

Economic and Policy Analysis of Technologies Uptake for the Smart Management of Agricultural Systems

Davide Viaggi¹, Giulia Maesano¹, Davide Menozzi²

¹ *Department of Agricultural and Food Sciences, Alma Mater Studiorum - University of Bologna.
Viale Fanin, 50 - 40127 Bologna, Italy*

² *Department of Food and Drug, University of Parma. Parco Area delle Scienze 47/A,
43124 Parma, Italy*

Introduction

This special issue of Bio-based and Applied Economics “Economic and Policy Analysis of the Adoption of Smart Agriculture Technologies” stems from the growing diffusion of innovative digital technologies as strategic solutions for the development of the agricultural sector.

Agriculture is undergoing a profound transformation thanks to the integration of new technologies (Vishnoi and Goel, 2024; Aijaz et al., 2025), with a view to the sustainable development of the sector (Norman and MacDonald, 2004; Nica et al., 2025). The combined economic and environmental benefits of technology adoption in agriculture are widely recognized in the literature (Giorgio et al., 2024; Papadopoulos et al., 2025). To illustrate, technologies in agriculture help address current interconnected challenges related to productivity, cost reduction, agri-food safety, natural resource conservation, animal welfare, worker safety, and, more generally, the achievement of sustainable development goals (Castillo-Díaz et al., 2025; Finger, 2023; Basso and Antle, 2020; Musa and Basir, 2022; Sridhar et al., 2023). In this context, technological innovations have enabled significant improvement of various agricultural processes through the introduction of different tools, such as the Internet of Things (IoT), sensors, robotics, drones, blockchain, and artificial intelligence (Sharma and Shivandu, 2024).

The diffusion of innovative digital tools in agriculture is growing (Shang et al., 2021), but their take up still varies significantly across countries, farm types, and production systems (Eastwood et al., 2019; Rose and Chilvers, 2018; Shepherd et al., 2020). This uneven pattern highlights the need to understand the mechanisms underlying the adoption of these technologies and suggests that digital transformation in agriculture is not just about technology, but also depends on social structures,

institutions, and interactions between networks and governance systems (Roberts et al., 2017; Jia, 2021), as well as farmers' personal attitudes and traits (Deißler et al., 2022).

This special issue contributes to the ongoing debate on how digitalization is reshaping agriculture. Combining behavioral theories, such as the theory of planned behavior (Ajzen, 1991), the technology acceptance model (Davis, 1989), and the unified theory of technology acceptance and use (Venkatesh et al., 2012), with economic and policy analyses, the articles examine in detail the factors that help or hinder farmers in adopting new technologies (Maesano et al., 2025; Cozzi et al., 2025; Moussaoui et al., 2025).

Presentation of the Special Issue

The articles collected in this special issue aim to offer a broad and multifaceted view of the dynamics linked to the diffusion of innovative digital technologies in the agricultural sector, considering the behavioral, economic, and political dimensions that influence the intention to adopt them.

Kühnemund and Recke (2025), drawing on the Technology Acceptance Model (TAM) framework, investigate the determinants that drive German pig farmers to introduce AI-based camera systems into livestock production. Their findings indicate that perceived ease of use, openness to innovation, and individual innovativeness are the main factors influencing adoption intention. Concerns about data ownership and privacy, however, play a lesser role in driving behavior. Overall, the authors argue that farmers place significant importance on the reliability and functionality of technology. However, trust and transparency are essential determinants of technology adoption. These findings underscore the importance of user-centered design and clear communication regarding how intelligent technologies are implemented in practice.

Cozzi et al. (2025) conduct a study in the Italian horticultural sector, to analyze the adoption of water-smart technologies. Based on data from a survey of 251 farmers in Italy, using an extended TAM3 framework, the authors find that perceived usefulness and social norms strongly influence adoption intentions. The results also show that ease of use is less influential in driving intentions. Their analysis highlights how social interaction and perceived benefits outweigh usability or socioeconomic characteristics in shaping farmers' behavior. From this perspective, the findings suggest that participatory and peer-learning environments can serve as effective channels to accelerate the diffusion of innovation. The findings are consistent with those of Sabbagh and Gutierrez (2025) and Kühnemund and Recke (2025), both of which emphasize the key role of social capital in linking technological potential to actual behavioral change.

Sabbagh and Gutierrez (2025) extend the Unified Theory of Acceptance and Use of Technology framework to analyze the adoption of Agriculture 4.0. The authors identify the main determinants of

adoption by comparing marginal and non-marginal areas. Their findings reveal that facilitating conditions, such as access to infrastructure and technical support, and social influence are the main predictors of adoption. Furthermore, according to the study's findings, perceived performance risks have been shown to be barriers to adoption. The authors conclude that adoption intentions depend not only on individual motivation, but also on social and territorial structures that enable knowledge exchange and reduce perceived risk. These findings echo previous work on the rural digital divide, highlighting the need for context-specific policies (Rose and Chilvers, 2018; Eastwood et al., 2019). Timpanaro et al. (2025) contribute to the literature debate by analyzing the methods of introducing digital tools and their effects in Sicilian citrus farming. Using a Living Lab approach, the authors demonstrate that digital technologies can increase yield per hectare, improve profitability, and enhance water efficiency on citrus farms. Their findings also indicate that participatory innovation processes promote knowledge exchange and collaboration, helping to reduce farmers' resistance to change. The study highlights the need for targeted training and institutional support to ensure that digitalization is effective and inclusive. This participatory perspective resonates with the call for innovation ecosystems that integrate technology into local socioeconomic contexts and sustainability goals.

Maesano et al. (2025) examine the factors influencing Italian consumers' intentions to purchase organic pasta traced using blockchain technology. Extending the Theory of Planned Behavior (TPB) framework (Ajzen, 1991), the authors assess the potential of blockchain in preventing and detecting food fraud. Their findings suggest that subjective norms, perceived behavioral control, and attitudes toward technology are the main predictors of purchase intention, while trust in traditional quality certifications plays a limited role. Therefore, consumers place greater trust in digital traceability tools than in conventional certification systems. However, from a consumer perspective, uncertainty remains about the practical benefits of these technologies, highlighting the need for a credible and transparent environment in which innovation provides clear added value.

Pacciani et al. (2025) evaluate digitalization levels, perceived benefits, needs, and barriers on a sample of 1,248 Italian farms. The results show that monitoring systems and connected machinery are the most used technologies. In addition, efficiency gains in farm and production management, improved operational control, and perceived benefits are key drivers of adoption, while financial and structural limitations remain significant obstacles. The authors call for coordinated policy measures to support the digital transition, combining advisory services, investment in infrastructure, and human capital development. Their conclusions are consistent with those of Sabbagh and Gutierrez (2025) and Timpanaro et al. (2025), who also emphasize the importance of governance coordination, training, and connectivity in promoting technology diffusion.

Finally, Moussaoui et al. (2025) employ a mixed-methods design, combining surveys and in-depth interviews to gather stakeholder perspectives on smart agriculture technologies and their policy integration. The results of the study show a broad agreement on the potential of technologies to improve agricultural efficiency, sustainability, and productivity; nonetheless, it also identifies persistent barriers, including high upfront costs and limited technical expertise. The authors highlight the need for financial incentives, capacity-building initiatives, and stronger infrastructure to encourage adoption. The conclusion of this study supports adaptive, multi-level governance frameworks that link top-down policy design with bottom-up innovation processes to ensure greater policy coherence. In line with Pacciani et al. (2025), their findings reinforce the view that digital transformation depends as much on systemic governance reform as on technological progress.

Cross-cutting insights and policy implications

This special issue offers different perspectives on the dynamics of technology adoption and the governance of digital transformation in agriculture. The evidence confirms that technology adoption is not merely a technical or economic process (though these aspects are very important), but it is a socio-institutional transition, that depends on mental constructs, social norms, and collective learning mechanisms, and is strongly influenced by the external conditions in which innovations are embedded. Behavioral models indicate that perceived usefulness and social influence are the main determinants of farmers' acceptance of innovations. Conversely, perceived risk, high costs, and institutional uncertainty remain the main barriers.

From a policy perspective, the findings highlight that monetary incentives alone will not ensure a successful digital transition unless they are part of coherent and flexible governance arrangements that align public and private resources, promote interoperability, and leverage synergies within the sector (Wolfert et al., 2017; Klerkx et al., 2019; Viaggi, 2019). The articles in this special issue suggest that effective strategies must combine investment with the development of digital infrastructure and educational programs to build long-term innovation capacity. More generally, the integration of behavioral and economic policy analysis in these articles demonstrates how interdisciplinary science can inform evidence-based solutions to ensure the deployment of smart technologies in the context of resilient agri-food systems.

ACKNOWLEDGEMENTS

The Guest Editors thank all authors for their valuable contributions, the anonymous reviewers for their constructive feedback, and the Bio-based and Applied Economics editorial team for their support

in publishing this Special Issue. This special issue was inspired by Agritech National Research Center (Spoke 3 – Enabling technologies and sustainable strategies for the smart management of agricultural systems and their environmental impact), which also funded six out of seven papers.

This Special Issue also saw the participation of our colleague Maurizio Canavari, who passed away prematurely at the beginning of 2025, far too soon. He was a curious, generous, and committed scholar, deeply engaged in the fields of agri-food economics and consumer behavior. His collaborative spirit enriched all those who had the privilege to work with him. Maurizio contributed to the conception, design, and realization of one of the studies included in this Special Issue, namely Cozzi et al. (2025). He leaves an indelible memory among his colleagues and students.

All guest editors contributed equally to the conception and writing of this editorial.

References

- Aijaz, N., Lan, H., Raza, T., Yaqub, M., Iqbal, R., & Pathan, M. S. (2025). Artificial intelligence in agriculture: Advancing crop productivity and sustainability. *Journal of Agriculture and Food Research*, 101762.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.
- Basso, B., & Antle, J. (2020). Digital agriculture to design sustainable agricultural systems. *Nature Sustainability*, 3(4), 254-256.
- Castillo-Díaz, F. J., Belmonte-Ureña, L. J., Gálvez-Sánchez, F. J., & Camacho-Ferre, F. (2025). Sustainable technological innovations in agriculture: Financial challenges and investment priorities
- Cozzi, E., Menozzi, D., Maesano, G., Canavari, M., & Mora, C. (2025). Digital Technology Adoption Among Italian Farmers: An Extended Technology Acceptance Model Approach in the Horticultural Sector. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17364>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.
- Deißler, L., Mausch, K., Karanja, A., McMullin, S., & Grote, U. (2022). A complex web of interactions: Personality traits and aspirations in the context of smallholder agriculture. *Bio-based and Applied Economics*, 12(1), 53-67.

Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B. (2019). Managing socio-ethical challenges in the development of smart farming: from a fragmented to a comprehensive approach for responsible research and innovation. *Journal of agricultural and environmental ethics*, 32(5), 741-768.

Finger, R. (2023). Digital innovations for sustainable and resilient agricultural systems. *European Review of Agricultural Economics*, 50(4), 1277-1309.

Giorgio, A., Penate Lopez, L. P., Bertoni, D., Cavicchioli, D., & Ferrazzi, G. (2024). Enablers to digitalization in agriculture: a case study from Italian field crop farms in the Po River Valley, with insights for policy targeting. *Agriculture*, 14(7), 1074.

Jia, X. (2021). Agro-food innovation and sustainability transition: A conceptual synthesis. *Sustainability*, 13(12), 6897.

Kühnemund, A., & Recke, G. (2025). Intention to use AI-Based Camera Systems in German Pig Farming: An Extended Technology Acceptance Model. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17220>

Maesano, G., Sadrmousavigargari, S., & Castellini, A. (2025). Consumer Intentions to Purchase Pasta with Blockchain-based Traceability. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17195>

Moussaoui, A., Ghelfi, R., & Viaggi, D. (2025). Agritech Policy Landscape: Insights from Relevant Stakeholders on Policy Issues and Strategic Plans in Italy. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17356>

Musa, S. F. P. D., & Basir, K. H. (2021). Smart farming: towards a sustainable agri-food system. *British Food Journal*, 123(9), 3085-3099.

Nica, I., Chiriță, N., & Georgescu, I. (2025). Triple Bottom Line in Sustainable Development: A Comprehensive Bibliometric Analysis. *Sustainability*, 17(5), 1932.

Norman, W., & MacDonald, C. (2004). Getting to the bottom of “triple bottom line”. *Business ethics quarterly*, 14(2), 243-262.

Pacciani, C., Catellani, E., Bacchetti, A., Corbo, C., Ciccullo, F., & Ardolino, M. (2025). Agriculture 4.0: Technological Adoption, Drivers, Benefits and Challenges in Italy. A Descriptive Survey. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17382>

Papadopoulos, G., Papantonatou, M. Z., Uyar, H., Kriezi, O., Mavrommatis, A., Psiroukis, V., ... & Fountas, S. (2025). Economic and Environmental Benefits of Digital Agricultural Technological Solutions in Livestock Farming: A Review. *Smart Agricultural Technology*, 100783.

Roberts, E., Anderson, B. A., Skerratt, S., & Farrington, J. (2017). A review of the rural-digital policy agenda from a community resilience perspective. *Journal of Rural Studies*, 54, 372-385.

Rose, D. C., & Chilvers, J. (2018). Agriculture 4.0: Broadening responsible innovation in an era of smart farming. *Frontiers in Sustainable Food Systems*, 2, 387545.

Sabbagh, M., & Gutierrez, L. (2025). Farmers' Intention Towards Investing in Agriculture 4.0 in Marginal and Non-marginal Conditions. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17229>

Shang, L., Heckeleei, T., Gerullis, M. K., Börner, J., & Rasch, S. (2021). Adoption and diffusion of digital farming technologies-integrating farm-level evidence and system interaction. *Agricultural systems*, 190, 103074.

Sharma, K., & Shivandu, S. K. (2024). Integrating artificial intelligence and Internet of Things (IoT) for enhanced crop monitoring and management in precision agriculture. *Sensors International*, 5, 100292.

Shepherd, M., Turner, J. A., Small, B., & Wheeler, D. (2020). Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution. *Journal of the Science of Food and Agriculture*, 100(14), 5083-5092

Sridhar, A., Ponnuchamy, M., Kumar, P. S., Kapoor, A., Vo, D. V. N., & Rangasamy, G. (2023). Digitalization of the agro-food sector for achieving sustainable development goals: a review. *Sustainable Food Technology*, 1(6), 783-802.

Timpanaro, G., Cascone, G., & Foti, V. T. (2025). Enabling Technologies in Citrus Farming: A Living Lab Approach to Agroecology and Sustainable Water Resource Management. *Bio-based and Applied Economics*, 4, <https://doi.org/10.36253/bae-17357>

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, 157-178.

Viaggi, D. (2019). Bioeconomy and the Common Agricultural Policy: will a strategy in search of policies meet a policy in search of strategies?. *Bio-Based and Applied Economics*, 7(2), 179–190.

Vishnoi, S., & Goel, R. K. (2024). Climate smart agriculture for sustainable productivity and healthy landscapes. *Environmental Science & Policy*, 151, 103600.

Accepted Manuscript