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Society 5.0-Inspired Digitalization Framework for Resilient and Sustainable Agriculture

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Abstract

This research paper proposes a digitalization framework based on Society 5.0 principles for promoting resilient and sustainable agricultural value chains in the context of climate change. Climate change is affecting the productivity and sustainability of agricultural systems and threatening food security in many parts of the world. Digitalization has the potential to enhance the resilience of agricultural value chains to climate change by improving efficiency, promoting sustainability, and reducing vulnerability to climate risks. This study reviews the literature to investigate the potential benefits and challenges of Society 5.0-inspired digitalization for agricultural value chains in the context of resilience and sustainability. Further, this study establishes critical design requirements for digitalization, which inform the development of a theoretical framework for Society 5.0-inspired digitalization framework in realizing resilient and sustainable agricultural value chains.

Keywords: Interoperability, User-friendly, Data Security, Scalability, Reliability, Policy and Regulation, Sustainable Development Goals (SDGs)

1 Introduction

Climate change is one of the global agricultural sector's most significant challenges. It is affecting the productivity and sustainability of agricultural systems and threatening food security in many parts of the world [3] [19]. In response to these challenges, there is a growing interest in digitalization and its potential to enhance the resilience of agricultural productivity and mitigate the effects of climate change [9] [18]. This research seeks to investigate the potential benefits and challenges of Society 5.0-inspired digitalization for agricultural value chains and to develop a theoretical framework to guide the development of digital technologies that support resilient and sustainable agricultural value chains.

Research Objectives:

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1. To identify the potential benefits and challenges of Society 5.0-inspired digitalization for agricultural value chains in the context of climate change.

2. To develop a theoretical framework for Society 5.0-inspired digitalization framework for resilient and sustainable agricultural value chains.

3. To explore the role of digital technologies in promoting climate-resilient and sustainable agricultural value chains.

In recent years, the concept of Society 5.0 has emerged as a potential solution to some of the challenges facing the agricultural sector in Kenya. Society 5.0 is an innovative approach that integrates technology and human society, focusing on sustainability, Inclusivity, and social well-being [32]. Digitalization is a crucial component of Society 5.0, enabling the integration of various technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data, to transform the various tasks of the agriculture value chain.

Agriculture plays a crucial role in economic development [21], ensuring food security [27], and in poverty eradication [10]. Indigenous farmers are the backbone of the agricultural sector in developing, but they often face several challenges, including limited access to finance, inadequate infrastructure, and low productivity. Additionally, the COVID-19 pandemic has brought about unprecedented challenges, exacerbating the challenges that smallholder farmers face [1].

In this research paper, we explore the potential of Society 5.0-inspired digitalization to promote sustainable farming practices in the context of resilience, sustainability, and adaptations to the effects of climate change. The rest of this paper is structured as follows, in section 2, we present the literature review analysis. Section 3 presents envisioned design requirements that the society 5.0 digitalization framework aspires to attain. In section 4, the discussions of the paper, and in section 5, we conclude the paper.

2 Literature review

2.1 Application of Meta-Governance Theory in Digitalization

The complexity of digitalization necessitates examining how different stakeholders collaborate at various phases for a common goal [33]. The challenge lies with multiple subjects involved within a complex structure. Often conflicts of interest arise, unclear roles, negotiations in - decision making, and technology development dynamic [11]. Therefore, the digitalization of the agricultural value chain is a typical meta-issue. "Meta-governance" is a high-level strategy in integrating hierarchical network-governance models, and of the market, in structuring and systematizing operation mechanisms in the market, government, and society. The theory of meta-governance depicts how different actors (governments, market participants, and societal actors) interact and their roles.

2.2 Digitalization of Agricultural Value Chains for Society 5.0

Digitalization is transforming the agricultural sector by providing new opportunities for enhancing the efficiency and sustainability of agricultural value chains [28]. Digital technology provides avenues for services and new opportunities in achieving sustainability and transformation of the agricultural value chains [24]. Digital technologies include networks such as 4G and 5G, cloud computing, and the Internet of Things (IoT), which are rapidly getting integrated into virtually all agricultural value chains with a focus on enhancing efficiency, effectiveness,

and sustainability [7]. Society 5.0 [8] combines digital technologies with social innovation to promote a human-centric society. The Society 5.0 salient features can help further to promote digitalization in the agricultural sector, and they are summarized in Table 1.

Table 1: Salient characteristics of Society 5.0 that inspire digitalization

Characteristic	**Explanation**
Innovation	Society 5.0 fosters a culture of innovation and encourages the advancement of novel technologies and business models aimed at tackling societal challenges and unlocking fresh opportunities [26].
Personalization-human-centred designs	In Society 5.0, the unique needs and requirements of individuals are acknowledged, and the focus is on crafting tailored solutions that cater to the specific needs of each individual [30].
Sustainability	In Society 5.0, there is a strong emphasis on building a sustainable society that effectively balances economic growth with environmental and social concerns [29] [34] .
Human-centric approach	The objective of Society 5.0 is to prioritize the well-being of individuals and position them at the heart of the development process, thereby fostering a sustainable, inclusive, and prosperous society [14] [40] .
Integration of digital technologies	Society 5.0 underscores the utilization of digital technologies like artificial intelligence, the Internet of Things, and big data to address societal challenges and elevate the standard of living. [23].
Collaboration	Society 5.0 promotes collaboration among stakeholders, including government, industry, academia, and civil society, to create innovative solutions to social problems [4].
Empowerment	The objective of Society 5.0 is to empower individuals and communities by facilitating their access to information and resources and encouraging their active participation in decision-making processes. [5] [31].

2.3 Sustainable Agricultural Transformation through digital empowerment

The sustainability of agricultural value chains is critical in attaining the Sustainable Development Goals (SDGs) [28], SDG 1 reducing poverty, SDG 2 zero hunger, and SDG 5 Gender equality for empowering women and the youth particular. Addressing these SDGs contributes to realizing economic transformation and empowerment through the initiative for climate ac-

tion (SDG 13). To ensure that digital technologies are applied sustainably, adopting a holistic approach that considers environmental, social, and economic considerations is vital. For example, digital technologies can promote sustainable agriculture practices, such as knowledge sharing on farming practices and supply chain management. Additionally, digital technologies can promote social equity by providing marginalized farmers access to market information and extension services remotely. The challenges to utilizing technology for sustainable agriculture include (i) digital divide, and (ii) lack of technical capacities among farmers

2.3.1 Digital divide

The digital divide is the widening of social inequalities in the advent of a technologically driven world [36]. These inequalities are in different forms [36], including (1)limited physical access to internet-powered digital devices, (2) insufficient skills in the utilization of digital devices, and (3) low motivational drive to innovatively utilize digital devices for advancements. The result is economic development and social welfare stagnation, thus marginalizing the less privileged communities. In the case of the Agricultural sector, the digital divide forms can exclude and further marginalize farmers from digital empowerment initiatives hence low-level realization levels of seamless digital services provision by relevant sector actors and entities. Research in Digital divide theory, conceptual explanations, and interdisciplinary approach applications can resolve economic and social inequalities and exclusions.

2.3.2 Lack of technical capacities among farmers

Many farmers lack the skills and knowledge to use digital technologies for farming resilience in sustaining their economic activities [20]. Technical capacity-building initiatives can help farmers overcome these barriers and improve their use of digital technologies. Governments, Non-governmental organizations and industry need make initiatives to develop digital skills programs customized for the farming sector.

2.4 Multi-Stakeholders Approach in Agricultural Value Chain Digital Transformation

Theoretically, all stakeholders are the inherent data providers and information users. Different stakeholders perform diverse responsibilities and activities that can scale agricultural value chain application scenarios with technological innovations. Providing services with Digital technology promotes sustainability transformation in the agriculture value chains. The intersection of activities determines the responsibilities of stakeholders and the information flows [11].

The social actors' diversity differentiates the different actors' needs. For example, Farmers and farmers' groups upload data during information collection, thus improving on efficiency in information use, thereby enhance professionalization of the process and operationalization of decision-making. Industry and or research institutions create enabling technologies for research data collection. In the analysis phase, offer analytical models and tools that support government institutions' management and enhance research for providing economic development ideas. Thus, the meta-governance theory [33] is handy in conceptualizing a digitalization framework for joint development and developing suitable incentive strategies. Attaining sustainable development depends on the collaborations between farmers, markets, research institutions, and governments to develop a symbiotic digital ecosystem among the different actors.

3 Society 5.0 Inspired Digitalization Framework for Agricultural Value Chains

In this section, the paper presents envisioned design requirements that the society 5.0 digitalization framework aspires to attain, functional and non-functional.

3.1 Opportunities and design requirements for resilient digital systems

Well designed resilient digital systems in agriculture can offer numerous opportunities and require specific design requirements to ensure their effectiveness. That is, systems should provide real-time data collection and analysis capabilities, allowing for proactive decision-making and prompt responses to changing conditions. Data collection and processing are pre-requisite in the agriculture value chain digitalization[2]. Further, digitalization relies on seamless communication and data exchange [25]. With reliable internet access, farmers may be able to adopt and benefit from digital tools and platforms. In the following subsections design requirements for a resilient and sustainable digital system are presented and discussed.

3.1.1 Interoperability and integration of digital platforms and tools:

Sustainable agricultural systems require the integration of various technologies, such as sensors, drones, and farm management software[15]. Ensuring compatibility and interoperability among these tools allows for seamless data sharing and analysis, enabling farmers to benefit from a holistic and comprehensive approach.

3.1.2 User-friendly interfaces

Well designed interfaces are a crucial component in realizing the contextual usability of a digital system [35]. Designing intuitive and user-friendly interfaces for digital tools and platforms facilitates their adoption by farmers, including those with limited technical expertise. Additionally, training and support to enhance digital literacy among farmers are essential to ensure the effective utilization of digital solutions [16].

3.1.3 Data security and privacy

Systems designed to be secure and confidential are necessary to ensure trust among the involved parties [38] [39]. As digitalization involves collecting and storing sensitive data, robust security measures should be in place to protect farmers' information and ensure their privacy.

3.1.4 Compliance to relevant policies and regulations

Adhering to policies related to data privacy, security, and agricultural practices promotes transparency and trust among stakeholders [37]. For instance, The agricultural policy [22] encompasses various facets of agriculture, including trade, insurance, rural economic growth, bioenergy, and organic farming. The primary objective of this policy is to provide support to farmers in the United States, improve farming productivity, and mitigate adverse environmental effects. Thus Compliance to relevant policies and regulations is crucial for the successful implementation of digitalization in agricultural value chains.

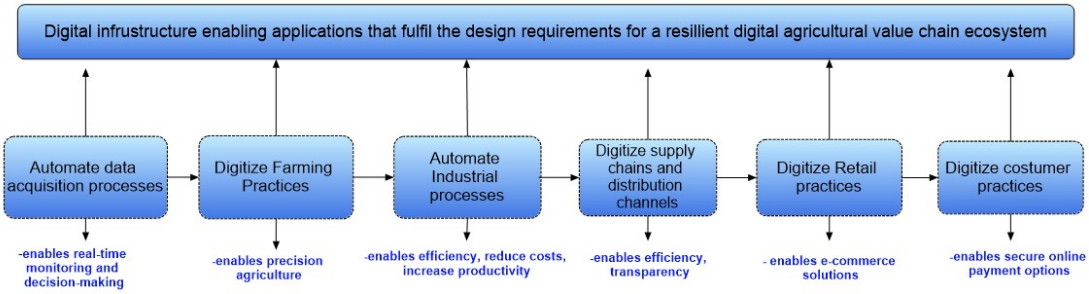

Figure 1: Society 5.0 Digitalization Framework for Resilient and Sustainable Agricultural value chain

3.1.5 Scalability and flexibility

Resilient digital systems should be scalable and flexible to accommodate changing needs and future growth. [12] defines scalability as the system's capability of incorporating additional nodes or resources. This includes the ability to handle increasing data volumes, support additional users, and adapt to emerging technologies. A scalable framework ensures that the solution can be adapted to meet the diverse needs of stakeholders across different scales, from smallholder farmers to large agribusinesses. Scalability allows for the integration of new technologies and data sources, enabling continuous improvement and innovation.

3.1.6 Reliability:

The effectiveness of data-driven systems relies on efficient procedures, data, and technologies [13]. Data consistency, data completeness [17], and data accuracy [6] are the fundamental elements that contribute to the reliability of data. Reliable systems ensure that stakeholders can trust the data and insights generated by the system. This promotes informed decision-making, reduces the risk of error, and increases the effectiveness of the system. Reliability also ensures that the system is available and accessible when needed, ensuring that critical data and services are not lost or delayed.

By addressing these requirements, digitalization can play a transformative role in designing sustainable agricultural systems, enabling farmers to make data-driven decisions, optimize resource use, mitigate environmental impacts, and achieve long-term sustainability.

3.2 The Conceptual Digitalization Framework

Figure 1 depicts the Society 5.0 Inspired Digitalization Framework for Agricultural Value Chains. This section presents and discusses the different aspects for digitalization of the agricultural value chain which are connected via a digital infrastructure in a seamless manner.

3.2.1 Automate data acquisition processes

Automating the data acquisition processes of actors within the agricultural value chain offers several advantages. Firstly, it enhances efficiency by reducing manual data collection efforts and streamlining data acquisition. Automated data collection eliminates the need for time-consuming and error-prone manual data entry, ensuring accurate and timely data capture.

This, in turn, enables real-time monitoring and decision-making, allowing stakeholders to respond quickly to changes in the agricultural value chain. Moreover, automating data acquisition processes improves data quality and integrity. Manual data collection can lead to errors and inconsistencies, and unreliable data. Automating the process allows data to be collected consistently and uniformly, ensuring consistency, completeness, and accuracy. This high-quality data forms the foundation for informed decision-making, enabling actors within the agricultural value chain to make data-driven decisions and optimize their operations. Additionally, automating data acquisition processes promotes data sharing and collaboration among different actors in the value chain. Automated systems allow data to be easily collected, stored, and shared across various stakeholders, enhancing transparency and facilitating better coordination. Data sharing promotes collaboration, enabling stakeholders to work together towards common goals and leverage shared insights for improved productivity and sustainability.

3.2.2 Digitize Farming Practices

Digitizing farming practices involves adopting digital technologies and tools to enhance and optimize agricultural activities. Farmers can benefit from improved efficiency, increased productivity, and enhanced decision-making capabilities by digitizing farming practices. One of the key benefits of digitization is the ability to collect and analyze data from farming operations. Through the use of sensors, Internet of Things (IoT) devices, and remote sensing technologies, farmers can gather real-time data on soil conditions, weather patterns, crop health, and other relevant parameters. This data can then be analyzed to gain valuable insights and make data-driven decisions regarding irrigation, fertilization, pest control, and overall farm management. Furthermore, digitization enables precision agriculture, where farming practices are tailored to specific areas or even individual plants.

With the help of digital tools such as GPS, drones, and satellite imagery, farmers can create precise field maps, accurately apply inputs like fertilizers and pesticides, and monitor crop growth in a targeted manner. This leads to optimized resource use, reduced waste, and improved crop yields. Digitization also facilitates better farm management and record-keeping. Farmers can use digital platforms and software solutions to manage inventories, track production processes, monitor financials, and analyze profitability. This streamlines administrative tasks and gives farmers a comprehensive view of their operations, allowing for better planning, budgeting, and performance evaluation.

Moreover, digitization promotes connectivity and knowledge sharing within the farming community. Online platforms, mobile applications, and social networks allow farmers to connect, exchange information, and learn from each other's experiences. This fosters a collaborative environment where best practices, innovative techniques, and market insights can be shared, leading to continuous learning and improvement.

3.2.3 Automate Industrial processes

It involves implementing various technologies, such as robotics, artificial intelligence, and the Internet of Things (IoT), to improve efficiency, reduce costs, and increase productivity. By automating industrial processes, companies can streamline their operations, reduce the risk of errors and accidents, and improve overall safety. Furthermore, automation can allow for better control and monitoring of processes, providing data for continuous improvement and decision-making.

3.2.4 Digitize supply chains and distribution channels

Digitizing supply chains involves integrating digital technologies and platforms to transform traditional supply chain processes and enhance efficiency, transparency, and effectiveness. By digitizing supply chains, businesses can streamline operations, improve visibility, and drive better decision-making throughout the entire supply chain ecosystem. One of the potential benefits of digitizing supply chains is the automation of manual and paper-based processes. Businesses can replace time-consuming and error-prone manual tasks with automated and streamlined processes by utilizing digital tools such as electronic data interchange (EDI), cloud-based platforms, and blockchain technology. This reduces manual data entry, improves data accuracy, and speeds up the flow of information between suppliers, manufacturers, distributors, and retailers.

Digitization enables real-time visibility and tracking of goods through the supply chain. With technologies like Internet of Things (IoT) devices, RFID tags, and GPS, businesses can capture and monitor data on the location, condition, and status of products in transit. This real-time visibility allows for proactive inventory management, improved demand forecasting, and enhanced responsiveness to customer needs. Additionally, digitizing supply chains promotes better collaboration and communication among partners. Digital platforms and software solutions enable seamless information sharing between different stakeholders, such as orders, invoices, and inventory levels. This enhances coordination, reduces lead times, and enables faster response to changes in demand or supply, ultimately improving overall supply chain agility.

3.2.5 Digitize Retail practices

Digitizing retail practices involves leveraging digital technologies to transform various aspects of the retail industry. This encompasses adopting digital platforms and tools to enhance customer experiences, streamline operations, and drive business growth. In digitalization, retailers can implement e-commerce solutions to establish online storefronts, enabling customers to browse and purchase products from the comfort of their homes. Additionally, digitalization allows retailers to employ data analytics to gain insights into customer preferences, buying patterns, and trends, enabling personalized marketing strategies and targeted promotions. Retailers can also integrate digital payment systems to provide convenient and secure customer transactions. Moreover, digital technologies facilitate inventory management, supply chain optimization, and real-time monitoring of stock levels, leading to improved efficiency and cost-effectiveness. By digitizing retail practices, businesses can enhance their competitiveness, expand their reach, and provide customers with seamless, personalized shopping experiences.

3.2.6 Digitize costumer practices

Digitizing consumer practices involves the integration of digital technologies and platforms to transform how consumers interact with products, services, and brands. It encompasses various aspects of the consumer journey, from product discovery and purchasing to post-purchase engagement and feedback. By digitizing consumer practices, businesses can enhance customer experiences, improve convenience, and gain valuable insights into consumer behaviors and preferences. One key aspect of digitizing consumer practices is the shift toward online shopping and e-commerce platforms. With the widespread availability of internet access and mobile devices, consumers have increasingly turned to digital channels to browse and purchase products. E-commerce platforms provide convenience and accessibility, allowing consumers to shop anytime, anywhere, and from various options. Businesses can leverage digital platforms to showcase their products, offer personalized recommendations, and provide seamless and secure online payment

options, enhancing the shopping experience.

Digitization enables businesses to collect and analyze consumer data to gain insights into their preferences, behaviors, and purchasing patterns. Through the use of customer relationship management (CRM) systems, businesses can capture and store data on customer interactions, transactions, and feedback. This data can then be analyzed to identify trends, segment customers, and personalize marketing efforts, resulting in targeted and more effective communication and product offerings.

Digital technologies enable businesses to engage with consumers through various channels, such as social media, mobile apps, and chatbots. These channels facilitate direct and interactive communication, allowing businesses to address customer inquiries, provide support, and gather real-time feedback. By leveraging these digital touchpoints, businesses can strengthen customer relationships, foster brand loyalty, and continuously improve their products and services based on consumer input. Furthermore, digitizing consumer practices opens up opportunities for personalized and immersive experiences. For example, virtual reality (VR) and augmented reality (AR) technologies can offer virtual product trials, immersive brand experiences, and interactive storytelling, creating a deeper and more engaging connection between consumers and brands. This level of personalization and interactivity can significantly enhance consumer satisfaction and loyalty.

Digitizing consumer practices brings numerous benefits, including enhanced convenience, personalized experiences, improved customer insights, and direct engagement. By embracing digital technologies, businesses can meet consumers' evolving needs and preferences, foster stronger relationships, and gain a competitive edge in the marketplace.

4 Discussions

Digitalization is transforming the agriculture sector in unprecedented ways. Society 5.0, a concept emphasizing the integration of technology and society in promoting sustainable and resilient agricultural practices. The literature suggests that digitalization can contribute to sustainable agricultural transformation by enhancing efficiency, productivity, and resilience [9]. Through digital technologies such as precision agriculture, farmers can optimize their production processes, reduce waste, and increase yields [28]. There are various challenges to the adoption of digitalization of the agricultural value chain and this include limited infrastructure and inadequate skills and knowledge are significant barriers to the adoption of digital especially in the context of developing countries.

5 Conclusion

Society 5.0-inspired digitalization framework has significant potential for promoting resilient and sustainable agricultural value chains. This research aimed to develop a framework that provides software developers, agricultural stakeholders, and policymakers with a platform to gain a technical understanding of the capabilities of technological infrastructures. The framework will facilitate the development of digital solutions that address the challenges of climate change and enhance the resilience of the agricultural value chain. The focus is to ensure that these solutions are tailored to the specific contexts of the agricultural value chain stakeholders, thereby promoting their sustainability and long-term viability. Future works should focus on interdisciplinary collaborations between researchers, policymakers, and practitioners to ensure

the co-creation of solutions that address complex challenges and align with sustainability and resilience goals in agricultural value chain practices.

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References

[1] Muzna Alvi, Prapti Barooah, Shweta Gupta, and Smriti Saini. Women's access to agriculture extension amidst covid-19: Insights from gujarat, india and dang, nepal. *Agricultural Systems*, 188:103035, 2021.

[2] Mohammad Amiri-Zarandi, Mehdi Hazrati Fard, Samira Yousefinaghani, Mitra Kaviani, and Rozita Dara. A platform approach to smart farm information processing. *Agriculture*, 12(6):838, 2022.

[3] Naveen Kumar Arora. Impact of climate change on agriculture production and its sustainable solutions. *Environmental Sustainability*, 2(2):95–96, 2019.

[4] Sara Bartoloni, Ernesto Calò, Luca Marinelli, Federica Pascucci, Luca Dezi, Elias Carayannis, Gian Marco Revel, and Gian Luca Gregori. Towards designing society 5.0 solutions: The new quintuple helix-design thinking approach to technology. *Technovation*, 113:102413, 2022.

[5] Tat-Dat Bui and Ming-Lang Tseng. Understanding the barriers to sustainable solid waste management in society 5.0 under uncertainties: a novelty of socials and technical perspectives on performance driving. *Environmental Science and Pollution Research*, 29(11):16265–16293, 2022.

[6] Li Cai and Yangyong Zhu. The challenges of data quality and data quality assessment in the big data era. *Data science journal*, 14, 2015.

[7] Othmane Friha, Mohamed Amine Ferrag, Lei Shu, Leandros Maglaras, and Xiaochan Wang. Internet of things for the future of smart agriculture: A comprehensive survey of emerging technologies. *IEEE/CAA Journal of Automatica Sinica*, 8(4):718–752, 2021.

[8] Mayumi Fukuyama. Society 5.0: Aiming for a new human-centered society. *Japan Spotlight*, 27(5):47–50, 2018.

[9] Beatrice Garske, Antonia Bau, and Felix Ekardt. Digitalization and ai in european agriculture: a strategy for achieving climate and biodiversity targets? *Sustainability*, 13(9):4652, 2021.

[10] Anja Gassner, David Harris, Kai Mausch, Anne Terheggen, C Lopes, RF Finlayson, and Philip Dobie. Poverty eradication and food security through agriculture in africa: Rethinking objectives and entry points. *Outlook on Agriculture*, 48(4):309–315, 2019.

[11] Jonna Gjaltema, Robbert Biesbroek, and Katrien Termeer. From government to governance... to meta-governance: a systematic literature review. *Public Management Review*, 22(12):1760–1780, 2020.

[12] Anisha Gupta, Rivana Christie, and R Manjula. Scalability in internet of things: features, techniques and research challenges. *Int. J. Comput. Intell. Res*, 13(7):1617–1627, 2017.

[13] Chayapol Kamyod. End-to-end reliability analysis of an iot based smart agriculture. In *2018 International Conference on Digital Arts, Media and Technology (ICDAMT)*, pages 258–261. IEEE, 2018.

[14] John G Keogh, Laurette Dube, Abderahman Rejeb, Karen J Hand, Nida Khan, and Kevin Dean. The future food chain: digitization as an enabler of society 5.0. *Building the Future of Food Safety Technology*, pages 1–48, 2020.

[15] Nawab Khan, Ram L Ray, Ghulam Raza Sargani, Muhammad Ihtisham, Muhammad Khayyam, and Sohaib Ismail. Current progress and future prospects of agriculture technology: Gateway to sustainable agriculture. *Sustainability*, 13(9):4883, 2021.

[16] Gezahagn Kudama, Mabiratu Dangia, Hika Wana, and Bona Tadese. Will digital solution transform sub-sahara african agriculture? *Artificial Intelligence in Agriculture*, 5:292–300, 2021.

[17] Ohbyung Kwon, Namyeon Lee, and Bongsik Shin. Data quality management, data usage experience and acquisition intention of big data analytics. *International journal of information management*, 34(3):387–394, 2014.

[18] Alana Lajoie-O'Malley, Kelly Bronson, Simone van der Burg, and Laurens Klerkx. The future (s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services*, 45:101183, 2020.

[19] Gurdeep Singh Malhi, Manpreet Kaur, and Prashant Kaushik. Impact of climate change on agriculture and its mitigation strategies: A review. *Sustainability*, 13(3):1318, 2021.

[20] Amber Marshall, Michael Dezuanni, Jean Burgess, Julian Thomas, and Chris K Wilson. Australian farmers left behind in the digital economy–insights from the australian digital inclusion index. *Journal of Rural Studies*, 80:195–210, 2020.

[21] Gerdien W Meijerink and Pim Roza. *The role of agriculture in economic development*. Number 4. Wageningen UR, 2007.

[22] Luca Montanarella. Agricultural policy: Govern our soils. *Nature*, 528(7580):32–33, 2015.

[23] Meghna M Nair, Amit Kumar Tyagi, and N Sreenath. The future with industry 4.0 at the core of society 5.0: Open issues, future opportunities and challenges. In *2021 international conference on computer communication and informatics (ICCCI)*, pages 1–7. IEEE, 2021.

[24] Aleksandr V Nemchenko, Tatyana A Dugina, Svetlana Y Shaldokhina, Evgeny A Likholetov, and Alexandr A Likholetov. The digital transformation as a response to modern challenges and threats to the development of agriculture. In *Smart Innovation in Agriculture*, pages 37–45. Springer, 2022.

[25] Barakat Oumkaltoum et al. Toward a business intelligence model for challenges of interoperability in egov system: Transparency, scalability and genericity. In *2019 International Conference on Wireless Technologies, Embedded and Intelligent Systems (WITS)*, pages 1–6. IEEE, 2019.

[26] Daniel Paschek, Caius-Tudor Luminosu, and Elif Ocakci. Industry 5.0 challenges and perspectives for manufacturing systems in the society 5.0. *Sustainability and Innovation in Manufacturing Enterprises: Indicators, Models and Assessment for Industry 5.0*, pages 17–63, 2022.

[27] Karolina Pawlak and Małgorzata Kołodziejczak. The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. *Sustainability*, 12(13):5488, 2020.

[28] Tianyu Qin, Lijun Wang, Yanxin Zhou, Liyue Guo, Gaoming Jiang, and Lei Zhang. Digital technology-and-services-driven sustainable transformation of agriculture: Cases of china and the eu. *Agriculture*, 12(2):297, 2022.

[29] Sebastian Saniuk, Sandra Grabowska, and Martin Straka. Identification of social and economic expectations: Contextual reasons for the transformation process of industry 4.0 into the industry 5.0 concept. *Sustainability*, 14(3):1391, 2022.

[30] Christian Seelos and Johanna Mair. Social entrepreneurship: Creating new business models to serve the poor. *Business horizons*, 48(3):241–246, 2005.

[31] Dudi Setiadi, Sri Nurhayati, Ansori Ansori, Mohamad Zubaidi, and Rudi Amir. Youth's digital literacy in the context of community empowerment in an emerging society 5.0. *Society*, 11(1):1–12, 2023.

[32] Hanlie Smuts and Alta Van der Merwe. Knowledge management in society 5.0: A sustainability perspective. *Sustainability*, 14(11):6878, 2022.

[33] Eva Sørensen. Metagovernance: The changing role of politicians in processes of democratic governance. *The American review of public administration*, 36(1):98–114, 2006.

[34] Maria C Tavares, Graça Azevedo, and Rui P Marques. The challenges and opportunities of era 5.0 for a more humanistic and sustainable society—a literature review. *Societies*, 12(6):149, 2022.

[35] Kim M Unertl, Richard J Holden, and Nancy M Lorenzi. Usability: making it real from concepts to implementation and end-user adoption. *Healthcare Information Management Systems: Cases, Strategies, and Solutions*, pages 165–175, 2016.

[36] Jan AGM Van Dijk. Digital divide research, achievements and shortcomings. *Poetics*, 34(4-5):221–235, 2006.

[37] Boris T Van Zanten, Peter H Verburg, Maria Espinosa, Sergio Gomez-y Paloma, Giuliano Galimberti, Jochen Kantelhardt, Martin Kapfer, Marianne Lefebvre, Rosa Manrique, Annette Piorr, et al. European agricultural landscapes, common agricultural policy and ecosystem services: a review. *Agronomy for sustainable development*, 34:309–325, 2014.

[38] Pan Yang, Naixue Xiong, and Jingli Ren. Data security and privacy protection for cloud storage: A survey. *IEEE Access*, 8:131723–131740, 2020.

[39] Xing Yang, Lei Shu, Jianing Chen, Mohamed Amine Ferrag, Jun Wu, Edmond Nurellari, and Kai Huang. A survey on smart agriculture: Development modes, technologies, and security and privacy challenges. *IEEE/CAA Journal of Automatica Sinica*, 8(2):273–302, 2021.

[40] İbrahim Yıkılmaz. New era: The transformation from the information society to super smart society (society 5.0). *Data, Information and Knowledge Management; Mert, G., Şen, E., Yılmaz, O., Eds*, pages 85–112, 2020.