. 2021; 9: 136253-136283. Available from: https://doi.org/10.1109/access.2021.3116814.
[31] Gyamfi EK, ElSayed Z, Kropczynski J, Yakubu MA, Elsayed N. Agricultural 4.0 leveraging on technological solutions: Study for smart farming sector. *arXiv: 2401.00814*. 2024. Available from: https://doi.org/10.48550/arxiv.2401.00814.
[32] Vani A, Reddy NS, Parsharamulu M, Mahesh N. Implementation of smart farming using IoT. *Asian Journal of Applied Science and Technology*. 2021; 5(2): 58-67. Available from: https://doi.org/10.38177/ajast.2021.5208.
[33] Hidayatno A, Rahman I, Rahmadhani A. Understanding the systemic relationship of industry 4.0 adoption in the Indonesian food and beverage industry. In *Proceedings of the 5th International Conference on Industrial and Business Engineering (ICIBE 19)*. New York, NY, USA: Association for Computing Machinery; 2019. p.344-348.
[34] Hasan MM, Islam MU, Sadeq MJ. Towards technological adaptation of advanced farming through AI, IoT, and Robotics: A Comprehensive overview. *arXiv: 2202.10459*. 2022. Available from: https://doi.org/10.48550/arxiv.2202.10459.
[35] Mba C, Guimarães EP, Ghosh K. Re-orienting crop improvement for the changing climatic conditions of the 21st century. *Agriculture & Food Security*. 2012; 1(1): 7. Available from: https://doi.org/10.1186/2048-7010-1-7.
[36] Chowdhury H, Argha DBP, Ahmed MA. Artificial intelligence in sustainable vertical farming. *arXiv: 2312.00030*. 2023. Available from: https://doi.org/10.48550/arxiv.2312.00030.
[37] Arbulu I, Lath V, Mancini M, Patel A, Tonby O. *Industry 4.0: Reinvigorating ASEAN Manufacturing for the Future*. Singapore: McKinsey & Company, Digital Capability Center; 2018.