

ORIGINAL RESEARCH

Open access

Agri-Food AI Readiness: A Framework for Data Infrastructure, Institutional Capacity, Farmer Capability, and Governance Maturity

Sofia Alvarez^{1*}, Miguel Herrera¹, Lucia Vega², Pablo Torres¹, Carla Rios²

Abstract

Artificial intelligence is increasingly promoted as a tool for improving agricultural productivity, food-system coordination, sustainability monitoring, risk prediction, quality control, and decision support. Across agri-food systems, AI is expected to support more timely decisions, more efficient resource use, and more adaptive responses to climatic, market, and production uncertainty. These expectations have encouraged investment in digital tools, analytics platforms, automated monitoring systems, and predictive applications. Yet the availability of AI tools does not mean that agri-food systems are prepared to use them effectively or responsibly. Readiness depends on the quality of data infrastructure, the strength of institutions, the capabilities of farmers and other users, and the maturity of governance arrangements. When these conditions are weak, AI implementation can deepen inequality, create dependence on opaque platforms, reduce trust, or generate risks that are difficult to identify and manage. This article develops an agri-food AI readiness framework that explains the conditions required for responsible and effective AI implementation. The framework conceptualises readiness as a socio-technical condition produced through the interaction of data infrastructure and digital capacity, institutional capacity and policy support, farmer capability and adoption readiness, and governance maturity and risk management. It emphasises that AI readiness is not a single technical threshold but a combined maturity condition across interconnected system dimensions. The framework contributes a structured way to assess whether agri-food systems are prepared to adopt, adapt, govern, and benefit from AI. It identifies how weaknesses in one dimension can reduce the effectiveness of the others, even where advanced technologies are available. By linking implementation capacity with governance responsibility, the framework supports more inclusive, trustworthy, and context-sensitive pathways for agri-food AI.

Keywords Digital agriculture, Agri-food AI readiness, Data infrastructure, Institutional capacity, Farmer capability, Governance maturity

*Correspondence:

Sofia Alvarez
sofia.alvarez@unam.mx

¹ Department of Agricultural Data Science, Faculty of Agriculture, National Autonomous University of Mexico, Mexico City, Mexico

² Department of Intelligent Food Systems, Faculty of Engineering, Monterrey Institute of Technology, Monterrey, Mexico

Introduction

Artificial intelligence is becoming increasingly prominent in agriculture and food systems through precision agriculture, predictive analytics, automation, remote sensing, supply-chain intelligence, climate-risk monitoring, food-quality assessment, and decision support. However, the growth of digital agriculture has also shown that technological change is shaped by social organisation, knowledge systems, business models, advisory relationships, and institutional contexts.

Agri-food AI readiness should therefore be framed as a socio-technical readiness condition rather than as a purely technical state [1].

AI adoption is often presented as a diffusion challenge in which new tools move from developers to users, but this framing can understate the diversity of agri-food systems. Farms, regions, supply chains, and institutions differ in their access to digital data, analytics capability, connectivity, financial resources, advisory support, and governance arrangements. Smart farming depends on integrated data flows, analytics capability, and decision infrastructures that can connect digital information to practical agricultural decisions [2].

A further limitation of application-centred AI debates is that they often highlight model performance without sufficiently examining the conditions that make models usable in agricultural environments. AI applications in agriculture require high-quality data, domain-specific modelling, appropriate validation, and implementation pipelines that connect outputs to farm management, environmental monitoring, or supply-chain decisions [3]. Without these conditions, technically sophisticated systems may remain fragile, inaccessible, or poorly aligned with the realities of agri-food work.

This article develops an agri-food AI readiness framework centred on four interdependent dimensions: data infrastructure and digital capacity, institutional capacity and policy support, farmer capability and adoption readiness, and governance maturity and risk management. The framework argues that readiness emerges when these dimensions align to support reliable, inclusive, accountable, and context-sensitive AI implementation. Responsible innovation and social legitimacy are therefore treated as core readiness requirements rather than optional additions to technological deployment [4].

AI Readiness in Agri-Food Systems

AI readiness refers to the capacity of an agri-food system to adopt, adapt, govern, and benefit from AI in ways that are technically reliable, institutionally supported, socially inclusive, and responsibly governed. It is not limited to whether an AI tool exists, whether a farm has access to software, or whether a platform can process agricultural data. Readiness also includes the ability to anticipate systemic risks, externalities, and implementation failures before AI systems become embedded in production, markets, advisory services, or food-system coordination [5].

Readiness differs from adoption because adoption describes whether a technology is used, while readiness concerns whether the conditions for meaningful and responsible use exist. A farm may adopt a digital service without having the data quality, interpretive support, bargaining power, or governance protection needed to benefit from it. In this sense, readiness includes the capacity to convert data and AI outputs into usable decision-support services that fit agricultural decision cycles and operational constraints [6].

Agri-food AI readiness is also shaped by trust, explainability, responsibility, and perceived fairness. Farmers and other agri-food actors may hesitate to use AI systems when outputs are difficult to interpret, data practices are unclear, or responsibility for errors is ambiguous. Farmer-facing AI adoption readiness therefore depends on trust-building conditions that allow users to understand, evaluate, and contest AI-supported recommendations [7].

At system level, readiness must be assessed across farms, supply chains, institutions, markets, advisory networks, and regulatory environments. AI used for crop monitoring, animal health, input optimisation, market forecasting, or sustainability reporting can influence decisions beyond the immediate user. For this reason, agri-food AI readiness should include the capacity to identify cross-system effects and manage risks that emerge when digital tools reshape decision authority, data access, and accountability [5].

Data Infrastructure and Digital Capacity

Data infrastructure is the foundation of agri-food AI readiness because AI systems depend on reliable, timely, representative, and usable data. Relevant data may come from sensors, satellites, farm records, machinery, weather systems, soil monitoring, market information, logistics systems, certification records, and food-system databases. Data infrastructure readiness requires interoperable agricultural data, models, and knowledge products that can be reused across decision contexts rather than remaining isolated in disconnected systems [8].

Digital capacity is not only a matter of storing data but also of enabling meaningful data circulation between farmers, advisers, researchers, service providers, businesses, and public institutions. AI readiness improves when data systems support feedback loops that allow local knowledge, farmer observations, and field-level realities to inform digital models and recommendations. Two-way data flows and participatory feedback mechanisms are therefore central to data readiness in agri-food systems [9].

Data readiness is weakened when data quality is inconsistent, platforms are fragmented, connectivity is uneven, and ownership rights are unclear. Farmers may be reluctant to share data when legal protections, benefit-sharing arrangements, and platform responsibilities are not transparent. Data infrastructure therefore becomes a governance-sensitive readiness dimension, because unclear data rights and weak trust arrangements can limit the flow and usefulness of agricultural data [10].

The readiness framework treats data infrastructure and digital capacity as a combined dimension because data systems must be technically functional and institutionally usable. Connectivity, interoperability, cybersecurity, standardisation, metadata quality, and platform access must be aligned with the practical needs of farms and agri-food organisations. **Table 1** summarises the data infrastructure and digital capacity requirements for agri-food AI readiness [8].

Table 1. Data Infrastructure and Digital Capacity Requirements for Agri-Food AI Readiness: Data Foundations, Interoperability Needs, Connectivity Conditions, Platform Capabilities, and Readiness Risks

Data infrastructure requirement	Readiness function	Implementation condition	Weak-readiness risk
Reliable data foundations	Provides usable inputs for AI models, decision-support tools, monitoring systems, and predictive analytics	Agricultural data are accurate, timely, representative, documented, and relevant to local production and food-system contexts	AI outputs become unreliable, biased, incomplete, or poorly adapted to field realities
Interoperable data systems	Allows data from farms, sensors, satellites, machinery, advisory services, markets, and supply chains to work across platforms	Common standards, metadata practices, data-sharing protocols, and model-compatible formats are in place	Data remain fragmented across incompatible systems, limiting scaling and cross-system learning
Connectivity and digital access	Enables continuous or timely data exchange between farms, institutions, service providers, and platforms	Rural connectivity, affordable devices, cloud or edge infrastructure, and technical support are available	Less-connected farms and regions are excluded from AI-enabled services and decision systems
Participatory data flows	Connects digital systems with farmer observations, local knowledge, field validation, and advisory feedback	Platforms enable two-way communication, feedback loops, farmer correction, and contextual interpretation	AI systems extract data without improving farmer agency, trust, or decision quality

Data governance readiness	Builds confidence that data can be shared, protected, accessed, and used fairly	Data rights, consent rules, privacy protections, cybersecurity safeguards, and benefit-sharing arrangements are clear	Data misuse, platform dependency, legal uncertainty, and distrust reduce participation
Platform and analytics capacity	Translates data into operational insights for production, sustainability, risk management, and supply-chain coordination	Analytics platforms are usable, explainable, secure, maintainable, and connected to decision processes	Tools remain technically available but operationally disconnected from agri-food decision-making

Institutional Capacity and Policy Support

Institutional capacity is a central readiness condition because AI implementation depends on more than the availability of private tools or farm-level willingness to experiment. Public agencies, research organisations, extension providers, producer groups, technology firms, and regulators all shape whether AI can be implemented coherently across agri-food systems. Institutional readiness requires clear roles and coordination between public and private actors in technology diffusion, especially where digital tools affect advisory services, production decisions, and innovation pathways [11].

Policy support must also strengthen the knowledge and advice systems that help farmers and agri-food organisations interpret AI outputs. Digital advisory systems can connect data, agronomic knowledge, local experience, and service delivery, but they require organisational capacity, professional skills, and trusted channels of communication. Advisory and extension systems therefore need digital capability if they are to support AI implementation rather than simply promote tool adoption [12].

Weak institutional capacity can produce fragmented pilots, duplicated platforms, unclear accountability, and uneven scaling. When supply-side actors dominate digital transformation without sufficient public coordination, agri-food AI can become shaped by platform interests, proprietary standards, and unequal access to digital services. Policy support must therefore address private-sector influence, platform power, and inclusive market conditions as part of AI readiness [13].

Institutional readiness also requires policy environments that encourage responsible innovation rather than only faster technology adoption. Financing mechanisms, procurement rules, data standards, extension strategies, and regulatory guidance should be aligned so that AI implementation is technically feasible, socially legitimate, and accountable. Public and private institutions need coordinated responsibilities because fragmented diffusion systems can leave farmers and smaller agri-food actors without the support required to benefit from AI [11].

Farmer Capability and Adoption Readiness

Farmer capability is a core dimension of agri-food AI readiness because AI systems ultimately influence practical decisions about production, labour, inputs, risk, marketing, and environmental management. Capability includes digital literacy, technical confidence, affordability, advisory support, and the ability to evaluate whether a tool fits the farm context. Farmer readiness also depends on incentive structures, perceived value, and the practical capacity to adopt precision technologies in ways that improve decision-making rather than add complexity [14].

Adoption readiness should not be reduced to a farmer’s willingness to use technology. Farmers may be open to innovation while still lacking trusted information, training, reliable connectivity, financial resources, or confidence in the relevance of AI-generated recommendations. Perceived usefulness, ease of use, and access to trusted information sources shape whether farmers view digital tools as credible and worth integrating into their work [15].

Usability is especially important because many AI-enabled services enter farms through apps, dashboards, connected machinery, and advisory platforms. Tools that do not fit everyday routines, labour constraints, or farm management practices may be ignored even if their underlying analytics are technically strong. The uptake of farm-level digital applications is therefore shaped by usability, digital skill, and everyday management fit [16].

Farmer capability also varies across farm sizes, production systems, regions, gendered contexts, and resource levels. A readiness framework must therefore recognise that adoption pathways are context-specific and that capability building should be locally responsive rather than based on a single universal user model. Precision agriculture adoption research shows that readiness strategies need to account for local production conditions, perceived benefits, constraints, and decision environments [17].

Governance Maturity and Risk Management

Governance maturity refers to the capacity to manage the risks, responsibilities, rights, and accountabilities associated with agri-food AI. AI systems can influence how data are collected, who controls analytics, whose knowledge is valued, and which actors gain bargaining power in digital food systems. Governance maturity must therefore address power asymmetries embedded in agricultural data analytics, particularly where data flows create dependency on platforms or external service providers [18].

Agri-food AI governance also requires attention to privacy, bias, transparency, liability, cybersecurity, auditability, and the social effects of automated or semi-automated decisions. These concerns are not abstract ethical issues; they affect whether farmers trust AI systems, whether institutions can justify their use, and whether affected actors can challenge harmful outcomes. AI ethics concerns must be translated into implementation rules and accountability practices that fit agricultural and food-system contexts [19].

Responsible AI governance should establish mechanisms for privacy protection, fairness, transparency, robustness, accountability, and sustainability. These mechanisms can include data-sharing agreements, audit procedures, procurement standards, explainability requirements, human oversight, grievance processes, and risk assessment protocols. Governance maturity is strongest when these mechanisms are embedded before AI systems are scaled rather than added after harms or failures appear [20].

Immature governance can allow AI deployment to outpace accountability, especially when systems influence credit access, insurance, input recommendations, environmental reporting, market coordination, or supply-chain compliance. In such settings, errors or biases may affect livelihoods, resource allocation, and institutional trust. Governance maturity is therefore necessary for legitimacy because unmanaged power asymmetries in agricultural data systems can turn AI readiness into a source of exclusion rather than shared capability [18].

Proposed AI Readiness Framework

The proposed Agri-Food AI Readiness Framework defines readiness as the combined maturity of four interdependent dimensions: data infrastructure and digital capacity, institutional capacity and policy support, farmer capability and adoption readiness, and governance maturity and risk management. The framework begins from the premise that no dimension is sufficient on its own. Governance maturity includes data ownership, access, power, and societal effects because these issues determine whether AI systems can be trusted and responsibly integrated into agri-food decision-making [21].

Figure 1 presents the proposed Agri-Food AI Readiness Framework, showing how data infrastructure, institutional capacity, farmer capability, and governance maturity jointly determine whether agri-food systems are prepared for responsible AI implementation.

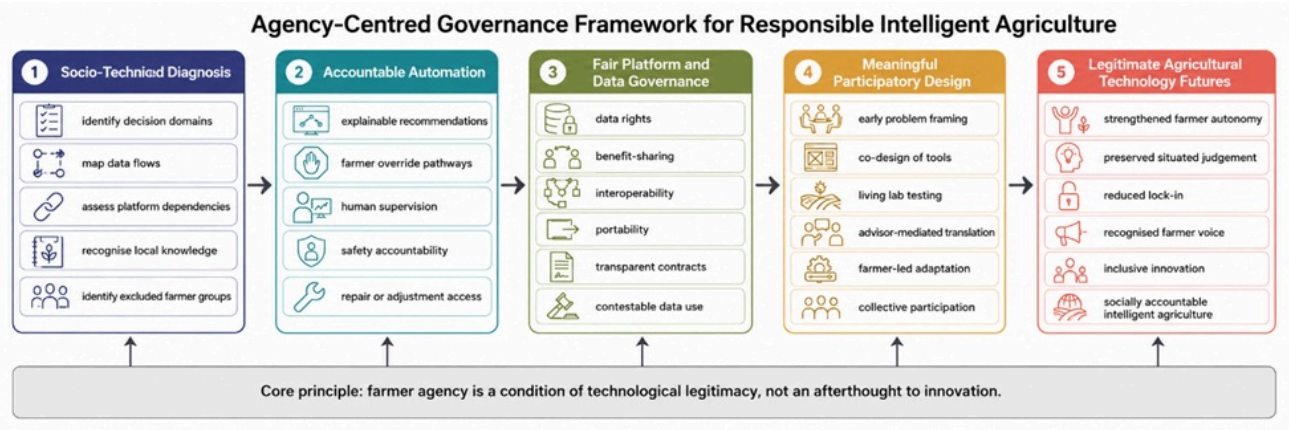


Figure 1. Integrated Agri-Food AI Readiness Framework Across Data, Institutions, Farmers, and Governance

The first relationship in the framework links data infrastructure with farmer capability. Data systems that are technically advanced but opaque, extractive, or disconnected from farmers’ needs may reduce participation and weaken adoption readiness. Readiness therefore depends on transparent data practices and fair benefit-sharing between farmers and digital platform actors [22].

The second relationship links institutional capacity with governance maturity. Institutions create the policies, advisory systems, standards, and coordination mechanisms through which AI is introduced, while governance systems define responsibilities, rights, oversight, and risk controls. Framework maturity should therefore move from fragmented technology deployment toward comprehensive responsible innovation that connects technical design with social, ethical, and institutional accountability [23].

The third relationship links all four dimensions through an implementation pathway that moves from basic readiness to adaptive readiness and then to responsible maturity. Basic readiness exists when minimum data, connectivity, advisory, and policy conditions are present; adaptive readiness exists when institutions and farmers can interpret, modify, and govern AI tools in context; responsible maturity exists when AI systems are accountable, inclusive, auditable, and aligned with public value. **Table 2** presents the proposed Agri-Food AI Readiness Framework integrating data infrastructure, institutional capacity, farmer capability, and governance maturity [24].

Table 2. Proposed Agri-Food AI Readiness Framework: Readiness Dimensions, Maturity Indicators, Implementation Conditions, Governance Responsibilities, and Risk Management Logic

Readiness dimension	Core maturity indicators	Implementation conditions	Governance responsibilities	Weak-readiness risks
Data infrastructure and digital capacity	Reliable data streams; interoperable systems; secure platforms; usable analytics; connectivity across farms and agri-food organisations	Investment in data standards, rural connectivity, cybersecurity, metadata quality, platform usability, and feedback mechanisms	Define data rights, consent procedures, access rules, privacy safeguards, and benefit-sharing arrangements	Poor data quality, fragmented platforms, biased outputs, exclusion of less-connected actors, and low trust in AI systems
Institutional capacity and policy support	Coordinated public and private roles; digitally capable extension; policy clarity; financing;	Alignment between research, extension, regulation, procurement, farmer organisations,	Set responsible innovation priorities, coordinate actors, prevent duplication, and	Fragmented pilots, weak scaling, duplicated infrastructure,

	standards; innovation support	and technology providers	ensure inclusion of smaller or marginalised actors	platform dominance, and unclear accountability
Farmer capability and adoption readiness	Digital literacy; technical confidence; affordability; advisory access; interpretive capacity; ability to contest recommendations	Context-relevant tools, training, trusted advisory support, participatory design, and farmer control over meaningful decisions	Protect farmer agency, support inclusive capability building, and ensure tools fit diverse production and resource contexts	Unequal adoption, dependency on opaque systems, low usability, exclusion of smaller farms, and reduced farmer autonomy
Governance maturity and risk management	Transparent rules; accountability mechanisms; auditability; risk assessment; liability clarity; responsible procurement	Privacy protection, explainability, human oversight, grievance channels, algorithmic auditing, and regulatory coordination	Monitor risks, assign responsibility, enforce standards, communicate uncertainty, and protect public value	Data misuse, unmanaged bias, cybersecurity harms, liability gaps, loss of legitimacy, and irresponsible scaling
Cross-dimensional alignment	Coherence among data, institutions, farmers, and governance systems; readiness assessment before scaling	Phased implementation, continuous evaluation, participatory governance, and adaptive learning	Ensure that AI deployment is technically robust, socially inclusive, and accountable across the agri-food system	Advanced tools fail because one or more readiness dimensions remain weak

Practical Implications and Future Research

For policymakers, food businesses, agricultural technology firms, extension organisations, farmer groups, regulators, and development agencies, the framework suggests that AI implementation should begin with readiness assessment rather than tool procurement alone. Practical implementation should balance productivity, farmer needs, environmental outcomes, and wider social consequences. Readiness tools should therefore evaluate not only technical capacity but also people, production contexts, governance arrangements, and sustainability implications [25].

Figure 2 translates the readiness framework into a staged assessment pathway, illustrating how agri-food systems can move from basic readiness through adaptive readiness toward responsible maturity.

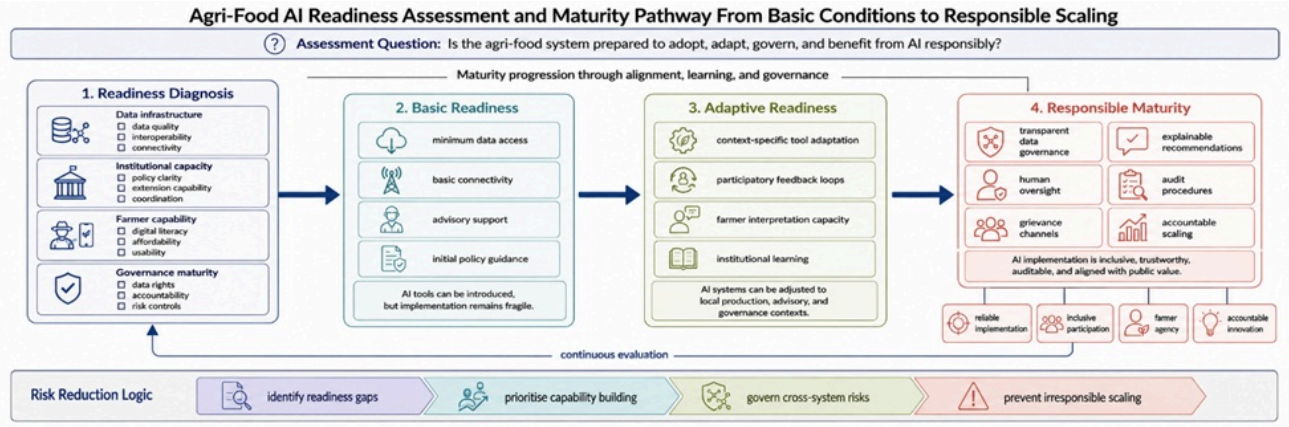


Figure 2. Agri-Food AI Readiness Assessment and Maturity Pathway From Basic Conditions to Responsible Scaling

The framework also implies that future research should examine how AI readiness is shaped by competing visions of agri-food transformation. Policy and platform strategies may prioritise different futures, such as efficiency, sustainability, market integration, automation, resilience, or farmer empowerment. Research should therefore investigate which beneficiaries, values, and food-system pathways are embedded in digital infrastructure design and policy support [26].

Future research should empirically test the proposed readiness dimensions across different regions, production systems, farm scales, and governance settings. Comparative studies could develop indicators for data maturity, institutional coordination, farmer capability, and governance accountability, while implementation research could examine how readiness affects AI outcomes in real agri-food settings. Transdisciplinary risk assessment is especially important for identifying vulnerabilities and socially robust implementation pathways before AI systems are widely scaled [27].

Conclusion

This article has developed an agri-food AI readiness framework linking data infrastructure, institutional capacity, farmer capability, and governance maturity. The central argument is that responsible AI implementation depends not only on advanced models, platforms, or automated tools, but on the systems that support, govern, and contextualise their use. Readiness gaps can weaken implementation, intensify inequality, reduce trust, enable data misuse, and leave risks unmanaged. A framework approach helps policymakers, institutions, technology developers, and farmer organisations assess whether agri-food systems are prepared for AI in ways that are effective, inclusive, trustworthy, and responsibly governed.

Acknowledgements

None

Conflict of interest

None

Financial support

None

Ethics statement

None

Received: 14 Oct 2025

Revised: 31 Oct 2025

Accepted: 08 Dec 2025

Published online: 15 March 2026

Rights and permissions

Open Access The author(s) retain copyright. This article is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. It may be shared and adapted for non-commercial purposes with appropriate attribution, an indication of changes, and

distribution of adaptations under the same license. Third-party material may be subject to separate terms identified in its credit line. View the license at <https://creativecommons.org/licenses/by-nc-sa/4.0/>.

References

Klerkx L, Jakku E, Labarthe P. A review of social science on digital agriculture, smart farming and Agriculture 4.0: New contributions and a future research agenda. *NJAS Wageningen J Life Sci.* 2019;90-91:100315.
<https://doi.org/10.1016/j.njas.2019.100315>.

Wolfert S, Ge L, Verdouw C, Bogaardt MJ. Big data in smart farming – a review. *Agric Syst.* 2017;153:69-80.
<https://doi.org/10.1016/j.agsy.2017.01.023>.

Kamilaris A, Prenafeta-Boldú FX. Deep learning in agriculture: A survey. *Comput Electron Agric.* 2018;147:70-90.
<https://doi.org/10.1016/j.compag.2018.02.016>.

Rose DC, Chilvers J. Agriculture 4.0: Broadening responsible innovation in an era of smart farming. *Front Sustain Food Syst.* 2018;2:87.
<https://doi.org/10.3389/fsufs.2018.00087>.

Tzachor A, Devare M, King B, Avin S, Ó hÉigeartaigh S. Responsible artificial intelligence in agriculture requires systemic understanding of risks and externalities. *Nat Mach Intell.* 2022;4(2):104-9.
<https://doi.org/10.1038/s42256-022-00440-4>.

Zhai Z, Martínez JF, Beltran V, Martínez NL. Decision support systems for Agriculture 4.0: Survey and challenges. *Comput Electron Agric.* 2020;170:105256.
<https://doi.org/10.1016/j.compag.2020.105256>.

Gardezi M, Joshi B, Rizzo DM, Ryan M, Prutzer E, Brugler S, et al. Artificial intelligence in farming: Challenges and opportunities for building trust. *Agron J.* 2024;116(3):1217-28.
<https://doi.org/10.1002/agj2.21353>.

Janssen SJC, Porter CH, Moore AD, Athanasiadis IN, Foster I, Jones JW, et al. Towards a new generation of agricultural system data, models and knowledge products: Information and communication technology. *Agric Syst.* 2017;155:200-12.
<https://doi.org/10.1016/j.agsy.2016.09.017>.

Eitzinger A, Cock J, Atzmanstorfer K, Binder CR, Läderach P, Bonilla-Findji O, et al. GeoFarmer: A monitoring and feedback system for agricultural development projects. *Comput Electron Agric.* 2019;158:109-21.
<https://doi.org/10.1016/j.compag.2019.01.049>.

Wiseman L, Sanderson J, Zhang A, Jakku E. Farmers and their data: An examination of farmers' reluctance to share their data through the lens of the laws impacting smart farming. *NJAS Wageningen J Life Sci.* 2019;90-91:100301.
<https://doi.org/10.1016/j.njas.2019.04.007>.

Eastwood C, Klerkx L, Nettle R. Dynamics and distribution of public and private research and extension roles for technological innovation and diffusion: Case studies of the implementation and adaptation of precision farming technologies. *J Rural Stud.* 2017;49:1-12.
<https://doi.org/10.1016/j.jrurstud.2016.11.008>.

Fielke S, Taylor B, Jakku E. Digitalisation of agricultural knowledge and advice networks: A state-of-the-art review. *Agric Syst.* 2020;180:102763.
<https://doi.org/10.1016/j.agsy.2019.102763>.

Birner R, Daum T, Pray C. Who drives the digital revolution in agriculture? A review of supply-side trends, players and challenges. *Appl Econ Perspect Policy.* 2021;43(4):1260-85.

<https://doi.org/10.1002/aep.13145>.

Barnes AP, Soto I, Eory V, Beck B, Balafoutis AT, Sanchez B, et al. Influencing incentives for precision agricultural technologies within European arable farming systems. *Environ Sci Policy*. 2019;93:66-74.

<https://doi.org/10.1016/j.envsci.2018.12.014>.

Caffaro F, Micheletti Cremasco M, Roccato M, Cavallo E. Drivers of farmers' intention to adopt technological innovations in Italy: The role of information sources, perceived usefulness, and perceived ease of use. *J Rural Stud*. 2020;76:264-71.

<https://doi.org/10.1016/j.jrurstud.2020.04.028>.

Michels M, Bonke V, Musshoff O. Understanding the adoption of smartphone apps in dairy herd management. *J Dairy Sci*. 2019;102(10):9422-34.

<https://doi.org/10.3168/jds.2019-16489>.

Li W, Clark B, Taylor JA, Kendall H, Jones G, Li Z, et al. A hybrid modelling approach to understanding adoption of precision agriculture technologies in Chinese cropping systems. *Comput Electron Agric*. 2020;172:105305.

<https://doi.org/10.1016/j.compag.2020.105305>.

Ryan M. Agricultural big data analytics and the ethics of power. *J Agric Environ Ethics*. 2020;33(1):49-69.

<https://doi.org/10.1007/s10806-019-09812-0>.

Ryan M. The social and ethical impacts of artificial intelligence in agriculture: Mapping the agricultural AI literature. *AI Soc*. 2023;38(6):2473-85.

<https://doi.org/10.1007/s00146-021-01377-9>.

Dara R, Hazrati Fard SM, Kaur J. Recommendations for ethical and responsible use of artificial intelligence in digital agriculture. *Front Artif Intell*. 2022;5:884192.

<https://doi.org/10.3389/frai.2022.884192>.

van der Burg S, Bogaardt MJ, Wolfert S. Ethics of smart farming: Current questions and directions for responsible innovation towards the future. *NJAS Wageningen J Life Sci*. 2019;90-91:100289.

<https://doi.org/10.1016/j.njas.2019.01.001>.

Jakku E, Taylor B, Fleming A, Mason C, Fielke S, Sounness C, et al. "If they don't tell us what they do with it, why would we trust them?" Trust, transparency and benefit-sharing in smart farming. *NJAS Wageningen J Life Sci*. 2019;90-91:100285.

<https://doi.org/10.1016/j.njas.2018.11.002>.

Eastwood C, Klerkx L, Ayre M, Dela Rue B. Managing socio-ethical challenges in the development of smart farming: From a fragmented to a comprehensive approach for responsible research and innovation. *J Agric Environ Ethics*. 2019;32(5-6):741-68.

<https://doi.org/10.1007/s10806-017-9704-5>.

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

<https://doi.org/10.1016/j.gfs.2019.100347>.

Rose DC, Wheeler R, Winter M, Lobley M, Chivers CA. Agriculture 4.0: Making it work for people, production, and the planet. *Land Use Policy*. 2021;100:104933.

<https://doi.org/10.1016/j.landusepol.2020.104933>.

Lajoie-O'Malley A, Bronson K, van der Burg S, Klerkx L. The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosyst Serv*. 2020;45:101183.

<https://doi.org/10.1016/j.ecoser.2020.101183>.

Zscheischler J, Brunsch R, Rogga S, Scholz RW. Perceived risks and vulnerabilities of employing digitalization and digital data in agriculture – socially robust orientations from a transdisciplinary process. *J Clean Prod*. 2022;358:132034.

<https://doi.org/10.1016/j.jclepro.2022.132034>.