Digital Transformation in the Agri-food Sector: A Comparative Analysis of Industry 4.0 Innovations by Italian Sustainability Leaders

Tamara Menichini, Gennaro Salierno and Nicoletta Maria Strollo
Department of Engineering, University of Rome Niccolò Cusano, Rome, Italy

tamara.menichini@unicusano.it
gennaro.salierno@unicusano.it
nicolettamaria.strollo@unicusano.it

Abstract: The agri-food sector is a key actor in the Italian economy and plays a crucial role in rescuing and accelerating progress towards the Sustainable Development Goals (SDGs). However, diverse sustainability challenges including environmental conservation, economic volatility, political changes and regulatory constraints affect the agri-food company's competitiveness and their ability to face global sustainability challenges. Exploiting digital innovation is then essential. By facilitating more efficient management of resources, reducing waste and improving supply chain transparency, digital innovations contribute to more sustainable, inclusive and resilient agri-food systems. This paper aims to understand the ongoing digital transformation of the Italian agri-food sector through a comparative analysis of innovative practices by Italian agri-food companies that are recognized as sustainability leaders. Among the Industry 4.0 (I4.0) technologies, sensors, blockchain, cyber security, and artificial intelligence appear to be the most adopted I4.0 solutions to help companies influence the social, economic and environmental dimensions of sustainable development.

Keywords: Agri-food Sector; Digital Technologies; Industry 4.0 Technologies; Sustainability Leaders, Sustainable Development Goals (Sdgs).

1. Introduction

With the 17 Sustainable Development Goals (SDGs), the United Nations' Agenda has presented the most urgent need to safeguard a responsible future for people and society as a whole (UN, 2015; Fiandrino et al., 2022). Particularly, a large number of the SDGs' targets are closely linked to the food system and require agricultural and food-industry companies to redefine their ongoing production practices (Hassoun et al., 2022; Chandan et al., 2023). Among these, SDG 2 "Zero Hunger", calls for increased investment in innovation to end hunger and any form of malnutrition (UN, 2015). The agri-food sector is one of the main sectors in the European economy in terms of employment and financial performance (Tanda, 2018; FDE, 2023) and comprises all businesses involved from "the farm to the fork", encompassing both the production and distribution phases (Mor et al., 2018). At a national level, the agri-food Italian companies demonstrated significant potential in supporting and accelerating the progress towards the SDGs (Paoloni et al., 2023). Indeed, the Italian agri-food sector has proved remarkable resilience during the COVID-19 pandemic in 2020, maintaining its operations to supply essential goods and thereby positively impacting the Italian economy (Zollet et al., 2021).

However, different sustainability challenges, including environmental conservation, economic volatility, political changes and regulatory constraints, affect the agri-food company's competitiveness and their ability to achieve SDGs (FAO, 2017; Borsellino et al., 2020; Jindřichovská et al., 2020). By exploring the different solutions to these global issues, several studies have detected the potential of Industry 4.0 in facilitating the progress towards a sustainable transition in the agri-food sector (Klerkx et al., 2019; Bai et al., 2020; Mondejar et al., 2021; Abbate et al., 2023; Alam et al., 2023; Stefanini & Vignali, 2024). Accordingly, the concept of Agriculture 4.0 is outlined to refer to the integration of digital technologies into productive processes (Rose & Chilvers, 2018; Frankelius et al., 2019; Da Silveira et al., 2021). Based on the Internet of Things (IoT), sensors, drones, robotics, cloud computing, artificial intelligence (AI), decision support software (DSS), and blockchain (Klerkx et al., 2019), Agriculture 4.0 is recognized as the primary pathway to enhance food production while simultaneously accounting what SDGs require (MacPherson et al., 2022; Secundo et al., 2022; Fragomeli et al., 2024). Indeed, digital innovations are proving to be highly supportive in making agri-food systems more sustainable, inclusive and resilient, by facilitating more efficient management of resources (Wolfert et al., 2017), reducing waste (Kazancoglu al., 2024) and improving supply chain transparency (Walter et al., 2017; Ebinger & Omondi, 2020). In this context, effective reporting allows companies to provide clear evidence of their initiatives and performance (Calabrese et al., 2020), thereby facilitating stakeholders to assess the alignment of digital practices with sustainability needs and track progress (Rosamartina et al., 2022).

However, given the relatively recent introduction of Agriculture 4.0, there remains significant uncertainty regarding its impact on sustainability (Klerkx & Rose, 2020). Particularly, how the digital technologies are

implemented by the agri-food sector to solve the main challenges of sustainability and address SDGs is still unclear (Masi et al., 2021; Secundo et al., 2022; Cricelli et al., 2024). Thus, there emerges a need to investigate how digitalization supports sustainability transition (Klerkx & Rose, 2020) and understand how technologies are integrated into business practices (MacPherson et al., 2022). Given the key role of the agri-food sector in the Italian economy and in light of the exposed research shortcomings, the present paper aims to understand the ongoing digital transformation of the Italian agri-food sector through a comparative analysis of innovative practices by Italian agri-food companies that are recognized as sustainability leaders. Particularly, by employing a content analysis approach, sustainability reporting documents are examined in order to identify what are the I4.0 digital technologies most adopted in business practices and which SDGs these technologies aim to contribute to through their adoption.

The rest of the paper is structured as follows. The next section details the content analysis approach including data collection and coding procedure. This is followed by results and discussion. Finally, the conclusions complete the paper.

2. Data Collection and Method

2.1 Sample Selection

The Italian agri-food system has proven significant progress and a strong capacity for the sustainable management of agricultural resources (Coluccia et al., 2020). This is primarily due to the strong connection between businesses and the local context, as well as the close interaction and active collaboration with key sector stakeholders (Arru, 2020). In addition, the wide variety of high-quality products by Italian agrifood companies drives the adoption of advanced digital technologies to sustain their competitive edge (Cricelli et al., 2024). Therefore, the Italian context is well-suited to be considered for the proposed analysis. Accordingly, a set of twelve (n=12) agri-food Italian companies has been selected among those recognized as sustainability leaders during 2024 by the ranking[1] (Table 1) of the Italian financial journal "Il Sole 24 Ore". The final sample consists primarily of Large companies, with only one SME. European companies qualify as Large if they have more than 250 employees and either a turnover exceeding €50 million or a total balance sheet exceeding €43 million; otherwise, they are considered SMEs (Halkos and Nomikos, 2021).

Table 1: Selected companies

Company	Dimension	Analysed Sustainability Reporting document	Source
C1. BARILLA	Large	Report (2023)	https://www.barilla.com/it-it
C2. F.LLI CARLI	Large	Report (2023)	https://www.oliocarli.it/
C3. BF GROUP	Large	Report (2022)	https://www.bfspa.it/
C4. COLUSSI GROUP	Large	Report (2022)	https://www.colussigroup.it/
C5. ORSERO GROUP	Large	Report (2023)	https://www.orserogroup.it/
C6. LA DORIA	Large	Report (2023)	https://www.gruppoladoria.it/
C7. LAVAZZA GROUP	Large	Report (2023)	https://www.lavazza.it/it
C8. NEWLAT FOOD	Large	website	https://www.newlat.it/
C9. OLEIFICIO ZUCCHI	Large	website	https://www.zucchi.com/
C10. PIETRO CORICELLI	Large	website	https://coricelli.com/
C11. SANPELLEGRINO	Large	Report (2023)	https://www.sanpellegrino-corporate.it/it
C12. BERLUCCHI	SME	Report (2022)	https://www.berlucchi.it/

[1] The provided ranking is an extract from the "Leader della sostenibilità 2024" overall ranking by "Il Sole 24 Ore", available at the web site: https://lab24.ilsole24ore.com/leader-sostenibilita/. It features the top 240 Italian companies of various sizes and sectors, recognized as the most sustainable in the country, based on an evaluation of their sustainability reports or equivalent documents according to an assessment process detailed on the same web site.

2.2 Content Analysis Approach

Content analysis is a research tool used to investigate if certain words and concepts are present within the content of writings or visual representations (Mayring, 2015), enabling the quantification of the frequency of specific elements but also catching their qualitative interpretation (Mayring, 2004). It has been widely used in corporate sustainability accounting research (Torelli et al., 2020) as well as to understand the level of disclosure on the companies' contribution to SDGs through reporting practices (Costa et al., 2022). Sustainability reporting documents include all reports and/or ways through which companies communicate their initiatives, performance, and results regarding sustainability: periodic communications, public statements, as well as sustainability reports and information provided through dedicated sections on company websites (Siew, 2015; GRI, 2016). According to this, content analysis has been increasingly employed in business research to examine not only annual reports but also media items (Bell et al., 2022).

In this paper, both qualitative and quantitative approaches to content analysis have been adopted. The coding frame (Table 2) has been developed according to Mayring (2004). Three specific variables were identified to reach the aim of the present research. According to the "Coding Rules", these variables were coded as 'YES' or 'NO' based on whether the specific requirements outlined in the "Definition" were met or not. Particularly, to support the analysis of the "Citing I4.0 DT" variable (V1), the reference to one or more digital technologies recognized in the literature as the most widely adopted in business practices (Dantas et al., 2021; Varriale et al., 2024) are considered. In the case of 'YES' the list of the disclosed digital technologies by the company is outlined. For the "Citing SDGs" variable (V2), the presence of an explicit reference to one or more 17 SDGs is examined. In the case of 'YES' the list of the disclosed SDGs by the company is outlined. Finally, the variable "I4.0-related SDGs" (V3) was examined only if both of the previous variables were simultaneously coded as 'YES' to determine if the company reports how the adopted digital technologies contribute to the achievement of the SDGs. In the case of 'YES' the connection between the disclosed digital technologies and the SDGs they aim to contribute to, is highlighted.

Table 2: Coding frame

Id	Variable Name	Definition	Coding Rules
V1	Citing I4.0 DT	Explicit references to adopted I4.0 digital technologies in the company's sustainability reporting document, according to the relevant digital technologies listed by Dantas et al. (2021) and Varriale et al. (2024).	If at least one of the relevant I4.0 digital technologies is mentioned in the company's sustainability reporting document, it is encoded as 'Yes' ('No', otherwise).
V2	Citing SDGs	Explicit references to the SDGs (UN, 2015) in the company's reporting document.	If at least one of the 17 SDGs is mentioned in the company's sustainability reporting document, it is encoded as 'Yes' ('No', otherwise).
V3	I4.0-related SDGs	Explicit reference to the connection between the adopted I4.0 digital technologies and the SDGs in the company's reporting document.	When the company's sustainability reporting document discloses one or more I4.0 digital technologies (V1) and how they contribute to the achievement of one or more SDGs (V2), it is encoded as 'Yes' ('No', otherwise).

The coding procedure was primarily applied to the most recently published sustainability reports; in the absence of a report, the specific sustainability section of the company's website was consulted. Three qualified members, referred to as coders, performed the coding process. To ensure reliability, each coder individually followed the coding process to avoid interpretative biases related to manual coding. Regular meetings were organized among the coders to discuss the discrepancies that emerged, during which each coder reviewed the analysis of their peers (Curtó-Pagès et al., 2021). After consultations, all discrepancies were resolved, reaching a complete agreement among the coders (Krippendorff, 2018).

3. Results and Discussion

The present section describes the results of the analysis of sustainability reporting documents from the Italian agri-food selected companies. Table 3 shows the values ('YES' or 'NO') of the proposed three variables and

specifies the I4.0 digital technologies (V1), and the SDGs (V2) as well as the connection between them (V3) identified from the conducted analysis.

Table 3: Results of sustainability reporting documents by selected companies. For each variable are shown the obtained value ('YES' or 'NO') and, in case of 'YES', the list of the disclosed I4.0 digital technologies (V1), SDGs (V2) and the connection between them (V3).

Company	Citing I4.0 DT (V1)	Description	Citing SDGs (V2)	Description	I4.0-related SDGs (V3)	Description
C1	YES	3D AI Blockchain Cyber security	YES	2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 15, 17	NO	-
C2	YES	Cyber security	YES	3, 7, 8, 12, 14, 15, 16	NO	-
C3	YES	Cloud technology Cyber security Sensors	YES	3, 6, 7, 8, 12, 13, 14, 15	NO	-
C4	YES	AI Sensors	YES	2, 3, 7, 8, 9, 10, 12	NO	-
C5	NO	-	YES	2, 3, 4, 6, 8, 12, 15	NO	-
C6	YES	AI Cyber security Sensors	YES	4, 5, 6, 7, 8, 9, 10, 12, 13, 15, 17	YES	Sensors for SDG 6, 13
C7	YES	AI Blockchain Sensors	YES	5, 8, 12, 13, 17	YES	Blockchain for SDG 12, 13
C8	NO	-	NO	-	NO	-
C9	YES	Blockchain	NO	-	NO	-
C10	YES	Blockchain	YES	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17	NO	-
C11	YES	Cloud technology Sensors	YES	2, 3, 4, 8, 10, 12, 13, 15, 17	NO	-
C12	NO	-	YES	2, 4, 6, 8, 12, 13, 15, 17	NO	-

As shown in Table 3, most companies (9 out of 12) provide evidence of integrating digital technologies into their business practices (variable V1, "Citing I4.0 DT"). Among others, sensors, blockchain, cybersecurity, and artificial intelligence result as the most widely adopted digital technologies by the selected companies. These findings align with the emerging literature that has explored the application of I4.0 technologies in the agri-food sector (Hassoun et al., 2022; Yadav et al., 2022). The variable "Citing SDGs" (V2) is the most frequently met, as nearly all companies (10 out of 12) explicitly reference multiple SDGs in their reporting documents. A broad and diversified contribution emerges from the selected companies, which is not limited to just a few specific SDGs. The most mentioned SDGs are SDG 8 "Decent Work and Economic Growth", SDG 13 "Climate Action", and SDG 15 "Life on Land". Particularly, half of the sample disclosed information about SDG 2 "Zero Hunger", in line with the United Nations calls for food producers for innovative solutions to eradicate hunger and malnutrition (UN, 2015). Moreover, according to the coding procedure, for companies where both variables V1 and V2 were coded as 'YES', it is possible to determine whether there is a connection between the adopted technologies and their contribution to the SDGs (V3). As a result, only two companies met the variable "I4.0-related SDGs" (V3) communicating, albeit in a narrative form and without the use of performance indicators, how the adopted technologies aim to contribute to the SDGs. Specifically, company "C6" reports having installed wireless sensor networks for its crops to contribute to SDG 6 "Clean Water and Sanitation" and SDG 13 "Climate Action". While company "C7" highlights its commitment to achieving SDG 12 "Responsible Consumption and Production" and SDG 13 "Climate Action" by implementing solutions involving blockchain-based traceability.

4. Conclusions

To effectively address the global needs of sustainability outlined by the UN SDGs, companies of various sizes and sectors must change their business approach by adopting innovative solutions (Cordova & Celone, 2019; Menichini & Strollo 2023). The present paper aligns with the literature which identifies the I4.0 digital technologies as the main pathway to address the most sustainability urgencies (Bai et al., 2020; Ejsmont et al., 2020; Akbari & Hopkins, 2022; Brogi & Menichini, 2024). Particularly, this study focused on the agri-food sector, whose business practices directly impact people and the planet in terms of food security and nutrition, making agri-food companies' initiatives crucial for the achievement of the SDGs (Hassoun et al., 2022; Chandan et al., 2023). Thus, the proposed paper aims to address the emerging need for a deeper understanding of the I4.0 digital technologies' adoption by agri-food companies to meet SDGs (MacPherson et al., 2022). For this purpose, a quali-quantitative content analysis has been performed to examine the sustainability reporting practices by the Italian agri-food companies. Indeed, the Italian agri-food sector is recognized as crucial for the Italian economy, being one of the main players in international trade, due to its proven capacity for the sustainable management of resources (Coluccia et al., 2020) through innovative solutions (Cricelli et al., 2024). Only the Italian agri-food companies recognized as agri-food sustainability leaders, according to the "Il Sole 24 Ore" ranking, have composed the set of companies under analysis. The use of quali-quantitative content analysis allowed for the quantification of the presence of digital technologies and the most frequently considered SDGs in the documents, as well as a qualitative understanding of their connections. The obtained results show alignment with other studies concerning the evaluation of the I4.0 digital technologies' adoption to improve business practices in the agri-food sector (Hassoun et al., 2022; Yadav et al., 2022). Findings point to greater attention on SDG 8 "Decent Work and Economic Growth", SDG 13 "Climate Action", and SDG 15 "Life on Land", despite the literature highlighting SDG 2 "Zero Hunger" as crucial for the agri-food sector (UN, 2015; Paoloni et al., 2023). Additionally, in the examined reporting documents, comprehensive insights into how companies plan to use digital technologies to support the achievement of the SDGs is still lacking, confirming the scarcity of transparency on how companies operate towards these global goals (MacPherson et al., 2022).

Leveraging the key characteristics of the Italian agri-food sector, which is distinguished by the high quality and wide range of its products, as well as dynamic global trade that favours the integration of I.4 technologies (Cricelli et al., 2024) the proposed study and results can be considered as best practices that are transferable and adaptable to the analysis of agri-food companies operating in other countries with similar production diversity. Therefore, future studies could focus on the comparative analysis of agri-food companies operating in different international contexts to identify additional opportunities for implementing I4.0 digital technologies, as well as exploring innovative I4.0 solutions that could further support the achievement of the SDGs in the agri-food sector on a global scale.

References

Abbate, S., Centobelli, P. and Cerchione, R., 2023. The digital and sustainable transition of the agri-food sector. *Technological Forecasting and Social Change*, 187, p.122222.

Akbari, M. and Hopkins, J.L., 2022. Digital technologies as enablers of supply chain sustainability in an emerging economy. *Operations Management Research*, *15*(3), pp.689-710.

Alam, M.F.B., Tushar, S.R., Zaman, S.M., Gonzalez, E.D.S., Bari, A.M. and Karmaker, C.L., 2023. Analysis of the drivers of Agriculture 4.0 implementation in the emerging economies: Implications towards sustainability and food security. *Green Technologies and Sustainability*, 1(2), p.100021.

Arru, B., 2020. An integrative model for understanding the sustainable entrepreneurs' behavioural intentions: an empirical study of the Italian context. *Environment, Development and Sustainability*, 22(4), pp.3519-3576.

Bai, C., Dallasega, P., Orzes, G. and Sarkis, J., 2020. Industry 4.0 technologies assessment: A sustainability perspective. *International journal of production economics*, *229*, p.107776.

Bell, Emma, Alan Bryman, and Bill Harley. *Business research methods*. Oxford university press, 2022.

Borsellino, V., Schimmenti, E. and El Bilali, H., 2020. Agri-food markets towards sustainable patterns. *Sustainability*, *12*(6), p.2193.

Brogi, S. and Menichini, T., 2024. The pathway towards circular economy: Measuring circular advantage of eco-innovations. *Business Strategy and the Environment*, *33*(4), pp.3005-3038.

Calabrese, A., Costa, R., Levialdi, N., Menichini, T. and Villazon Montalvan, R.A., 2020. Does more mean better? Exploring the relationship between report completeness and environmental sustainability. *Sustainability*, *12*(24), p.10635.

Chandan, A., John, M. and Potdar, V., 2023. Achieving UN SDGs in food supply chain using blockchain technology. *Sustainability*, *15*(3), p.2109.

Coluccia, B., Valente, D., Fusco, G., De Leo, F. and Porrini, D., 2020. Assessing agricultural eco-efficiency in Italian Regions. *Ecological Indicators*, *116*, p.106483.

Cordova, M.F. and Celone, A., 2019. SDGs and innovation in the business context literature review. *Sustainability*, *11*(24), p.7043.

Costa, R., Menichini, T. and Salierno, G., 2022. Do SDGs really matter for business? Using GRI sustainability reporting to answer the question. *European Journal of Sustainable Development*, *11*(1), pp.113-113.

Cricelli, L., Mauriello, R., Strazzullo, S. and Camilleri, M.A., 2024. Assessing the impact of Industry 4.0 technologies on the social sustainability of agrifood companies. *Business Strategy and the Environment*.

Curtó-Pagès, F., Ortega-Rivera, E., Castellón-Durán, M. and Jané-Llopis, E., 2021. Coming in from the cold: A longitudinal analysis of SDG reporting practices by Spanish listed companies since the approval of the 2030 agenda. *Sustainability*, *13*(3), p.1178.

Da Silveira, F., Lermen, F.H. and Amaral, F.G., 2021. An overview of agriculture 4.0 development: Systematic review of descriptions, technologies, barriers, advantages, and disadvantages. *Computers and electronics in agriculture*, *189*, p.106405.

Dantas, T.E.T., de-Souza, E.D., Destro, I.R., Hammes, G., Rodriguez, C.M.T. and Soares, S.R., 2021. How the combination of Circular Economy and Industry 4.0 can contribute towards achieving the Sustainable Development Goals. *Sustainable production and consumption*, *26*, pp.213-227.

Ebinger, F. and Omondi, B., 2020. Leveraging digital approaches for transparency in sustainable supply chains: A conceptual paper. *Sustainability*, *12*(15), p.6129.

Ejsmont, K., Gladysz, B. and Kluczek, A., 2020. Impact of industry 4.0 on sustainability—bibliometric literature review. *Sustainability*, *12*(14), p.5650.

Fiandrino, S., Scarpa, F. and Torelli, R., 2022. Fostering social impact through corporate implementation of the SDGs: Transformative mechanisms towards interconnectedness and inclusiveness. *Journal of Business Ethics*, *180*(4), pp.959-973.

Food and Agriculture Organization of the United Nations, 2017. *The future of food and agriculture: Trends and challenges*. Fao.

Food Drink Europe, 2023. "Data & trends of the European food and drink industry 2020", available at: https://www.fooddrinkeurope.eu/wp-content/uploads/2023/12/FoodDrinkEurope-Data-Trends-Report-2023-digital.pdf (accessed August 2024).

Fragomeli, R., Annunziata, A. and Punzo, G., 2024. Promoting the Transition towards Agriculture 4.0: A Systematic Literature Review on Drivers and Barriers. *Sustainability*, *16*(6), p.2425.

Frankelius, P., Norrman, C. and Johansen, K., 2019. Agricultural innovation and the role of institutions: lessons from the game of drones. *Journal of Agricultural and Environmental Ethics*, *32*, pp.681-707.

Global Reporting Initiative, GRI 2016. GRI 101: Foundation 2016. Amsterdam: Global Reporting Initiative. https://www. globalreporting. org/standards/media/1036/gri-101-foundation-2016. pdf. (Accessed August 2024).

Halkos, G. and Nomikos, S., 2021. Corporate social responsibility: Trends in global reporting initiative standards. *Economic Analysis and Policy*, *69*, pp.106-117.

Hassoun, A., Prieto, M.A., Carpena, M., Bouzembrak, Y., Marvin, H.J., Pallarés, N., Barba, F.J., Bangar, S.P., Chaudhary, V., Ibrahim, S. and Bono, G., 2022. Exploring the role of green and Industry 4.0 technologies in achieving sustainable development goals in food sectors. *Food Research International*, *162*, p.112068.

Jindřichovská, I., Kubíčková, D. and Mocanu, M., 2020. Case study analysis of sustainability reporting of an agri-food giant. *Sustainability*, *12*(11), p.4491.

Kazancoglu, Y., Lafci, C., Kumar, A., Luthra, S., Garza-Reyes, J.A. and Berberoglu, Y., 2024. The role of agri-food 4.0 in climate-smart farming for controlling climate change-related risks: A business perspective analysis. *Business Strategy and the Environment*, *33*(4), pp.2788-2802.

Klerkx, L. and Rose, D., 2020. Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?. *Global Food Security*, *24*, p.100347.

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*, p.100315.

Krippendorff, K., 2018. *Content analysis: An introduction to its methodology*. Sage publications.

MacPherson, J., Voglhuber-Slavinsky, A., Olbrisch, M., Schöbel, P., Dönitz, E., Mouratiadou, I. and Helming, K., 2022. Future agricultural systems and the role of digitalization for achieving sustainability goals. A review. *Agronomy for Sustainable Development*, *42*(4), p.70.

Masi, A., Ciccullo, F. and Pero, M., 2021, June. Digitalizing agri-food supply chains to achieve Sustainable Development Goals: a systematic literature review. In *2021 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)* (pp. 1-8). IEEE.

Mayring, P., 2004. 5.12 Qualitative Content Analysis. *A companion to qualitative research*, pp.266-269.

Mayring, P., 2015. Qualitative content analysis: Theoretical background and procedures. *Approaches to qualitative research in mathematics education: Examples of methodology and methods*, pp.365-380.

Menichini, T. and Strollo, N.M., 2023. The combination of circular economy practices and industry 4.0 technologies for achieving Sustainable Development Goals (SDGs): a critical review. *ACADEMIC JOURNAL*, *1*.

Mondejar, M.E., Avtar, R., Diaz, H.L.B., Dubey, R.K., Esteban, J., Gómez-Morales, A., Hallam, B., Mbungu, N.T., Okolo, C.C., Prasad, K.A. and She, Q., 2021. Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet. *Science of The Total Environment*, 794, p.148539.

Mor, R.S., Bhardwaj, A. and Singh, S., 2018. Benchmarking the interactions among performance indicators in dairy supply chain: an ISM approach. *Benchmarking: An International Journal*, *25*(9), pp.3858-3881.

Paoloni, M., Tutino, M., Paoloni, N. and Santolamazza, V., 2023. Financing innovation in agri-food industries: an analysis of the Italian micro, small and medium enterprises. *British Food Journal*, *125*(13), pp.183-204.

Rosamartina, S., Giustina, S. and Angeloantonio, R., 2022. Digital reputation and firm performance: The moderating role of firm orientation towards sustainable development goals (SDGs). *Journal of Business Research*, *152*, pp.315-325.

Rose, D.C. and Chilvers, J., 2018. Agriculture 4.0: Broadening responsible innovation in an era of smart farming. *Frontiers in Sustainable Food Systems*, *2*, p.87.

Secundo, G., Schena, R., Russo, A., Schiavone, F. and Shams, R., 2022. The impact of digital technologies on the achievement of the Sustainable Development Goals: evidence from the agri-food sector. *Total Quality Management & Business Excellence*, pp.1-17.

Siew, R.Y., 2015. A review of corporate sustainability reporting tools (SRTs). *Journal of environmental management*, *164*, pp.180-195.

Stefanini, R. and Vignali, G., 2024. The influence of Industry 4.0 enabling technologies on social, economic and environmental sustainability of the food sector. *International Journal of Production Research*, *62*(10), pp.3800-3817.

Tanda, A., 2018. The food and beverages stock performance during and after the 2007-2011 crisis. *International Journal of Business Performance Management*, *19*(3), pp.280-288.

Torelli, R., Balluchi, F. and Furlotti, K., 2020. The materiality assessment and stakeholder engagement: A content analysis of sustainability reports. *Corporate Social Responsibility and Environmental Management*, *27*(2), pp.470-484.

United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development A/RES/70/1. Resolution adopted by the General Assembly on 25 September 2015, (p. 35). Paris.

Varriale, V., Cammarano, A., Michelino, F. and Caputo, M., 2024. The role of digital technologies in production systems for achieving sustainable development goals. *Sustainable Production and Consumption*.

Walter, A., Finger, R., Huber, R. and Buchmann, N., 2017. Smart farming is key to developing sustainable agriculture. *Proceedings of the National Academy of Sciences*, *114*(24), pp.6148-6150.

Wolfert, S., Ge, L., Verdouw, C. and Bogaardt, M.J., 2017. Big data in smart farming–a review. *Agricultural systems*, *153*, pp.69-80.

Yadav, V.S., Singh, A.R., Raut, R.D., Mangla, S.K., Luthra, S. and Kumar, A., 2022. Exploring the application of Industry 4.0 technologies in the agricultural food supply chain: A systematic literature review. *Computers & Industrial Engineering*, *169*, p.108304.

Zollet, S., Colombo, L., De Meo, P., Marino, D., McGreevy, S.R., McKeon, N. and Tarra, S., 2021. Towards territorially embedded, equitable and resilient food systems? Insights from grassroots responses to COVID-19 in Italy and the city region of Rome. *Sustainability*, *13*(5), p.2425.