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Integrating Technology and Sustainability in Agricultural Supply Chains: Pathways to Market Efficiency

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ABSTRACT

Purpose: This study aims to explore how emerging technologies, such as information and communication technologies (ICTs), the Internet of Things (IoT), big data analytics, and block-chain, can be effectively integrated with sustainable practices to enhance efficiency and resilience in agricultural supply chains. It seeks to understand how these technologies contribute to achieving economic, environmental, and social sustainability within agricultural value networks. **Methodology:** The paper undertakes a comprehensive review of theoretical and empirical studies published between 2013 and 2018. It synthesizes findings from academic and policy literature that investigate the intersections of technology, sustainability, and agricultural market systems, highlighting key implementation mechanisms and contextual factors. **Findings:** The review identifies major pathways through which technology drives sustainability and efficiency, including enhanced traceability, precision in resource management, adaptive logistics, and improved market access for farmers. However, persistent barriers, such as weak infrastructure, governance challenges, interoperability issues, and exclusion of smallholders, limit the full potential of digital integration. **Implications:** The study underscores the importance of investing in digital infrastructure, fostering data-sharing standards, and strengthening institutional frameworks. It calls for collaborative efforts between public and private stakeholders to build capacity and design inclusive platforms that support sustainable transformation in agriculture. **Originality/Value:** This research contributes to the ongoing discourse by providing a structured synthesis of how technology and sustainability can be jointly leveraged in agricultural supply chains. It highlights actionable insights and a forward-looking research agenda for policymakers, agribusinesses, and development agencies seeking to align digital innovation with sustainability goals.

Keywords: Agricultural Supply Chains, Sustainability, Digital Technologies, Market Efficiency, Block-chain and IoT,

INTRODUCTION:

Agricultural supply chains are complex, fragmented systems spanning smallholder producers, aggregators, processors, transporters, retailers and consumers. Pressure from population growth, climate variability, resource constraints, and rising consumer demand for quality and sustainability places new demands on these chains to be efficient, resilient and environmentally responsible. Recent years have seen rapid diffusion of technologies (mobile ICT, sensors, IoT, big-data analytics, and initial block-chain prototypes) that promise to transform information flows, coordination and trust across agri-food systems. This paper reviews recent literature to explore how these technologies can be intentionally integrated with sustainable supply-chain management (SSCM) practices to generate market efficiency while attending to social and environmental objectives.

The conceptual foundation for sustainable supply-chain management (SSCM) recognizes that sustainability must go beyond narrow “green” interventions to include balanced economic, environmental and social goals across supply-chain actors, *(Ahi, P. & Searcy, C. , 2013)*. Use of digital technologies in agriculture further opens possibilities for inclusion, traceability, and resource-efficiency.

2. Conceptual Background: Sustainable Supply Chains and Technological Affordances:

2.1 Sustainable supply-chain management (SSCM):

SSCM literature defines sustainability in the supply-chain context as the coordinated management of material, information and financial flows that improves environmental performance, social welfare and long-term economic viability for stakeholders. Ahi and Searcy's comparative analysis emphasizes that SSCM is broader than a narrow "green supply chain" definition and requires governance and measurement across multiple actors and stages, *(Ahi, P. & Searcy, C. , 2013)*. Historically, supply-chain studies focused on operational efficiency and cost; the sustainability orientation adds the triple-bottom line dimension (economic-environment-social). In recent years, two areas have gained significant prominence within supply chain management (SCM). First, sustainable supply chain management (SSCM) has emerged as a critical focus, attracting extensive scholarly attention. Second, information technology (IT) is increasingly recognized as a vital driver of efficiency and effectiveness in supply chain operations, *(Thöni, A. & Tjoa, A. M., 2017)*.

2.2 Technological affordances relevant to agriculture:

Several technological classes are particularly salient:

- ***ICT and mobile platforms:***

  These reduce information asymmetries between producers and buyers, improve price discovery and enable market aggregation. For example, in developing country agriculture, ICT systems have been shown to connect producers to buyers, reduce transaction time and improve linkages, *(Mudda, S. K., Giddi, C. B., & PVGK, M., 2017)*.

- ***IoT and smart sensors (soil moisture sensors, weather stations, machine sensors***):

  These enable site-specific management (precision agriculture) and operational monitoring of perishable goods. The concept of "smart, connected products" explains how embedding sensing and connectivity into assets changes coordination and operations, *(Porter, M. E. & Heppelmann, J. E., 2014)*.

- ***Big data analytics and decision support:***

  Transforming streams of sensor, satellite, transaction and market data into actionable insights for yield optimization, risk management and demand forecasting, *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*.

- ***Distributed ledger technologies (block-chain) and complementary ID/IoT tools:***

  These enable tamper-resistant traceability, provenance records, and automated contracting. Early prototypes and conceptual studies (2016–2018) highlight block-chain's potential to increase transparency and reduce information frictions in food chains, *(Wageningen Economic Research, 2017)*. The results of one research study suggest that block-chain holds significant potential for creating transparent food supply chains, with numerous initiatives already emerging across different food sectors. However, its widespread adoption among farmers and systems remains limited due to persistent challenges related to technology, awareness, education, and regulatory and policy frameworks, *(Kamilaris, A., Fonts, A., & Prenafeta-Boldύ, F. X., 2019)*.

- ***Cloud computing and virtualization of supply chain:***

For instance, the idea of "Cloud of Things" in precision agriculture highlights how cloud + IoT facilitate real-time supply-chain management, *(Satpute, P. & Mohanpukar, A., 2015)*.

Together, these technologies can reshape transaction costs, information latency and trust mechanisms across agricultural supply chains, the key levers for market efficiency.

3. Literature Review: Pathways from Technology to Sustainable Market Efficiency:

This section synthesizes evidence from the literature on the principal mechanisms by which technology supports sustainability and market efficiency in agricultural supply chains.

3.1 Market access, price information and transaction costs:

Multiple studies and practitioner reports demonstrate that mobile ICT and digital marketplaces improve farmers' information on prices and buyer demand, enabling better timing and channel choices and often higher returns or reduced marketing inefficiencies. For example, in the Indian context, Mudda et al., *(Mudda, S. K., Giddi, C. B., & PVGK, M., 2017)*, note that IT systems can empower small and marginal farmers who have poor access to market and production information. Similarly, the broader ICT literature identifies drivers for ICT adoption in sustainable supply chains (Leonidou, Palihawadana & Theodosiou, 2018 as cited in, *(Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., & Panchal, G., 2018)*, showing how information flow is central to sustainability initiatives. These improved information flows reduce the "search" part of transaction costs and can reduce the margin that intermediaries take, thereby improving market efficiency and smallholder integration.

3.2 Precision resource use and environmental efficiency:

Precision agriculture and sensor-based management reduce input waste (water, fertilisers and pesticides) by enabling site-specific application and timely interventions. Wolfert et al., *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*, provide a review of big data and smart farming tools in the agri-sector, highlighting how resource-use efficiency is improved and yield per unit input is enhanced. The cloud + IoT proposal by Satpute & Mohanpukar, *(Satpute, P. & Mohanpukar, A., 2015)*, shows how virtualization of supply chain management can support demand-responsive logistics and information flow, thereby reducing waste and improving sustainability. Reduced input waste e.g. less chemical runoff, less water overuse, supports environmental sustainability, while improved yields support economic performance, an alignment of the triple bottom line. The growing demand to measure the environmental impacts of agricultural production presents a valuable opportunity for collaboration between the agricultural sector and the scientific community, *(Thomson, A. M., et al., 2017)*.

3.3 Traceability, safety, and consumer trust:

Traceability systems are central to food safety and sustainability claims. Olsen & Borit, *(Olsen, P. & Borit, M., 2018)*, clarify the components of a food traceability system: identification of units, recording transformations (joining/splitting), and recording of attributes. Technological advances (RFID, mobile scanning and block-chain) change how these components are implemented and who controls the data, *(Olsen, P. & Borit, M., 2018)*. The 2017 report by, *(Wageningen Economic Research, 2017)*, on "Block-chain for Agriculture and Food" describes how traceability systems in food-chains can serve reputational and safety functions. The transparency afforded by digital traceability reduces risk of food safety incidents and can shorten recall times, thereby reducing waste and economic loss, improving chain efficiency.

3.4 Coordination, contracts and financing:

Smart contracts enabled by distributed ledgers and improved data flows permit faster verification of delivery conditions and could shorten payment cycles, critical for smallholders. Meanwhile, richer data on production and post-harvest quality can broaden access to finance (asset-backed lending, input credit), improving economic sustainability. While empirical studies in the 2013–18 period remain limited, theoretical work, e.g. *(Tian, F., 2016)*, shows how block-chain offers potential enabling functions in agri-supply chains, *(Tian, F.,* *2016)*. Further, broader studies of ICT within supply chains show that information flows serve as enabling resources for sustainability initiatives, *(Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., & Panchal, G., 2018)*. To enhance coherence and sustainability across the agri-food sector, stronger linkages are needed throughout the production and processing value chain. This includes connecting different stages of production, aligning currently isolated farming practices, and fostering collaboration across research domains. Such integration promotes holistic understanding of how technologies, practices, and materials collectively influence productivity and sustainability at local, regional, national, and global levels, *(Albajes, R., Cantero-Martínez, C., Capell, T. , & et a, 2013)*.

3.5 Operational efficiency and waste reduction:

Real-time monitoring (temperature, humidity and shock) during transport and storage, enabled by IoT sensors and mobile reporting, reduces spoilage by enabling corrective actions and optimising routing and storage decisions. When combined with predictive analytics, logistics can be scheduled to minimise idle time and losses, improving both economic returns and environmental footprint. While direct empirical evidence from the 2013–18 period is limited, the conceptual frameworks, *(Satpute, P. & Mohanpukar, A., 2015)*, anticipate such waste reduction effects.

4. Barriers, Risks and Governance Considerations:

While the literature documents substantial potential, it also consistently flags barriers. Some of these are:

- ***Infrastructure and connectivity gaps:***

  In rural areas, reliable networks or consistent energy supply may be lacking, limiting practical reach of ICT/IoT solutions, *(Mudda, S. K., Giddi, C. B., & PVGK, M., 2017)*.

- ***Data interoperability and standards:***

  Diverse platforms, proprietary formats and lack of common identifiers hinder seamless data exchange. For instance, the “precision to prescription” article, *(IEEE Internet of Things Newsletter, 2016)*, highlights the challenge of integrating multiple sensor data sets into actionable information due to data incompatibility.

- ***Governance, trust and equity:***

  Technologies like block-chain address some trust issues, but cannot alone resolve underlying verification problems (e.g., false inputs). Social governance (who controls data, who benefits) is central to equitable outcomes, *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*. As a disruptive innovation, block-chain technology possesses strong potential to transform and enhance sustainable supply chain management practices, *(Nayak, G. & Dhaigude, A. S., 2019)*.

- ***Costs and business models:***

  High up-front costs, ambiguous ROI and unclear business models slow adoption, especially among smallholders. Public-private partnerships and aggregator models are frequently mentioned.

- ***Skills and extension systems:***

  Farmers and local firms need training and extension support to use tools effectively and to interpret analytics. Mudda et al., *(Mudda, S. K., Giddi, C. B., & PVGK, M., 2017)*, identify lack of training on ICTs as a key limiting factor.

- ***Smallholder inclusion:***

  Fragmented smallholder systems pose organisational challenges for sensor deployment, data aggregation and cost-sharing.

- ***Regulatory and legal frameworks:***

  Especially for traceability and block-chain-based contracts, regulatory clarity is often missing. Land-use changes within forest–agriculture interfaces pose both risks and potential benefits for ecosystems, communities, and the climate. An increasing number of innovative strategies, driven by institutional reforms, incentive mechanisms, and information technologies, are being developed to guide where and how commodity-based agriculture expands in relation to forest areas, *(Newton, P., Agrawal, A., & Wollenberg, L., 2013)*.

Each of these barriers interacts with sustainability concerns: e.g., exclusion of smallholders may undermine social equity; lack of interoperability may limit environmental gains from efficiencies; unclear business models may mean economic benefits are captured by larger firms rather than producers.

5. Practical Pathways for Integration:

The findings of one review article indicate that achieving economic benefits in sustainable agri-food supply chains depends on fostering innovation, enhancing collaboration among supply chain partners, reducing uncertainties, and integrating global best practices with green and lean initiatives, *(Mor, R. S., Singh, S., Bhardwaj, A., & Singh, L. P., 2015)*. The analysis by another research reveals that while block-chain technology holds significant potential to enhance supply chain sustainability, it cannot ensure that all stakeholders consistently provide accurate, standardized, and verifiable data, *(Pavlić Skender, H. & Zaninović, P. A., 2019)*. Synthesising of the literature, suggests several actionable pathways to integrate technology with sustainability goals in agricultural supply chains.

5.1 Build interoperable, layered information architectures:

Design systems that separate (a) identification/traceability layers (RFID/QR, block-chain hashes), (b) sensor/telemetry layers (IoT), and (c) analytics/decision support layers (cloud & ML). The separation allows different actors to adopt at their pace while preserving integration via standard APIs and data schemas, *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017); (Olsen, P. & Borit, M., 2018)*. Standardization of data and APIs supports scalability and reduces vendor-lock-in.

5.2 Focus on use-cases with clear shared benefits:

Prioritise pilot projects where measurably reduced loss, faster payments or premium market access create shared incentives. For instance, industry pilots of block-chain for fresh produce (e.g., 2017/18) illustrate traceability plus reputation risk reduction. These bounded use-cases (food safety, premium markets) make business cases easier and link technological adoption to sustainability outcomes, *(Wageningen Economic Research, 2017)*.

5.3 Aggregate smallholders through digital cooperatives and marketplaces:

Digital aggregation (group selling via mobile platforms) decreases per-unit costs and creates scale economies that make investments in cold chain, sensors and data platforms viable. The ICT for inclusive value chains literature, *(FAO, 2015)*, emphasises aggregation as a strategy for ensuring smallholder inclusion and market efficiency.

5.4 Invest in standards, identity and provenance verification:

Standards for product identifiers, attribute schemas (e.g., organic, fair trade), and verification processes are necessary to ensure that the data captured is trustworthy. Block-chain or distributed ledger systems are valuable only if the inputs they record are reliable; hence, hybrid designs combining physical verification with digital records are essential, *(Olsen, P. & Borit, M., 2018); (Tian, F., 2016)*.

5.5 Support capacity building and inclusive governance models:

Training, digital literacy and transparent benefit-sharing mechanisms (e.g., revenue-sharing for data) reduce adoption barriers and mitigate risks that technology merely concentrates gains with powerful intermediaries. Wolfert et al., *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*, emphasise governance and business models as critical to realising socio-economic benefits.

5.6 Design for sustainability across the triple bottom line:

Adopt metrics and performance indicators that capture not only economic outcomes (yield, margin and cost reduction) but also environmental (input reduction, emissions, waste loss) and social (inclusion of smallholders, wage fairness, labour conditions). The SSCM literature emphasises the need for integrated measurement across multiple dimensions, *(Ahi, P. & Searcy, C. , 2013)*. The study by these authors explores the underlying reasons why businesses delay incorporating performance-oriented sustainability measures within global agri-food supply chains, *(Gold, S., Kunz, N., & Reiner, G., 2017)*.

6. Illustrative Example: Tracing Leafy Greens:

Between 2016 and 2018, several industry pilots used unit-level QR/RFID mapping and block-chain ideas to trace fresh produce from farm to shelf, with retailers reporting faster identification of contamination sources and reduced recall times. These pilots combined unit-level identifiers with batch metadata, cold-chain monitoring sensors, and shared ledgers accessible to certified actors, *(Wageningen Economic Research, 2017)*. They illustrate two points: (1) traceability investments are most compelling where food safety and reputation risk are high; and (2) realising full value requires integrating physical sensors, clear data governance and buyer willingness to pay for traceable origin. The globalization of supply chains has increased the complexity of their management and oversight. As a decentralized digital ledger, block-chain technology offers significant potential to address these challenges by enhancing transparency, traceability, and security across global supply chain networks, *(Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L., 2019)*. The effective implementation and management of emerging industrial technologies are crucial for optimizing time, reducing costs, and enhancing both employee engagement and customer satisfaction, *(Peter, O. & Mbohwa, C., 2018)*.

7. Policy Implications and Institutional Roles:

Public policy can catalyse technology-sustainability integration in several ways:

1. Investing in rural digital infrastructure (broadband, energy) that enables sensor networks and market platforms.
2. Supporting standards development and open data schemas to ensure interoperability and reduce vendor lock-in, *(Olsen, P. & Borit, M., 2018)*.
3. Funding blended demonstrations and risk-sharing mechanisms that lower adoption costs for small-holder consortia.
4. Regulatory frameworks for data governance and privacy, clarifying ownership, permissible uses and benefit-sharing. Wolfert et al., *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*, highlight governance as a central challenge for big-data adoption in agriculture.
5. Extension and capacity-building programmes aimed at digital literacy, smallholder inclusion and linkages to market platforms.
6. Incentivising supply-chain actors to adopt sustainability technologies, for example via subsidy or recognition programmes tied to reduce post-harvest loss, improved traceability or resource-use efficiency.

8. Research Agenda:

Based on gaps identified in the literature from 2013–2018 and thereafter, priority research areas include:

- ✓ Rigorous impact evaluations of ICT/IoT interventions on household incomes, equity and environmental metrics across diverse agro-ecologies, and testing whether the market-efficiency gains are realised in practice.
- ✓ Business model innovation that sustains shared infrastructure (cold-chain, sensor networks) and ensures equitable returns to smallholders rather than capture by larger actors.
- ✓ Methodologies for reliable ground-truthing of digital provenance (linking physical verification with immutability of ledger). While frameworks exist, *(Tian, F., 2016)*, empirical studies remain limited.
- ✓ Interoperability standards and lightweight protocols for low-bandwidth, rural contexts. Many sensor/IoT proposals assume strong connectivity which may not hold in remote small-holder settings, *(Mudda, S. K., Giddi, C. B., & PVGK, M., 2017)*.
- ✓ Socio-technical governance models. Who owns the data, who controls the platform, how revenue is shared among producers, transporters, processors, retailers and how sustainability gains are distributed.
- ✓ Longitudinal studies on adoption and sustainability outcomes. Many technological interventions focus on pilots; fewer examine systemic adoption, scaling and longer-term sustainability, *(Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J., 2017)*.
- ✓ Environmental metrics linked to supply chain technologies, e.g., quantifying how sensor-based logistics lead to measurable emissions or input-use reductions, hence linking technology adoption explicitly to environmental outcomes.
- ✓ Inclusion of women and marginalised groups in digital supply-chain ecosystems. Many smallholders are female or marginalised; how technology platforms account for their participation is under-explored.

CONCLUSION:

Between 2013 and 2018 scholarship and practice converged on a view that technology can be a powerful enabler of market efficiency and sustainability in agricultural supply chains, but only when adoption is coupled with standards, governance and inclusive business models. ICT and mobile platforms reduce information asymmetry and enable market access; IoT and precision tools reduce resource intensity and loss; big data enables forecasting and optimisation; and distributed ledger technologies can strengthen traceability and trust when combined with reliable verification and interoperable systems. To translate potential into broad, equitable impact, stakeholders must invest in interoperable architectures, capacity building, standard-setting and pilots with measurable shared benefits. Policy and industry collaboration will be essential to ensure that the digitalization of agri-supply chains advances economic returns without compromising environmental stewardship or social equity.

REFERENCES:

Ahi, P., & Searcy, C. . (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production, 52*, 329–341. doi:https://doi.org/10.1016/j.jclepro.2013.02.026

Albajes, R., Cantero-Martínez, C., Capell, T. , & et a. (2013). Building bridges: an integrated strategy for sustainable food production throughout the value chain. *Mol Breeding 32*, 743–770. doi:https://doi.org/10.1007/s11032-013-9915-z

FAO. (2015). ICT uses for inclusive agricultural value chains. *Food & Agricultural Organisation for United Nations*. Retrieved from www.fao.org/publications

Gold, S., Kunz, N., & Reiner, G. (2017). Sustainable global agrifood supply chains: exploring the barriers. *Journal of industrial ecology, 21*(2), 249-260.

IEEE Internet of Things Newsletter. (2016). Precision to prescription: Challenges in integrating multi-sensor agricultural data. *IEEE Internet of Things Community*. Retrieved from https://iot.ieee.org/newsletter/march-2016/precision-to-prescription.html

Kamilaris, A., Fonts, A., & Prenafeta-Boldύ, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in food science & technology, 91*, 640-652. doi:https://doi.org/10.1016/j.tifs.2019.07.034

Mor, R. S., Singh, S., Bhardwaj, A., & Singh, L. P. (2015). Technological implications of supply chain practices in agri-food sector-a review. *International Journal of Supply and Operations Management, 2*(2), 720.

Mudda, S. K., Giddi, C. B., & PVGK, M. (2017). A study on the digitization of supply chains in agriculture – an Indian experience. *Journal of Agricultural Informatics, 8*(1). doi:https://doi.org/10.17700/jai.2017.8.1.287

Nayak, G., & Dhaigude, A. S. (2019). A conceptual model of sustainable supply chain management in small and medium enterprises using blockchain technology. *Cogent Economics & Finance, 7*(1), 1667184.

Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., & Panchal, G. (2018). Evaluating the Drivers to Information and Communication Technology for Effective Sustainability Initiatives in Supply Chains. *International Journal of Information Technolog & Decision Making, 17*(1), 21-41.

Newton, P., Agrawal, A., & Wollenberg, L. (2013, December). Enhancing the sustainability of commodity supply chains in tropical forest and agricultural landscapes. *Global Environmental Change, 23*(6), 1761-1772. doi:https://doi.org/10.1016/j.gloenvcha.2013.08.004

Olsen, P., & Borit, M. (2018). The components of a food traceability system. *Trends in Food Science & Technology*. doi:https://doi.org/10.1016/j.tifs.2018.05.004

Pavlić Skender, H., & Zaninović, P. A. (2019). Perspectives of blockchain technology for sustainable supply chains. *In Integration of information flow for greening supply chain management (Cham: Springer International Publishing)*, 77-92.

Peter, O., & Mbohwa, C. (2018, October). The interlink between sustainable supply chain management and technology development in industry. *In Proceedings of the international conference on industrial engineering and operations management (Vol. 2018, No. Nov*, 425-430.

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review, 92*(11), 64–88.

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International journal of production research, 57*(7), 2117-2135.

Satpute, P., & Mohanpukar, A. (2015). Cloud of Things for Supply Chain Management in Precision Agriculture. *National Conference on Advances in Computing (NCAC2015), 1*, 35-38.

Thomson, A. M., Ramsey, S., Barnes, E., Basso, B., Eve, M., Gennet, S., . . . Wick, G. (2017). Science in the supply chain: collaboration opportunities for advancing sustainable agriculture in the United States. *Agricultural & Environmental Letters, 2(1)*, 170015.

Thöni, A., & Tjoa, A. M. (2017). Information technology for sustainable supply chain management: a literature survey. *Enterprise Information Systems, 11*(6), 828-858.

Tian, F. (2016). An agri-food supply chain traceability system for China based on RFID & block-chain technology. *13th International Conference on Service Systems and Service Management (ICSSSM 2016).*

Wageningen Economic Research. (2017). Block-chain for Agriculture and Food. *Report 2017-112*.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2017). Big data in smart farming – a review. *Agricultural Systems, 153*, 69–80.
