

ISSN 2280-6180
www.fupress.net



BAE

VOL. 15, NO. 3, 2026

**Bio-based and
Applied
Economics**



fup
FIRENZE
UNIVERSITY
PRESS

Bio-based and Applied Economics is the official journal of the Italian Association of Agricultural and Applied Economics – AIEAA (www.aieaa.org; E-mail: info@aieaa.org).

Editor in Chief

FABIO BARTOLINI, Università di Ferrara, Italy

SILVIA CODERONI, Università di Teramo, Italy

Associated Editors

LUIGI BIAGINI, Università della Tuscia, Italy

SIMONE CERRONI, Università degli Studi di Trento, Italy

RICCARDO D'ALBERTO, Università di Verona

LAURA GARCÍA HERRERO, Alma Mater Studiorum - Università di Bologna, Italy

ORIANA GAVA, Centro di Ricerca Politiche e Bioeconomia, Firenze, Italy

DAVIDE MENOZZI, Università degli Studi di Parma, Italy

DONATO ROMANO, Università degli Studi di Firenze, Italy

MATTEO ZAVALLONI, Università degli Studi di Urbino, Italy

International Editorial Board

J.Awudu Abdulai, University of Kiel, Germany

Adewale Adenuga, AFBI, UK

J.M. Garcia Alvarez-Coque, Universitat Politècnica de Valencia, Spain

Filippo Arfini, Università di Parma, Italy

Witsanu Attanavich, Kasetsart University, Thailand

Jesus Barreiro-Hurle, Joint Research Centre of the European Commission

Martina Bozzola, Queen's University Belfast, UK

Allan Buckwell, Imperial College London, UK

Vincenzina Caputo, Michigan State University, USA

Pavel Ciaian, Joint Research Centre, EU Commission, Seville, Spain

Alessandro Corsi, Università di Torino, Italy

Maria De Salvo, Università di Catania, Italy

Salvatore di Falco, University of Geneva

Janet Dwyer, CCRI, Gloucester, UK

Linda Fulponi, OECD, Paris, France

Gioacchino Garofoli, Università dell'Insubria, Varese, Italy

Franco Mantino, CREA-PB, Italy

Jane Mariara, Partnership for Economic Policy

Alan Matthews, Trinity College Dublin

Mario Mazzocchi, Università di Bologna, Italy

Ashok Mishra, Arizona State University, USA

Giancarlo Moschini, Iowa State University, USA

John Mburu, University of Nairobi

Vincent Requillart, University of Tolosa, France

Deborah Roberts, University of Aberdeen, UK

Severino Romano, Università della Basilicata, Italy

Jutta Roosen, TUM, Germany

Elena Saraceno, Former EU Commission officer, Belgium

Sara Savastano, IFAD, Italy

Riccardo Scarpa, Università di Verona, Italy

Paolo Sckokai, Università Cattolica del Sacro Cuore, Piacenza, Italy

Richard Sexton, UC Davis, USA

Bhavani Shankar, SOAS/LIDC, London, UK

Alessandro Sorrentino, Università della Tuscia, Italy

Kostas Stamoulis, FAO, Roma, Italy

Gianluca Stefani, Università di Firenze, Italy

Jo Swinnen, Katholieke Universiteit Leuven, Belgium

Maximo Torero, FAO

Bruce Traill, University of Reading, UK

Jan Douwe Van der Ploeg, Wageningen University, The Netherlands

Guido Van Huylenbroeck, Ghent University, Belgium

Davide Viaggi, Università di Bologna, Italy

Stephan Von Cramon Taubadel, University of Gottingen, Germany

Paul Winters, University of Notre Dame, UK

Journal Contacts:

Silvia Coderoni, Dipartimento di Bioscienze e Tecnologie Agro-Alimentari e Ambientali, Via Balzarini 1, 64100 Teramo;

E-mail: scoderoni@unite.it

Fabio Bartolini, Dipartimento di Scienze Chimiche, Farmaceutiche ed Agrarie, Via L. Borsari 46, 44121 Ferrara;

E-mail: fabio.bartolini@unife.it

Available online at: <http://www.fupress.com/bae>

© 2026 Firenze University Press

Università degli Studi di Firenze

Firenze University Press

via Cittadella, 7 - 50144 Firenze, Italy

www.fupress.com

E-mail: journals@fupress.com

ISSN 2280-6180 (print)

ISSN 2280-6172 (online)

Direttore Responsabile: Corrado Giacomini

Registrata al n. 5873 in data 10 maggio 2012

del Tribunale di Firenze

BAE

Bio-based and Applied Economics

Volume 15, Issue 3 - 2026

Firenze University Press

Bio-based and Applied Economics

<https://www.fupress.com/bae>

ISSN: 2280-6180 (print) | ISSN: 2280-6172 (online)



© 2026 Author(s)

Content license: except where otherwise noted, the present work is released under Creative Commons Attribution 4.0 International license (CC BY 4.0: <https://creativecommons.org/licenses/by/4.0/legalcode>). This license allows you to share any part of the work by any means and format, modify it for any purpose, including commercial, as long as appropriate credit is given to the author, any changes made to the work are indicated and a URL link is provided to the license.

Metadata license: all the metadata are released under the Public Domain Dedication license (CC0 1.0 Universal: <https://creativecommons.org/publicdomain/zero/1.0/legalcode>).

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com



Citation: Gava, O., Galioto, F., Vanni, F., Schwarz, G. & Povellato, A. (2026). Priority policy areas to support agroecology transitions in rural Europe: insights from an actor-centred approach. *Bio-based and Applied Economics* 15(3): 3-12. doi: 10.36253/bae-18613

Received: September 11, 2025

Accepted: April 20, 2026

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Silvia Coderoni

Associated Editor: Matteo Zavalloni

ORCID

OG: 0000-0001-7930-9251

FG: 0000-0002-9473-3867

FV: 0000-0003-4009-3013

GS: 0000-0001-9833-7362

AP: 0000-0002-6980-4862

Priority policy areas to support agroecology transitions in rural Europe: insights from an actor-centred approach

ORIANA GAVA^{1*}, FRANCESCO GALIOTO², FRANCESCO VANNI¹, GERALD SCHWARZ³, ANDREA POVELLATO⁴

¹ Council for Agricultural Research and Economics, Research Centre for Agricultural Policies and Bioeconomy, via della Toscana 21, 50127 Firenze, Italy

² Council for Agricultural Research and Economics, Research Centre for Agricultural Policies and Bioeconomy, Borgo XX Giugno 74, 06121 Perugia, Italy

³ Thünen Institute of Farm Economics, Bundesallee 63, 38116, Braunschweig, Germany

⁴ Council for Agricultural Research and Economics, Research Centre for Agricultural Policies and Bioeconomy, Viale dell'Università, 14, 35020 Legnaro (PD), Italy

*Corresponding author. E-mail: oriana.gava@crea.gov.it

Abstract. Agroecology is increasingly recognised as a pathway to sustainable food systems, yet its uptake in Europe remains limited, raising questions about the effectiveness of current policy support. This Policy Paper identifies priority policy areas to support agroecology transitions by integrating actor perspectives through a participatory mixed-methods approach combining multi-criteria analysis and qualitative evaluation. Evidence from 15 European case studies shows that policy instruments perform differently across transition goals (adoption, positioning, amplification). Knowledge promotion and payments for investments emerge as key enablers for adoption and market positioning, while networking and cooperation are critical for territorial scaling. By contrast, certification schemes and food policies require redesign to better address equity concerns and improve connectivity across actors and scales. The findings highlight the importance of adapting, combining, and sequencing existing policy instruments in line with transition goals and governance conditions. Overall, the paper provides actionable insights for policymakers seeking to create enabling environments for agroecology in Europe, with implications relevant beyond the European context.

Keywords: mixed-methods, participatory research, policy mechanisms, actor-centred approach, multi-actor platform.

1. INTRODUCTION

Agroecology is an integrated, science-based, and transdisciplinary approach to the redesign of agri-food systems for sustainability, and is increasingly recognized as a vital strategy for achieving sustainable agriculture aligned with environmental, social, and economic goals (HLPE, 2019; Wezel et al., 2009). Despite its potential to address climate, food, and biodi-

versity crises (Bezner Kerr et al., 2023), scaling agroecology remains an unresolved challenge in Europe, where uptake is still limited (Rega et al., 2022). The literature highlights persistent failures of existing instruments to remove structural barriers and lock-ins that hinder agroecology transitions (Peeters et al., 2021; Place et al., 2022; Williams et al., 2024). To date, the Common Agricultural Policy (CAP), while including provisions for organic farming and environmental stewardship, has often prioritised conventional practices, limiting its transformative potential (Runhaar, 2021). Future policy intervention is expected to play a pivotal role by creating enabling environments for amplification processes (Boix-Fayos and de Vente, 2023; Ewert et al., 2023; Lam et al., 2020).

Recent literature on agroecology transitions emphasises the need for tailored policy frameworks that respond to local contexts and socio-economic realities (Gava et al., 2025; Prost et al., 2023). The challenge is not to reinvent the wheel, but to build on existing instruments and frameworks by placing actors at the centre of decision-making. This ensures that local goals are considered and avoids a one-size-fits-all approach. While previous studies have mapped barriers and proposed broad policy mixes (Lampkin et al., 2020; Peeters et al., 2021), there is still limited evidence on how actors' goals influence policy prioritisation across different transition stages, a gap increasingly acknowledged in the literature (Fiore et al., 2024; Helenius et al., 2020). Addressing this gap is critical for designing context-sensitive and goal-oriented policy frameworks that move beyond generic recommendations and support systemic change (Niggli et al., 2021; Prost et al., 2023). This is directly relevant for policy design, as identifying which policy areas matter most cannot be separated from why they matter to actors pursuing different transition goals. By explicitly linking actors' goals to policy prioritisation, this study bridges the gap between general policy frameworks and the identification of policy areas that are most relevant for accelerating agroecology transitions.

Against this background, this article contributes to the science-policy dialogue by providing an examination of policy priorities that are potentially useful for scaling agroecology through an actor-centred lens. Drawing on participatory research within the UNISECO project across 15 European case studies (Schwarz et al., 2022), the aim of the article is to identify which policy areas matter most under different transition goals (adoption, positioning, and amplification) and to highlight opportunities for improving existing instruments. The analytical and methodological approach and the underlying data draw on earlier work developed within the UNISECO project (Galioto et al., 2021; Gava et al., 2025,

2022; Linares Quero et al., 2022) and are used here to inform the policy cycle. The article offers an actor-oriented perspective on the performance of policy instruments within broader governance dynamics. By placing actors at the centre of the policy process, the proposed approach captures both the goals of accelerating agroecology transitions and the policy priorities that can serve as meaningful levers aligned with actors' needs and expectations on the ground. The findings provide practical insights for policymakers and practitioners seeking to create enabling environments for agroecology, supporting more inclusive and transformative policy design.

2. EVIDENCE AND ANALYSIS

2.1. Methods and data

The analytical and methodological frameworks and data build on earlier research developed within the UNISECO project (Galioto et al., 2021; Gava et al., 2025, 2022; Linares Quero et al., 2022), additional supporting theoretical, methodological explanation and data for this specific paper are available from the Supplementary materials. Evidence presented here results from the combination of participatory multi-criteria analysis and qualitative evaluation of policy instruments (structured towards policy areas) identified through a participatory process in 15 case studies across Europe (Table 1).

Each case study represents a distinct transition goal:

- Adoption: introducing agroecological practices within conventional systems;
- Positioning: creation and stabilisation of demand for agroecological products;
- Amplification: territorial scaling of agroecology through collective and transformative strategies.

Actors engaged in the evaluation at the case study level were drawn from the project's Multi-Actor Platforms, ensuring representation of farmers, advisors, value chain actors, policymakers, researchers, civil society organizations, and consumers (Zawalińska et al., 2022).

2.2. Performance and qualitative mechanisms explaining policy performance¹ across transition goals

This section synthesises evidence from the multi-criteria analysis and the qualitative evaluation to assess how major policy areas perform across three agroecology transition goals. The analysis highlights relative pri-

¹ Selected illustrative case study examples are chosen for their explanatory value. This does not imply that each mechanism is unique to a single case study, nor that other mechanisms were absent in the same contexts.

Table 1. Policy areas and intervention logic, with example policy instruments from the case studies.

Policy areas	Intervention logic	Examples from the case studies
Agri-environment payments	Encouraging the adoption and maintenance of agroecological practices and/or the creation/restoration of habitats or landscape elements	Action and result-based agri-environment payments; Organic farming; Payments for non-productive investments
Certification schemes	Food labelling to reduce information asymmetry business-to-consumer about the sustainability of farming methods and the produced food	Carbon farming; Carbon footprint; Biodiversity-friendly; Climate-friendly
Context-specific and cross-cutting	Heterogeneous group of instruments, for which patterns could not be identified, displaying a variety of aims, including economic growth, job creation, better quality of life in rural areas, landscape management, forestry, hygiene and food safety, biomass for fuel and energy production	Regional policy; LEADER; Fiscal policy; Hygiene and food safety regulations; Wildlife laws; Land use planning; Forestry laws; Tax reduction for biofuels
Food policies	Regulating food from production to end-of-life to improve its sustainability, with special attention to the phases of processing, distribution, and consumption	Green public procurement; Short food chains; School meal programs; Food carbon tax
Income and market support	Keeping the viability of farming, regulating agricultural markets and producer organisations	Direct area-based payments; Greening payments; Cross-compliance; Payments for areas with specific constraints
Knowledge promotion	Advancing knowledge about sustainable farming, including agroecology, also by triggering knowledge creation and diffusion across multiple actors, from farmers to consumers	Advisory services; Information and training; Continuing education; Formal education
Networking and cooperation	Creating/maintaining formal or informal networks of collaborating actors across multiple disciplines	Operational groups; Cooperatives (machinery, storage, sales, marketing); Innovation hubs
Payments for investments	Supporting (loans for) capital investments, especially in physical assets on farm	Farm modernization and investment; Diversification of farm activities; Payments for physical assets; Payments for other gainful activities

oritisations patterns (rankings are available from Table A1) and the mechanisms explaining why specific policy areas matter at different stages. Detailed results are reported in the Supplementary materials.

2.2.1. Agri-environment payments

Agri-environment payments show a supportive but generally moderate performance across transition goals. They are valued as entry points that compensate income losses and encourage participation, particularly in early stages. However, their contribution to long-term transformation remains limited unless integrated with complementary instruments and governance frameworks. In Nivala (Finland), for example, such payments supported initial engagement in sustainable feedstock production for a collective biogas initiative.

2.2.2. Certification schemes

Certification schemes show mixed performance across transition goals and tend to rank lower for amplification. Qualitative evidence highlights a mechanism centred on

information asymmetry reduction and market signalling, which can support positioning by enhancing consumer trust and enabling product differentiation. Illustratively, in Lithuania and Latvia, certification supported market positioning through producer cooperatives and sustainability labelling. However, actors also identified important constraints, including administrative burden, compliance costs, and misalignment with local agroecological values. These factors can exclude smaller producers and limit scalability, reducing the contribution of certification schemes to broader agroecology transitions unless equity safeguards and supportive measures are introduced.

2.2.3. Context-specific and cross-cutting instruments

Context-specific and cross-cutting instruments include a heterogeneous set of policies addressing local challenges and broader sustainability objectives, such as fiscal measures, land-use planning, biodiversity protection, and energy policy. Their performance varies across transition goals and depends strongly on alignment with territorial conditions and coordination with other policy areas. Qualitative evidence points to a place-based adap-

tation mechanism: when tailored to local socio-economic and biophysical contexts, these instruments can help remove specific bottlenecks and reinforce agroecological transitions. For example, in Lake Lucerne (Switzerland), a nitrogen tax incentivised lower livestock density and supported diversification toward low-input arable systems. However, actors also highlighted risks of fragmentation and unintended effects when such instruments are implemented in isolation. Overall, these findings suggest that context-specific and cross-cutting instruments are most effective when embedded in integrated governance frameworks that ensure coordination, coherence, and alignment with broader agroecological strategies.

2.2.4. Food policies

Food policies, including public procurement, short supply chains, and awareness campaigns, also rank relatively low, particularly for amplification. The qualitative analysis points to a demand-creation mechanism that remains weak when food policies are implemented in isolation from supply-side support. For example, in Transylvania (Romania) and Scotland (United Kingdom), food policies contributed to awareness-raising and local market initiatives but had limited impact on scaling agroecological production. Actors highlighted that administrative complexity, limited adaptability to local contexts, and weak coordination with producer support constrain their effectiveness. These findings suggest that food policies are more likely to contribute to agroecology transitions when integrated with investment support, knowledge promotion, and coordination mechanisms that strengthen producer capacity and market connectivity.

2.2.5. Income and market support

Income and market support instruments display mixed performance, with higher relevance in adoption contexts and declining relevance for amplification. Qualitative evidence suggests that these instruments mainly stabilise farm viability and enable experimentation, rather than directly driving agroecological transformation. In Nienburg (Germany), greening payments were perceived as providing the financial buffer needed for farmers to experiment with conservation agriculture.

2.2.6. Knowledge promotion

Knowledge promotion emerges as a consistently high-performing policy area across all transition goals.

It ranks among the top priorities for adoption and positioning and remains critical for amplification. Qualitative evidence indicates distinct mechanisms across stages: in adoption contexts, advisory services reduce uncertainty and support individual decision-making; in positioning contexts, they facilitate coordination and shared understanding along the value chain; and in amplification contexts, they enable collective learning and territorial scaling. For example, in the Basque Autonomous Community and Navarra (Spain), actors highlighted how collective training and advisory networks supported territorial expansion of agroecological practices.

2.2.7. Networking and cooperation

Networking and cooperation instruments gain importance as transitions move from individual adoption to collective scaling. They perform moderately for adoption and positioning but become among the most relevant policy areas for amplification. The underlying mechanism is collective action: these instruments support coordination among farmers, advisors, value-chain actors, and public authorities, fostering shared governance arrangements. For instance, in Auvergne-Rhône-Alpes (France), multi-actor forums supported cooperation in the development of a territory of sustainable viticulture.

2.2.8. Payments for investments

Payments for investments perform strongly for adoption and positioning and remain relevant for amplification. Their effectiveness is explained by a risk-reduction mechanism that enables concrete changes in farm infrastructure and practices. In early stages, they support feasibility and experimentation; in later stages, they help consolidate investments at territorial level when aligned with broader strategies. Illustratively, in Chianti (Italy), investment support facilitated the development of sustainable viticulture infrastructure, enabling scaling at territorial level.

3. DISCUSSION

3.1. Policy options

The evidence shows that the relevance and performance of policy instruments vary across agroecology transition goals, reflecting the different actions and coordination requirements involved. This confirms that uni-

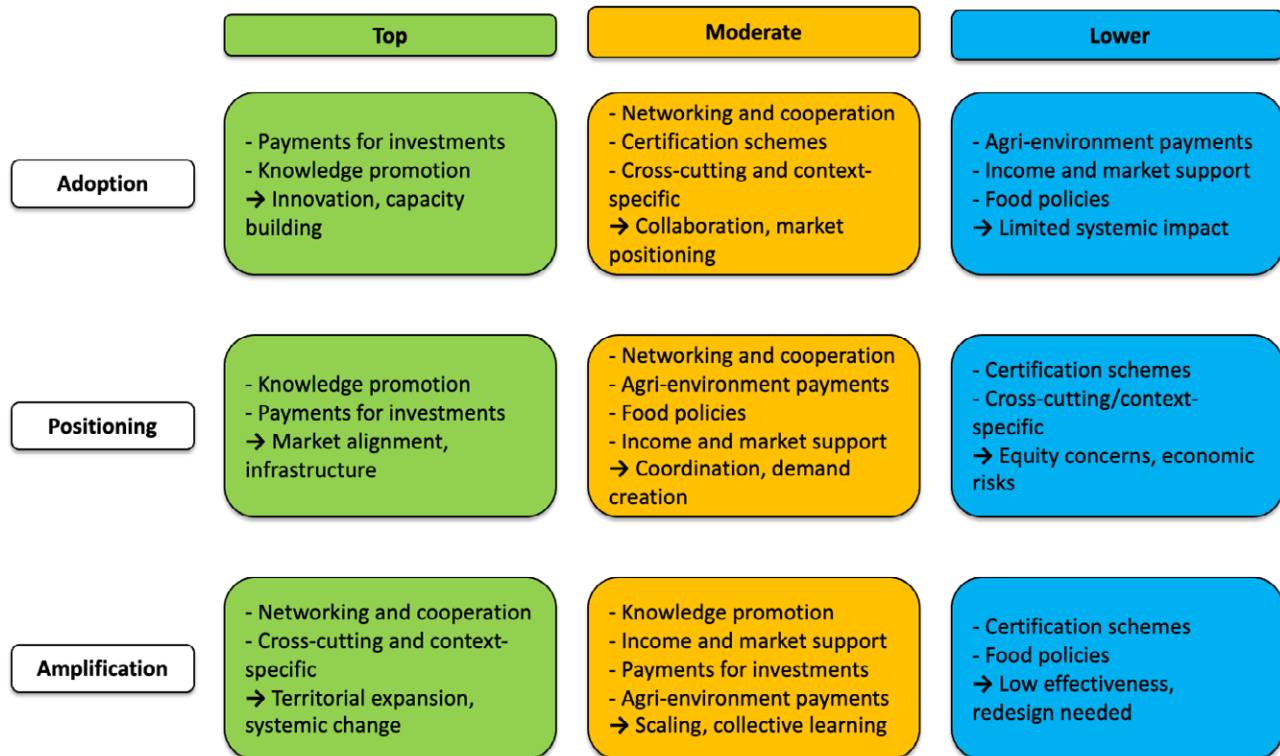


Figure 1. Priority policy area blocks (top, moderate, lower ranking) by transition goal, highlighting different needs.

form policy is unlikely to be effective and that policy support needs to evolve as transitions progress (Figure 1).

For adoption actions, which aim to introduce agroecological practices in conventional farming systems, top-ranked instruments such as payments for investments and knowledge promotion are particularly relevant. These instruments support technical implementation and capacity building, enabling farmers to initiate change. This aligns with the need for technical information and financial tools to implement changes on farm and to develop business strategies for better positioning the produced food on the market. Moderate-ranked instruments like networking and cooperation and certification schemes contribute to market positioning and collaboration, while lower-ranked instruments such as agri-environment payments and food policies show limited systemic impact, indicating a need for redesign or complementary support mechanisms (Frison and Clément, 2020; Salliou et al., 2019).

Positioning actions, which focus on stabilising demand for agroecological products, benefit most from instruments like knowledge promotion and payments for investments, which align with market infrastructure and actor goals. Moderate-ranked instruments including networking and cooperation and agri-environment pay-

ments facilitate coordination and demand creation. Lower-ranked instruments such as certification schemes and cross-cutting/context-specific policies raise equity concerns and economic risks, suggesting that their design may not fully support positioning objectives. Coordination between public agencies and training centres is an important governance issue to be addressed. New governance models should involve research institutes, advisory services, small farms and other local value chain actors through networking instruments and regional policies (Helenius et al., 2020).

Amplification actions, aimed at scaling agroecology through collective agency, are best supported by networking and cooperation and cross-cutting/context-specific instruments, which enable territorial expansion and systemic change. Moderate-ranked instruments like knowledge promotion and agri-environment payments foster collective learning and scaling. Lower-ranked instruments such as certification schemes and food policies are perceived as less effective, highlighting the need for reconsidering their design to better support transformative goals. Strategic plans for agroecology are required to ensure its diffusion and consolidation in the long period. Long-term strategies should be evidence-based, draw on clear and cost-effective rules, and favour

services, small farms, and civil society organisations. These include decentralized and territorial governance, particularly in contexts where land access and resource management shape farmers' autonomy and resilience (Sirdey et al., 2023); mosaic of regionally adapted systems and participatory governance to support agroecological transitions aligned with the Green Deal (Donham and Wezel, 2022).

Strategic plans for agroecology should be long-term and evidence-based, explicitly recognising that different policy instruments activate distinct mechanisms at different transition stages, and therefore require sequencing and combination across adoption, positioning, and amplification goals (Frison and Clément, 2020; Helenius et al., 2020; Salliou et al., 2019).

4. CONCLUSIONS

This article provides policy-relevant evidence on how existing policy instruments can better support agroecology transitions in Europe. By integrating actor perspectives from 15 European case studies, it identifies which policy areas are most relevant for different transition goals (adoption, positioning, amplification) and explains how their effectiveness changes as transitions evolve.

The findings show that while all policy areas contribute to agroecology transitions, their prominence and effectiveness vary by transition stage. Knowledge promotion and payments for investments emerge as key enablers across adoption and positioning, while networking and cooperation are essential for scaling agroecology at the territorial level. In contrast, certification schemes and food policies currently play a more limited role and require redesign to better address equity and connectivity. Overall, the results highlight that policy effectiveness depends less on introducing new instruments than on adapting, combining, and sequencing existing ones in line with actors' goals and governance conditions.

From a policy perspective, the analysis underscores the need for better-tailored strategies to address the socio-economic barriers faced by diverse farming systems and territorial contexts. Strengthening advisory services, supporting capacity building, and improving governance, particularly at intermediate and territorial levels, are critical. Rather than creating new tools, policy efforts should focus on adjusting the design and governance of existing instruments to better align with agroecological principles.

This study has limitations that are relevant for interpretation. Fieldwork was conducted before ex-post evidence on CAP 2023–2027 became available, and the

analysis relies on actor perceptions rather than measured impacts. Future policy-oriented research could strengthen the evidence base by combining this actor-centred framework with longitudinal data and quasi-experimental approaches (e.g. before–after comparisons or comparative analyses between similar territories exposed to different policy mixes) to triangulate perceived and observed outcomes. While the empirical focus is European, the framework and lessons identified offer transferable insights for other regions seeking to design context-sensitive policies to support agroecology transitions.

ACKNOWLEDGMENTS

This work was supported by Horizon 2020, the European Union's research and innovation funding programme from 2014 to 2020 (UNISECO– 'Understanding & improving the sustainability of agro-ecological farming systems in the EU', Grant Agreement No. 773901). The contributions of Gerald Schwarz were also partly funded through research of the Horizon Europe project AGROECOLOGY (European Partnership 'Accelerating Farming Systems Transition: Agroecology

Living Labs and Research Infrastructures', Grant Agreement No. 101132349). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The authors thank all stakeholders in the EU and case study level activities of the UNISECO project for their contributions. The authors also thank all research partners in the UNISECO projects who contributed to data collection in the case studies.

REFERENCES

- Bezner Kerr, R., Postigo, J.C., Smith, P., Cowie, A., Singh, P.K., Rivera-Ferre, M., Tirado-von der Pahlen, M.C., Campbell, D., Neufeldt, H., 2023. Agroecology as a transformative approach to tackle climatic, food, and ecosystemic crises. *Current Opinion in Environmental Sustainability* 62, 101275. <https://doi.org/10.1016/j.cosust.2023.101275>
- Boix-Fayos, C., de Vente, J., 2023. Challenges and potential pathways towards sustainable agriculture within the European Green Deal. *Agricultural Systems* 207, 103634. <https://doi.org/10.1016/j.agsy.2023.103634>
- Donham, J., Wezel, A. 2022. 10 steps to achieve the European green Deal. Policy Brief. AE4EU. <https://www.agroecology-europe.org/new-policy-brief-from-ae4eu-10-steps-to-achieve-the-european-green-deal/>

- Donham, J., Wezel, A., Migliorini, P. 2022. Improving eco-schemes in the light of agroecology. Policy Brief. AE4EU. <https://www.ae4eu.eu/ae4eu-policy-brief/>
- Duru, M., Therond, O., Fares, M., 2015. Designing agroecological transitions; A review. *Agron. Sustain. Dev.* 35, 1237–1257. <https://doi.org/10.1007/s13593-015-0318-x>
- Ewert, F., Baatz, R., Finger, R., 2023. Agroecology for a Sustainable Agriculture and Food System: From Local Solutions to Large-Scale Adoption. *Annual Review of Resource Economics* 15, 351–381. <https://doi.org/10.1146/annurev-resource-102422-090105>
- Fiore, V., Borrello, M., Carlucci, D., Giannoccaro, G., Russo, S., Stempfle, S., Roselli, L., 2024. The socio-economic issues of agroecology: a scoping review. *Agricultural and Food Economics* 12, 16. <https://doi.org/10.1186/s40100-024-00311-z>
- Frison, E., Clément, C., 2020. The potential of diversified agroecological systems to deliver healthy outcomes: Making the link between agriculture, food systems & health. *Food Policy, Sustainable Food Systems for Healthy Diets in Europe and Central Asia* 96, 101851. <https://doi.org/10.1016/j.foodpol.2020.101851>
- Galioto, F., Gava, O., Povellato, A., Vanni, F., 2021. Innovative Market and Policy Instruments to Promote the Agro-ecological Transition Strategies. UNISECO Deliverable 5.4. <https://doi.org/10.5281/ZENODO.5578065>
- Gava, O., Povellato, A., Galioto, F., Pražan, J., Schwarz, G., Quero, A.L., Iragui, U.Y., Massa, C.A., Zilāns, A., Carolus, J., 2022. Policy instruments to support agroecological transitions in Europe. *EuroChoices* 21, 13–20. <https://doi.org/10.1111/1746-692X.12367>
- Gava, O., Vanni, F., Schwarz, G., Guisepelli, E., Vincent, A., Pražan, J., Weissshaidinger, R., Frick, R., Hrabalová, A., Carolus, J., Yoldi, U.I., Pyysiäinen, J., Smyrniotopoulou, A., Vlahos, G., Balázs, K., Szilágyi, A.J., Jegelevičius, G., Mikšytė, E., Zilans, A., Frățilă, M., Rös, E., Miller, D., Povellato, A., 2025. Governance networks for agroecology transitions in rural Europe. *Journal of Rural Studies* 114, 103482. <https://doi.org/10.1016/j.jrurstud.2024.103482>
- Helenius, J., Hagolani-Albov, S.E., Koppelmäki, K., 2020. Co-creating Agroecological Symbioses (AES) for Sustainable Food System Networks. *Front. Sustain. Food Syst.* 4. <https://doi.org/10.3389/fsufs.2020.588715>
- HLPE, 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutritio (No. 14), HLPE Reports. High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Securit, Rome, Italy.
- Lam, D.P.M., Martín-López, B., Wiek, A., Bennett, E.M., Frantzeskaki, N., Horcea-Milcu, A.I., Lang, D.J., 2020. Scaling the impact of sustainability initiatives: a typology of amplification processes. *Urban Transform* 2, 3. <https://doi.org/10.1186/s42854-020-00007-9>
- Lampkin, N., Schwarz, G., Bellon, S., 2020. Policies for agroecology in Europe, building on experiences in France, Germany and the United Kingdom. *Landbauforschung : journal of sustainable and organic agricultural systems* 103–112. <https://doi.org/10.3220/LBF1611684471000>
- Landini, F., Gallardo Lopez, F., Ramirez Valverde, G., Aguilar Calegare, M., Kellen Onofre Dos Santos, D., 2021. How much do extension agents and advisors value agroecology in different countries? Contributions to the understanding of their potential role in scaling up agroecology. *Agroecology and Sustainable Food Systems* 45, 1554–1578. <https://doi.org/10.1080/21683565.2021.1933296>
- Linares Quero, A., Iragui Yoldi, U., Gava, O., Schwarz, G., Povellato, A., Astrain, C., 2022. Assessment of the Common Agricultural Policy 2014–2020 in Supporting Agroecological Transitions: A Comparative Study of 15 Cases across Europe. *Sustainability* 14, 9261. <https://doi.org/10.3390/su14159261>
- Niggli, U., Sonneveld, M., Kummer, S., 2021. Pathways to Advance Agroecology for a Successful Transformation to Sustainable Food Systems.
- Peeters, A., Lefebvre, O., Balogh, L., 2021. A Green Deal for implementing agroecological systems: Reforming the Common Agricultural Policy of the European Union. *Landbauforschung : journal of sustainable and organic agricultural systems* 83–93. <https://doi.org/10.3220/LBF1610123299000>
- Place, F., Niederle, P., Sinclair, F., Carmona, N.E., Guéneau, S., Gitz, V., Alpha, A., Sabouring, E., Hainzelin, E., 2022. Agroecologically-conductive policies: A review of recent advances and remaining challenges. Center for International Forestry Research (CIFOR). <https://doi.org/10.17528/cifor-icraf/008593>
- Prost, L., Martin, G., Ballot, R., Benoit, M., Bergez, J.-E., Bockstaller, C., Cerf, M., Deytieu, V., Hossard, L., Jeuffroy, M.-H., Leclère, M., Le Bail, M., Le Gal, P.-Y., Loyce, C., Merot, A., Meynard, J.-M., Mignolet, C., Munier-Jolain, N., Novak, S., Parnaudeau, V., Poux, X., Sabatier, R., Salembier, C., Scopel, E., Simon, S., Tchamitchian, M., Toffolini, Q., van der Werf, H., 2023. Key research challenges to supporting farm transitions to agroecology in advanced

- economies. A review. *Agron. Sustain. Dev.* 43, 11. <https://doi.org/10.1007/s13593-022-00855-8>
- Rastorgueva, N., Bassignana, C.F., Angarita, E., Fasso, A., Hassink, J., Goris, M., Schmutz, U., Conroy, J., Dinç, S., Wezel, A., Migliorini, P., 2025. Agroecological Living Labs as entry points for transition towards sustainable food systems: a novel framework for the evaluation of living labs at different scales. *Agroecology and Sustainable Food Systems* 0, 1–34. <https://doi.org/10.1080/21683565.2025.2477215>
- Rega, C., Thompson, B., Niedermayr, A., Desjeux, Y., Kantelhardt, J., D'Alberto, R., Gouta, P., Konstantidelli, V., Schaller, L., Latruffe, L., Paracchini, M.L., 2022. Uptake of Ecological Farming Practices by EU Farms: A Pan-European Typology. *EuroChoices* 21, 64–71. <https://doi.org/10.1111/1746-692X.12368>
- Runhaar, H., 2021. Four critical conditions for agroecological transitions in Europe. *International Journal of Agricultural Sustainability* 19, 227–233. <https://doi.org/10.1080/14735903.2021.1906055>
- Salliou, N., Muradian, R., Barnaud, C., 2019. Governance of Ecosystem Services in Agroecology: When Coordination is Needed but Difficult to Achieve. *Sustainability* 11, 1158. <https://doi.org/10.3390/su11041158>
- Sanderson Bellamy, A., Ioris, A.A.R., 2017. Addressing the Knowledge Gaps in Agroecology and Identifying Guiding Principles for Transforming Conventional Agri-Food Systems. *Sustainability* 9, 330. <https://doi.org/10.3390/su9030330>
- Schoonhoven, Y., and Runhaar, H., 2018. Conditions for the adoption of agro-ecological farming practices: a holistic framework illustrated with the case of almond farming in Andalusia. *International Journal of Agricultural Sustainability* 16, 442–454. <https://doi.org/10.1080/14735903.2018.1537664>
- Schwarz, G., Vanni, F., Miller, D., Helin, J., Pražan, J., Albanito, F., Fratila, M., Galioto, F., Gava, O., Irvine, K., Landert, J., Quero, A.L., Mayer, A., Monteleone, D., Muller, A., Rös, E., Smyrniotopoulou, A., Vincent, A., Vlahos, G., Zilāns, A., 2022. Exploring Sustainability Implications of Transitions to Agroecology: a Transdisciplinary Perspective. *EuroChoices* 21, 37–47. <https://doi.org/10.1111/1746-692X.12377>
- Sirdey, N., Scopel, E., Ferrier, G., Khann, L., Ermolli, M., Paracchini, M.L., 2023. Mapping the contribution of agroecological transitions to the sustainability of food systems [WWW Document]. JRC Publications Repository. <https://doi.org/10.2760/171903>
- Stone, T. F., Alami, S., Bach, J. L., Bindelle, J., Busse, M., Ciaccia, C., ... Berg, T. R. (2026). Agroecology Living Labs to transform food systems: a critical review at the science-policy-society nexus in Europe. *Agroecology and Sustainable Food Systems*, 50(6), 1271–1312. <https://doi.org/10.1080/21683565.2025.2560915>
- Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., Rivera, M., Chebach, T., Ashkenazy, A., 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *J Rural Stud* 59, 232–241. <https://doi.org/10.1016/j.jrurstud.2017.01.020>
- Tataridas, A., and Freitas, H., 2024. The path forward: integrating agroecology into global policy frameworks. *Agroecology and Sustainable Food Systems* 48, 924–933. <https://doi.org/10.1080/21683565.2024.2343045>
- Teixeira, H.M., Van den Berg, L., Cardoso, I.M., Vermue, A.J., Bianchi, F.J.J.A., Peña-Claros, M., Tiftonell, P., 2018. Understanding Farm Diversity to Promote Agroecological Transitions. *Sustainability* 10, 4337. <https://doi.org/10.3390/su10124337>
- Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., David, C., 2009. Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development* 29, 503–515. <https://doi.org/10.1051/agro/2009004>
- Williams, T.G., Bürgi, M., Debonne, N., Diogo, V., Helfenstein, J., Levers, C., Mohr, F., Stratton, A.E., Verburg, P.H., 2024. Mapping lock-ins and enabling environments for agri-food sustainability transitions in Europe. *Sustain Sci* 19, 1221–1242. <https://doi.org/10.1007/s11625-024-01480-y>
- Zawalińska, K., Smyrniotopoulou, A., Balazs, K., Böhm, M., Chitea, M., Florian, V., Fratila, M., Gradziuk, P., Henderson, S., Irvine, K., Konstantidelli, V., Krupin, V., Latruffe, L., Mikšytė, E., Miller, D., Monteleone, D., Polaschegg, M., Schwarz, G., Tzanopoulos, J., Tzouramani, I., Vlahos, G., Wojciechowska, A., 2022. Advancing the Contributions of European Stakeholders in Farming Systems to Transitions to Agroecology. *EuroChoices* 21, 50–63. <https://doi.org/10.1111/1746-692X.12378>

ANNEX

Table A1. Policy ranking based on multi-criteria analysis' single score after aggregation.

Transition goal	Policy area	N. obs	Avg	Median	Min	Max
Adoption	Agri-environment payments	70	3.0	3.2	0	5
	Certification schemes	19	3.3	3.4	1.9	4.5
	Context-specific and cross-cutting	58	3.5	3.5	0.1	5
	Food policies	24	2.6	3.0	0	4.2
	Income and market support	20	2.9	3.0	0	4.8
	Knowledge promotion	50	3.6	3.6	2	5
	Networking/Cooperation	40	3.3	3.3	1.3	5
	Payments for investments	56	3.6	3.7	1.5	5
Positioning	Agri-environment payments	69	3.3	3.3	1.3	4.9
	Certification schemes	13	3.0	3	0.5	5
	Context-specific and cross-cutting	60	2.4	2.8	0	4.3
	Food policies	114	3.3	3.6	0	5
	Income and market support	86	3.2	3.3	0	5
	Knowledge promotion	57	3.5	3.7	0	5
	Networking/Cooperation	49	3.3	3.3	1.5	4.7
	Payments for investments	51	3.4	3.6	1.9	5
Amplification	Agri-environment payments	94	3.3	3.6	0	5
	Certification schemes	25	3.2	3.4	0	4.7
	Context-specific and cross-cutting	16	3.7	3.8	2.3	5
	Food policies	57	1.6	0	0	4.9
	Income and market support	37	3.4	3.4	1.8	4.8
	Knowledge promotion	59	3.6	3.6	2.6	4.6
	Networking/Cooperation	74	3.7	3.9	1	5
	Payments for investments	70	3.3	3.2	1.6	5



Citation: Giannecchini, A., Baldi, L., Donati, M. & Arfini, F. (2026). How milk quotas and the CAP affect GI Systems: The case of Parmigiano Reggiano PDO. *Bio-based and Applied Economics* 15(3): 13-27. doi: 10.36253/bae-18285

Received: July 23, 2025

Accepted: December 10, 2025

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Fabio Bartolini
Associated Editor: Luigi Biagini

ORCID

AG: 0009-0005-2538-8245
LB: 0000-0002-7505-1174
MD: 0000-0002-3957-842X
FA: 0000-0002-5179-2541

How milk quotas and the CAP affect GI Systems: The case of Parmigiano Reggiano PDO

ALBERTO GIANNECCHINI^{1,*}, LISA BALDI², MICHELE DONATI², FILIPPO ARFINI¹

¹ Department of Economics and Management, University of Parma, Italy

² Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy

*Corresponding author. E-mail: alberto.giannecchini@unipr.it

Abstract. This article investigates the application of the milk quota system to Geographical Indications (GIs), using the Parmigiano Reggiano PDO cheese as a case study. Firstly, an overview on the empirical context focuses on the evolution of the cheese production under the rules set by the GI-Group. Afterwards, an ex-ante analysis evaluates the impacts of the milk quota rules under the CAP 2023-2027 scheme on the Parmigiano Reggiano PDO production system. The latter assessment is addressed through an Agent-Based Model based on the Positive Mathematical Programming approach. The results indicate that the quota system leads to a concentration of production in larger dairy farms, with environmental and social effects that negatively impact the sustainable rural development model advocated by the Common Agricultural Policy.

Keywords: agent-based modeling, positive mathematical programming, agricultural policy, milk quota, geographical indication.

1. INTRODUCTION

In 1984, the European Union (EU) introduced the milk quotas regime to curb the overproduction of milk, which had placed a large financial strain on the European Agricultural Guarantee Fund (Petit, 1987). This policy represented one of the most controversial decisions in the Common Agricultural Policy (CAP 2023-2027), and it has contributed to justify the later reforms (Barbero *et al.*, 1984; Oskam *et al.*, 2010). EU milk quotas were gradually loosened until their final abolishment starting from April 1, 2015, in order to give farmers a higher flexibility in responding to the growing demand for milk and dairy products in the European market (Jongeneel *et al.*, 2023). This policy decision made the EU dairy sector more competitive by increasing exports, but it also introduced additional volatility in milk prices and, consequently, in farmers' incomes. However, this provision didn't completely eliminate production quotas, but a new scheme tailored to Geographical

Indication (GI) production groups was created instead. More precisely, for GI dairy products (e.g. Parmigiano Reggiano, Comté, Roquefort) there was no continuation of the old EU quotas, but many GI Groups and Producer Organizations introduced their own private or collective supply management rules (sometimes called self-regulation or consortium-based production controls). Differently from the old centralized system, these schemes constitute consortium-agreed market regulation measures or planning mechanisms to balance supply with demand, maintain quality, and stabilize prices.

This article aims to offer a novel contribute to the existing literature by addressing milk quotas under the modified policy framework concerning GI products, specifically with reference to the Parmigiano Reggiano (PR) PDO cheese value chain, which was chosen because of its high economic relevance at regional level (the area of production represents 18% of all the milk produced in Italy (CLAL, 2025a) and the availability of rich and updated data. The importance of this type of case study is supported by Donati *et al.* (2020), who demonstrated that GI products make a significantly higher contribution to the local economy compared to their standard counterparts.

The assessment of the quota policy is elaborated by employing an Agent-Based modelling approach which allows to evaluate comprehensively the three dimensions of sustainability: i) the economic performance, assessed through the gross margin generation, ii) the social impacts (referred to the effects on less profitable activities, *i.e.* the structural changes in the production system), and iii) the environmental outcomes in terms of greenhouse gases emissions. The objective is to answer to the following research question: how do milk quotas affect the sustainability of the PR PDO rural system? Different simulation scenarios will be compared to assess whether the scheme has positive or negative impacts and to identify potential trade-offs across the aforementioned dimensions. To make the analysis closer to reality, it also includes one of the CAP 2023-2027 greening measures, so that the results will account for environmental constraints and European subsidies too, likewise in the real market, where farmers not only must respect the rules established by their own GI Consortium with regard to inputs and processes, but they are also subject to the greening constraints that affect productive structures, costs, and revenues.

The paper is structured as follows: Section 2 focuses on the legislative background and relevant literature, and the description of the evolution of the PR PDO quota system according to the rules of the PR-GI Group. Section 3 describes the methodology of the Agent-Based

model. Section 4 presents the results, while Section 5 discusses them and draws the conclusions of the study.

2. CONTEXTUAL BACKGROUND

2.1. The legislative framework

The removal of milk quotas was performed gradually to avoid market setbacks. A significant milestone is represented by the Regulation (EU) 261/2012 on contractual relationships in the milk and dairy sector, that sought to prepare the dairy market for the new context following the CAP 2023-2027 shift from the enforcement of direct market instruments to indirect interventions with the objective of stabilizing agricultural prices and ensuring stable incomes for farmers (Pieri and Rama, 2017; Chiodini, 2016). Specifically, the abolishment of milk quotas in 2015 was first announced in the Regulation (EU) 72/2009, whereas Regulation 8, which at the same time deferred a discussion on the consequences of this decision for PDO cheese producers (Art. 4, Amendment 36 to Regulation (EC) 1234/2007). The Regulation (EU) 261/2012, Article 17, stated that Member States should be authorized to establish production control measures for GI cheeses, because of their importance (especially for vulnerable areas) and to guarantee their quality and value added. The Italian Government applied this provision through the Decree of 12 October 2012 (Art. 5, par. 1), which recognizes the GI Producer Groups' Authority to regulate their cheese supply and establish the procedures and conditions for submitting production control plans.

After these reforms, the current EU no longer enforces quotas on milk and dairy products, thus granting Producers Organizations (POs), Interbranch Organizations (IOs), and other groups (as defined under the Regulation (EU) 1151/2012) the freedom to autonomously regulate production based on their specific performances and characteristics. The Regulation (EU) 261/2012 was issued in connection with the Regulation (EU) 1151/2012 (repealed by the Regulation (EU) 1143/2024), establishing the GI system (Protected Designation of Origin, Protected Geographical Indication, and Traditional Specialty Guaranteed, commonly referred to as PDOs, PGIs, and TSGs) to ensure fair remuneration for producers, consistent protection of product names across the EU, and clear consumer information regarding the characteristics that enhance the value of GI products (Regulation (EU) 1151/2012, Art. 4). The latter Regulation also defined POs and IOs as entities responsible for ensuring product quality, reputation, and legal protection, as well as promoting value-

added attributes (Regulation (EU) 1151/2012, Art. 45). However, the innovative provisions of this policy framework, intended to enhance market efficiency, appeared to be incomplete as they did not permit all GIs to adjust supply in response to changing market demand. Notably, only GIs in dairy, fruit, and vegetable sectors were authorized to manage production volumes (Regulations (EU) 261/2012 and (EC) 1234/2007). Only recently, the Regulation (EU) 1143/2024 expanded this right to almost all food products recognized as GIs (Art. 33, par. 3, let. c).

Such regulatory framework causes the coexistence of two parallel production systems: the non-GI market, where milk is traded without constraints, and the GI market, where it can be indirectly regulated by imposing a threshold on the final product volumes. In other words, the aforementioned evolution finally led to a surreptitious reintroduction of the abolished system of milk quotas, which is intended to secure higher prices for producers, but that also establishes a system of asset capitalization in milk production, thus transforming it into an exclusive right that generates barriers to entry and rent-seeking effects. However, unlike the previous quotas regime, the current policy is markedly different as each GI Group can adopt a tailored scheme for the governed PDO/PGI. Regarding the Italian context, the two most reputable “PDO grana cheeses” (Parmigiano Reggiano and Grana Padano PDO) have two different quota systems: the rules of Parmigiano Reggiano PDO assign the milk quotas to farmers in the form of milk volumes (tons), while the rules for Grana

Padano PDO assign the quotas to dairies in the number of cheese wheels (Dongo, 2022; PRG, 2014). As highlighted by Pieri and Rama (2017) and Carletti and Giangiulio (1998), the system governing the allocation of production rights exhibited rent-seeking dynamics that facilitated the concentration of milk production among larger farms, with significant implications for both rural development and farm management. In terms of rural development, the monetization of quotas by farmers who exited the sector altered the regional development trajectory by removing smaller producers from the supply chain. From a farm management perspective, the consolidation of production among remaining dairy farms often necessitated the assumption of debt, thereby exacerbating financial and operational pressures. This, in turn, undermined the competitiveness and resilience of these farms. The Parmigiano Reggiano Cheese Consortium indicates a growing proportion of farms experiencing economic losses between 2019 and 2023, a trend partly attributable to the inherent complexity of implementing effective management control systems in agri-

culture, which constrains operational efficiency (Campiotti, 2024).

2.2. Impacts of milk quotas in Europe: evidence from the literature

There is an extensive stream of literature analyzing the effects of milk quotas both at national and regional levels in the EU context, but it only addresses the old European regime, especially regarding the potential implications of its abolition. Before delving into the discussion, it is essential to emphasize that the present study will refer to two distinct types of “efficiency”: i) economic efficiency (or profitability), which is the ability to maximize profits and thereby generate a higher gross margin, and ii) productive efficiency (or productivity), understood as the ability to produce a greater amount of output given the same input level.

With respect to the policy outcomes, the article by Corbett (1992) argues that the quota scheme discouraged production efficiency and competitiveness, led to market polarization (large producers becoming larger and small farms increasing in number), and caused a stagnation of the dairy industry across the whole European level. However, Baldock *et al.* (2008) highlighted how milk quotas had a positive impact on maintaining production in Italian Less Favored Areas (LFAs), primarily through the redistribution of unused quotas, thus mitigating the ongoing phenomenon of concentration of production from mountainous LFAs to more profitable farms (registered from 1995 to 2004); this came with positive environmental effects, as the maintenance of agricultural activities in less productive, marginal regions is essential for the preservation of soil, biodiversity, and landscape.

Regarding the scenarios of quotas abolition, Lips and Rieder (2005) estimated how milk output and price would have changed in the EU at the country level. In particular, it was found through a Computable General Equilibrium model that raw milk prices decreased on average by 22% and those of dairy products by 12.6%, in response to modest average output increases of 2.9% and 1.8%, respectively. This led to the conclusion that the removal of quotas would have overall minor effects on the European milk production, even though the output changes are heterogeneous for each country. Baptiste *et al.* (2012), using a bioeconomic model based on Positive Mathematical Programming, found that, without quotas, milk production in Western France is expected to increase and to concentrate in more competitive regions, thus altering the geographical distribution of supply. The predictions presented in the study

by Markus *et al.* (2011) for the removal of quotas, made through the CAPRI model, indicate an overall increase in milk production by 4.4% and a reduction in price by 1.6%, while agricultural income is expected to register a total loss of 2% (nearly 4.7 billion €). As dairy herds are simulated to increase, nitrogen emissions are estimated to grow accordingly, even though the increase is relatively moderate (0.66-1.41%). On the other hand, no considerable changes in arable land use were found. Boere *et al.* (2015) focused on farm dynamics in terms of land use changes in the Netherlands. Their results show that quotas hamper land expansion for milk production, which becomes faster towards the time period in which they are removed, while land decreases are faster in the presence of quotas because they can be sold (thus making it easier for farms to exit dairy farming). Moreover, the model adds to the analysis various socio-economic characteristics of farm holders: a higher education is correlated with more substantial marginal changes in both increases and decreases of land, having successors makes land expansion faster and its reduction slower, full-time labor involvement reduces land changes, and older farm operators are less inclined to alter land use too. More recently, Philippidis and Waschik (2019) applied the monopolistic Melitz model to simulate the changes in the EU milk market from 2020 to 2030 in two scenarios: the baseline, where quotas remain, and the abolition case. The authors found that in the baseline, under the hypothesis of perfect competition, milk prices are expected to increase on average by 31.9 index points by 2030, and dairy prices, due to price transmission effects, by 11.5 index points; meanwhile, downstream dairy production remains static. When quotas are removed, both milk and dairy prices fall (respectively by 39.1 and 10.9 index points) while production volumes grow (more or less markedly depending on the country). An imperfect competition experiment reveals similar results, but it gives additional information about the supply-chain structure, where a “shake-out” of small farms occur as production concentrates into fewer, larger farms. Madau *et al.* (2017) and Bórawski *et al.* (2020) found that the removal of milk quotas fostered the expansion of production, higher efficiency in the use of inputs, and an increase of milk yields. The same phenomenon was confirmed by Náglova *et al.* (2021), who presented several cases in Northern Europe where the abolition of quotas was correlated with greater milk productive efficiency; notably, EU milk production grew steadily between 2014 and 2018, while experiencing a reduction of about 900,000 cows in 22 EU countries (particularly in Germany, France, and Italy). From the environmental point of view, Läßle *et al.* (2022) found that the absence of milk quotas promotes increased green-

house gases (GHG) and nitrogen emissions, exacerbating environmental degradation and contributing to climate change; conversely, quotas can help limit GHG emissions but may lead to the concentration of nitrate production on larger farms.

3. THE EX-ANTE ASSESSMENT OF THE MILK QUOTA SYSTEM

To address the research questions stated in Section 1, the study enhances the farm-based model AGRISP (*Agricultural Regional Integrated Simulation Package*) to analyze the following aspects: i) how trading quotas impact farmers’ economic performance, ii) to what extent this policy favors or hampers marginal farms, and iii) what are the environmental effects in terms of CO₂ emissions.

3.1. The evolution of the milk quotas system for Parmigiano Reggiano PDO

The area of production (breeding, milking, and feeding) established by the Product Specification of the Parmigiano Reggiano PDO Group (PRG), considered in this analysis, is strictly limited to the provinces (NUTS 3 level) of Parma, Reggio-Emilia, Modena, Bologna, and Mantua (PRG, 2025a). The regulation of milk production by a quota system was first introduced in 2014 to align milk supply and demand, ensuring that overproduction did not result in price reductions, thus destabilizing farmers’ incomes. Other objectives, aligned with the Regulation (EU) 1308/2013, include the support to vulnerable areas, quality assurance, and the strengthening of producers’ bargaining power (PRG, 2014). The PRG effectively maintained the milk price above that in the non-GI market (Figure S.1). The PR Production Plan (PRG, 2014) defines the supply control mechanisms. At the start of every year, the PRG determines a total equilibrium production level and assigns each farmer a milk quota proportional to its production capacity. Milk produced beyond this quota does not lose its suitability for transformation into PR cheese but, if total output surpasses the equilibrium level by year-end, farmers must pay a contribution proportional to their excess.

The Production Plan defines quotas as “intangible assets”, meaning that they can also be sold or rented to other farmers; to safeguard farmers producing in LFAs, the quotas located in mountain areas cannot be bought by farmers in plain or hill areas, and vice versa. Moreover, a discount on additional contributions is applied for mountain farms.

Detailed information on the characteristics of farmers supplying milk for PR cheese production is provided in the Supplementary Materials. At the macro level, PR cheese production steadily grew from 3,298,000 wheels in 2014 to 4,079,000 in 2024, at an average annual rate of 1.6% (CLAL, 2025a). Conversely, active farms decreased from 3,186 in 2014 to 2,606 in 2020, with a 27% reduction in farms below 800 tons/year of production and a 19% increase in farms above 800 tons/year (PRG, 2022). According to Deserti and Bertolini (2021), this occurred because elderly farmers were unable to keep up with innovations and closed their operations, with the allocation of milk quotas accelerating this trend. Indeed, quotas were transferred from minor to more extensive, competitive dairy farms. Bertolini and Giovannetti (2020) explained how farmers' innovations increased milk protein content, resulting in better curdling yield, as between 2015 and 2018, the milk needed to produce one cheese wheel was reduced by 5.4%. While a single cow produced, on average, 14 forms/year in 2005, production per cow had increased to 18.5 forms/year by 2021 (PRG, 2023). The quota scheme has a substantial impact, as the production threshold has been exceeded increasingly over the years, thereby burdening farmers with growing contributions to be paid (Figure S.2). While the additional contribution for surplus production increased, the volumes of exchanged quotas decreased over the years (Figure S.3).

Finally, the elasticity of produced milk with respect to the assigned quotas is almost unitary. In contrast, the price elasticity is lower, suggesting that farmers adjust production more reactively to quotas than to price (Table S.1).

The quota scheme has contributed to the renewal of the PR system by concentrating production towards farms with higher capacity and productivity, which represents a relevant structural change in the supply chain. This process occurred despite quota purchases (or leases) and contribution payments, which certainly had an impact on the economic and financial management of farms. Although quotas are not binding, resulting in milk production consistently exceeding the equilibrium threshold, the price guarantee associated with them, coupled with the PRG promotional activity, allowed PR producers to invest in their businesses.

3.2. Data

The sample counts 79 farms covering the PR cheese production area, extracted from the national Italian 2023 FADN-RICA database and restricted to those specialized in milk production (identified by the farm-type code

Table 1. Structure of the sample: # of dairy farms.

Province	< 10 ha	11 - 20 ha	21 - 50 ha	51 - 100 ha	Total
Parma	7	6	4	1	18
Bologna	2	0	1	0	3
Modena	1	2	7	1	11
Reggio-Emilia	5	4	10	0	19
Mantua	8	9	10	1	28
Total	23	21	32	3	79

Source: RICA database (2023).

"450"). Further details on the dataset are provided in Table 1. The FADN database, through the RICA at the Italian level, provides data at the individual farm level including detailed information on land utilization, subsidies paid to farmers, crops prices, and family structure of farms.

It is assumed that farmers maximize their gross margin (GM) subject to constraints related to environmental practices and production quotas, as described in the next paragraph. A comparative statics approach is used: different equilibrium points are compared based on data from a single year and that all agents are simulated simultaneously. In particular, the granularity of the data allows to simulate the exchange of quotas and land, as less efficient farms in terms of GM transfer their quotas to more efficient agents, consequently also changing their sizes (if production levels decrease, the non-utilized land will also be transferred). While economic and sociodemographic data can be directly extracted from the RICA for each farm, additional metrics to measure the emission levels and estimate environmental outcomes are needed. Specifically, nitrogen emissions produced by cows are based on data provided by the national Regulation 15/12/2017 of the Emilia-Romagna Region, which considers 82.8 kg of NO_2 (nitrogen dioxide) per dairy cow and 36.0 kg of NO_2 per rebreeding cow. The amount of emitted CO_2 (carbon dioxide) is also computed for each activity by following the IPCC (Intergovernmental Panel on Climate Change) guidelines (IPCC, 2008; Solazzo *et al.*, 2016); the respective values per hectare of production are showed in Table 2.

3.3. The model

AGRISP is an Agent-Based Model (ABM) based on Positive Mathematical Programming (PMP), built in GAMS (*General Algebraic Modeling System*)¹, introduced

¹ GAMS is a software used for mathematical programming capable of solving large-scale linear, nonlinear, and mixed-integer optimization problems through computer code.

Table 2. Tons of CO₂ emissions per hectare.

Cereals		Animal feed		Industrial crops		Dairy milk	
durum wheat	1.33	alfalfa	0.50	beetroot	1.45	milk	5.50
soft wheat	1.55	protein crops	1.04	potato	2.27		
sorghum	1.33	pastures	2.24	tomato	2.24		
rice	8.50	other forages	0.67	soja	0.81		
barley	0.99			oleaginous	0.82		
other cereals	1.33			sunflower	0.82		
				maize	3.52		
				vegetables	2.21		

Source: own computations on IPCC guidelines and FADN data, as in Baldi et al. (2023).

by Arfini *et al.* (2005) and further developed over the years to include a more detailed representation of farm relationships (Arfini *et al.*, 2011; Gigante *et al.*, 2014), environmental metrics, including CO₂ emissions and water consumption (Donati *et al.*, 2013), and policy scenarios, such as the CAP 2023-2027 greening measures (Sollazzo *et al.*, 2014; Baldi *et al.*, 2024).

The approach underlying the AGRISP model is based on the three elements listed here:

1. development of individual cost functions to address farmers' heterogeneity;
2. calibration for each farm reproducing their observed activity levels using the so called "self-selection", a rule representing the agents' willingness to adopt the activities that satisfy their strategy while being aware of all those available (Paris and Arfini, 2000);
3. introduction of ABM rules to simulate the exchange of resources (here the production quotas) by using the common cost function matrix, which provides farmers with the information on those activities not included in their production plan but that could be adopted.

The general objective function to be maximized is defined as follows:

$$max_{GM} = \sum_j (p_{n,j} x_{n,j}) - \frac{1}{2} \sum_j (x'_{n,j} \widehat{Q}_{n,j} x_{n,j} + \hat{u}_{n,j} x_{n,j}) \quad (1)$$

subject to:

$$A_n X_n \leq b_n \quad (2)$$

where p represents the market prices for each activity j and farm n , and x is the vector of production levels. Q constitutes the non-linear part of the PMP equation; it is a symmetric positive semi-definite matrix, ensured through the Cholesky factorization, while u is the vector of marginal cost deviations per farm with respect to the frontier cost function Qx . In equation 2, A is the matrix

of technical coefficients of limiting production factors (here constituted by land), and b is the vector of their availability. A limitation of the model lies in the $x'Qx$ matrix as, due to computational constraints, the many activities practiced by the agents have to be aggregated into macro-categories (for instance, single crop species are grouped into broader classifications such as "cereals", "oilseeds", and so on); while this reduces the dimensions of the matrix, it may slightly hamper the model accuracy.

Two groups of constraints (equations 3-4, where λ is the vector of differential marginal costs) are introduced to implement the 'self-selection' process, providing the necessary structure to represent farmers' production decisions. This mechanism not only enables the model to distinguish between activated and non-activated practices, but also extends beyond basic PMP by allowing the simulation of farmers' potential access to all available production activities and their choice of those that are most economically convenient from the full set of available options.

$$mc_{n,k}|x_k > 0 : \bar{\lambda}_{n,k} + \bar{c}_{n,k} = Q_k x_n + u_{n,k}, k = 1, \dots, j_n \quad (3)$$

$$mc_{n,k}|x_k = 0 : \bar{\lambda}_k + \bar{c}_k \leq Q_k x_n + u_{n,k}, k = 1, \dots, j - j_n \quad (4)$$

The first constraint (equation 3) implies that realized productions have a marginal cost (mc) equal to that of all the existing productions j across the frontier. The second one (equation 4) regards the estimation for non-activated productions, based on the relation $mc(x) \equiv \bar{\lambda} + \bar{c} = Q\bar{x}$, where the common element of the cost function for all farms is obtained from the average marginal cost observed in the sample (Arfini *et al.*, 2005). The parameters of the costs matrix Q are estimated through the Maximum Entropy approach, which consists in maximizing the level of uncertainty relative to the probability distribution of each element of the matrix, as explained in detailed in Paris and Howitt (1998). Differently from

other methods, like the Least Squares, the Maximum Entropy can be used when variable costs are known - as in this case - and is more consistent with the “inertia” characterizing economic decisions in agricultural businesses (Paris and Howitt, 1998). The ABM is strongly based on this estimation, as the willingness of agents to exchange resources among them depends on their specific marginal costs.

In AGRISP, dairy production relies on the following assumptions: i) milk price covers the costs of production (equation 5) and ii) the livestock is linked to the available land through the produced fodder crops (equation 6, where y is the feed required per unit of milk).

$$p_{n,milkxn,milk} \leq c_{n,milkxn,milk} \quad (5)$$

$$y_{n,fodderxn,milk} - x_{n,fodder} \leq 0 \quad (6)$$

The market price for fodder crops is set equal to 0 as it is assumed that farmers do not sell it, but reuse it entirely for milk production; feed includes pastures, alfalfa, and other forages, while silage maize is excluded as it is prohibited from the PR cheese product specification (PRG, 2025a).

To regulate the mechanisms of quota exchange, the following ABM constraints are developed in GAMS. Firstly, each farmer has the option to either sell or buy production quotas but, as established in the PR Production Plan to protect activities in marginal areas (PRG, 2014), only farmers in the same agrarian regions can interact among them (*i.e.*, quotas in mountain areas cannot be sold to plain and hill areas, and vice-versa). The price of quotas is exogenous and fixed at the average level observed in 2022, which is equal to 130 €/ton (PRG, 2025b). In particular:

$$\sum_j x_{n,milk} \leq \bar{x}_{n,milk} + Z_n - V_n \quad \forall n \quad (7)$$

$$\sum_n Z_n - \sum_n V_n = 0 \quad \forall n \quad (8)$$

where it is ensured that the total produced milk ($\sum x_{n,milk}$) does not exceed the initial level of production $\bar{x}$ plus the rented quotas Z_n and minus the sold quotas V_n . Equation 8 ensures that the exchange of quotas is consistent with the available level. To avoid that farmers sell and buy quotas at the same time, the following control point for each agent is introduced:

$$Z_n V_n = 0 \quad (9)$$

meaning that either Z_n , V_n , or both must be equal to zero for each farm, and therefore situations where both have

values different from 0 are avoided. Finally, the following constraints are introduced to trace transfers for each pair of farms:

$$Z_n = \sum_m Z_{n,m} \quad \forall n \quad (10)$$

$$V_m = \sum_n V_{n,m} \quad \forall m \quad (11)$$

$$Z_{n,m} - V_{n,m} = 0 \quad \forall n \forall m \quad (12)$$

where $Z_{n,m}$ and $V_{n,m}$ are the matrices for pairs of farms n and m respectively buying and selling quotas. Specifically, equation 12 ensures that the quotas bought buy one farm are equal to those sold by the other farm. Finally, it is assumed that farmers older than 65 and with no successors do not participate in the trading of quotas and receive a pension equal to 12,000 €. In fact, it is reasonable to assume that older conductors with no future perspectives for their activity would be less inclined to make investments and significantly change the structure of their farm; this tendency is also confirmed by the analysis of Boere *et al.* (2015) (Section 2). When a farm reduces its production or exits the market (because production levels become zero), its land has to be transferred to another farm in order to keep the total UAA constant in the model. Consequently, constraints analogous to those written for milk quotas are also imposed on the land factor to enable its exchange among agents (Baldi *et al.*, 2023). This relationship is represented as:

$$\sum_j (A_{n,j} x_{n,j}) \leq b_n + R_n - T_n \quad \forall n \quad (13)$$

where R and T are respectively the transferred and acquired hectares of land by each farm, subject to the same control points and behavioral rules as those listed above for quotas. Unlike the quota-related constraints, which are activated only in the scenario simulating the scheme, the land-related ones remain active across all scenarios.

3.3.1. Environmental constraints

In addition to the previous behavioral constraints, also environmental aspects are included in the model. The CAP 2023-2027 greening measures, more specifically the GAEC 7, aims at maintaining soil fertility and biodiversity by encouraging farmers to rotate different crops. In AGRISP, this standard is implemented through requirements on crop diversification and crop rotation on arable land (European Commission, 2013). Crop diversification is developed as follows:

$$S_{n,j} \leq 0.75A \quad (14)$$

$$S_{n,j} + T_{n,j} \leq 0.95A \quad (15)$$

where S is the main crop, which cannot occupy more than 75% of the utilized land if the farm owns more than 10 ha of utilized agricultural area (UAA); in the second constraint, applied to farms with more than 30 ha of UAA, the two main crops (S and T) cannot occupy more than 95% of the surface. These constraints ensure a diversified use of land as stated by the CAP 2023-2027 greening measures.

Crops rotation, which requires changes between botanical groups, is introduced through the following equation:

$$x_{n,alfalfa} + x_{n,proteics} + x_{n,soja} + x_{n,forages} + x_{n,beet} + x_{n,tomato} = x_{n,wheat} + n_{n,maize} + n_{n,barley} + x_{n,sorgum} \quad (16)$$

Since AGRISP is a static, non-recursive model for comparative static analysis, equation 16 simplifies the condition on annual rotation by assuming that the same share of land is used for wheat, legumes and forages. Similar simplifications are also commonly used in dynamic mathematical programming models, where the farm is divided into roughly equal parts and the acreage of each crop is maintained constant, so that crop rotation is treated as a land-share parameter (Cortignani and Dono, 2020). Finally, greenhouse gas emissions are computed for each activity as described in Sollazzo *et al.* (2016), based on the guidelines provided by the regional legislation and the IPCC (Section 3.2).

3.4. Simulation scenarios

The milk quotas scheme is assessed by simulating four policy scenarios, described in Table 3. All simulation scenarios include the CAP 2023-2027 greening constraints and payments, as well as those allowing land transfers, described in Section 3.3. In the following sections, the changes in economic, structural, and environmental performances will be examined by analyzing the outcomes of introducing quotas into a free market (baseline vs. quota_trade), and how farms respond to a price increase under both the free market (baseline vs. baseline_price) and the constrained market (quota_trade vs. quota_trade_price) scenarios. Since AGRISP is a static model, all discussed values are always referred to one year of activity.

Table 3. Simulated policy scenarios.

Name	Description
baseline	No quotas policy is applied, and farmers can produce without production constraints.
baseline_price	An increase in milk price by 7% is applied.
quota_trade	The ABM constraints for the exchange of quotas among farmers are introduced and, therefore, the additional costs and revenues from buying and selling are added to the general equation (1).
quota_trade_price	The scenario quota_trade is modified by setting an increase in milk price by 7%.

4. RESULTS

The simulated impacts of milk quotas are compared with the reference scenario (baseline) and are described in this section. Figure 1 depicts the policy effects on crop production, while Figure 2 presents the changes in milk production.

As expected, the productive structure of farms remains mostly unchanged, as they specialize in milk production and therefore always dedicate most of their land to fodder crops. On the other hand, the policy has more visible impacts on milk production. Compared to the baseline scenario, the implementation of quotas does not limit milk production very effectively.

However, when the milk price rises, production grows less markedly than in the absence of quotas. In particular, production is highly responsive to price in the non-constrained market, as it nearly doubles (Figure 2); even though its elasticity remains more than proportional to price when quotas are imposed, this reaction – previously more uncontrolled – is now dampened (Table 4).

To illustrate the structural effects of the policy, in Figures 3 and 4 the number of farms is categorized by altimetric areas and UAA classes, respectively. The variations in their numbers reflect the activation and deactivation of sample farms as they expand or contract their land. When farmers' production levels fall to zero, they exit the market. The total number of farms is slightly lower when the policy is not enforced. As shown in Figure 3, between baseline and baseline_price, there is a slight increase in farms across all three areas, whereas when milk prices rise due to the policy's effect, there is an incentive to enter the market only for mountain and hill farms. Figure 4 shows that small producers remain mostly stable across the scenarios, while the activity of medium-large farms (21-50 ha) is more strongly promoted when quotas are applied.

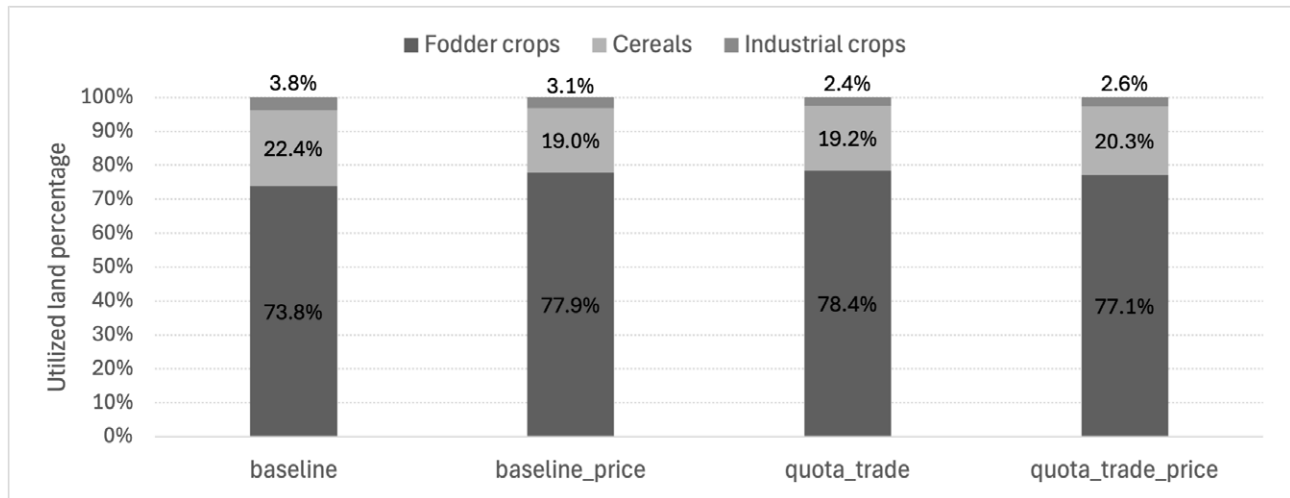


Figure 1. Comparison of changes in land utilization. Source: own elaborations on simulation results.

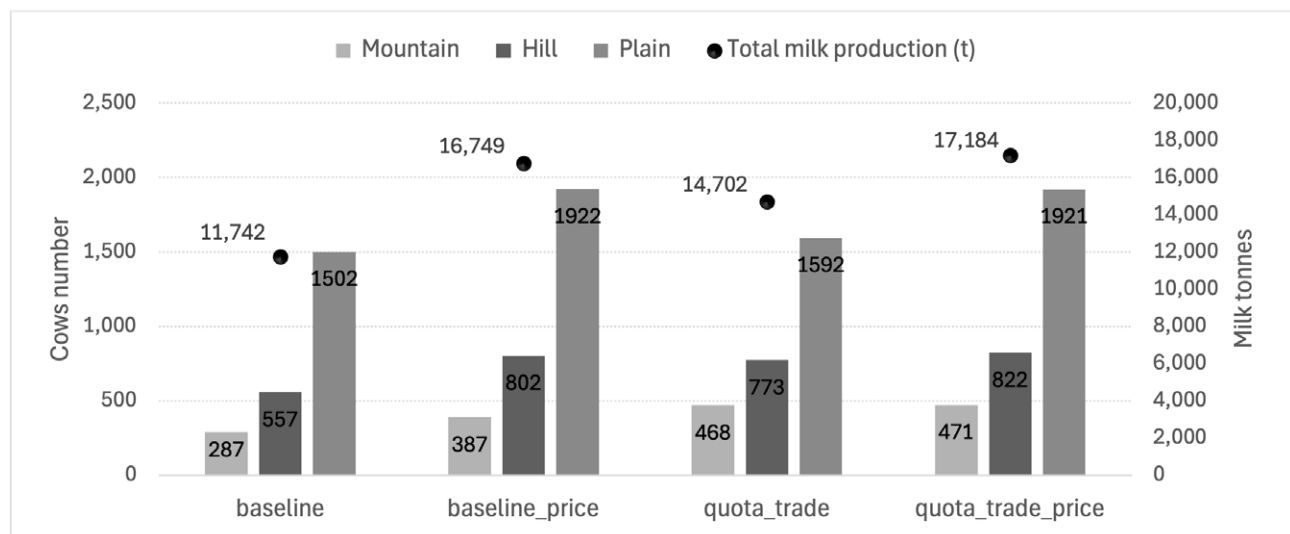


Figure 2. Comparison of changes in milk production. Source: own elaborations on simulation results.

Table 4. Elasticity of milk production to price.

Compared scenarios	Elasticity
baseline vs baseline_price	6.1
quota_trade vs quota_trade_price	2.4

Source: own elaborations on simulation results.

The economic impacts are shown in Figure 5, where the average Gross Saleable Product (GSP) and the Gross Margin (GM) per farm are plotted. While production volumes grow by 14% without quotas and by 4% with them in place, profits increase by 4% and 6%, respec-

tively. In Table 5, farm dimensions and their productivity (average milk production level per cow) are compared. Even though milk production (and consequently the GSP) is higher in the quota_trade scenario than in the baseline, the GM is slightly worse. Conversely, when milk price rises (in quota_trade_price), there is an improvement in quota_trade, but the GM is always lower than in the scenario where price increases without quotas being enforced (baseline_price). On the other hand, Table 5 highlights how in both quota scenarios there are more cows but concentrated in less farms. The quota trading mechanism fosters productivity, albeit not to a

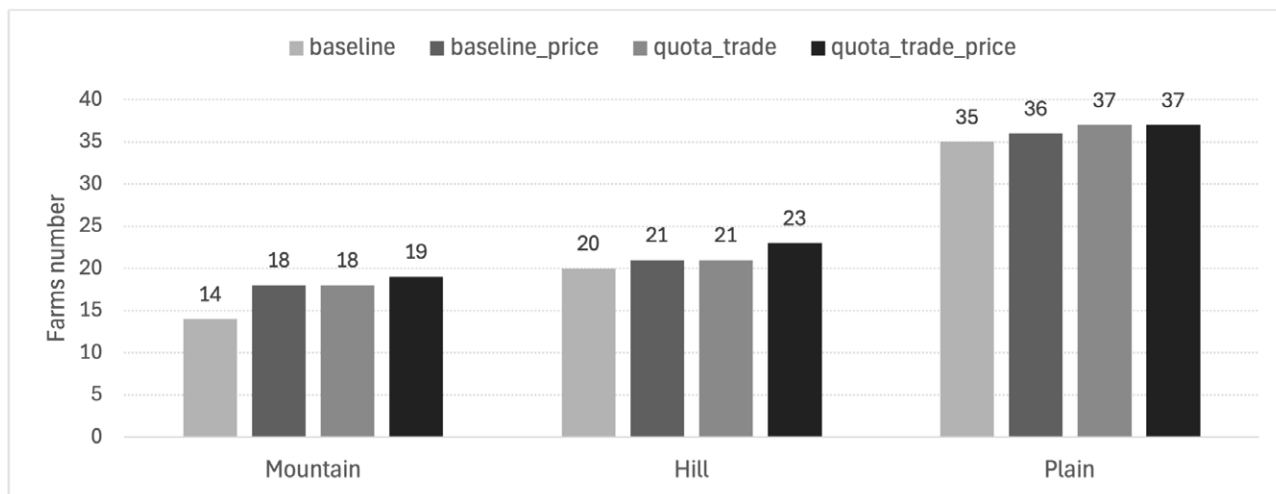


Figure 3. Dynamic number of farms per area and policy scenario. Source: own elaborations on simulation results.

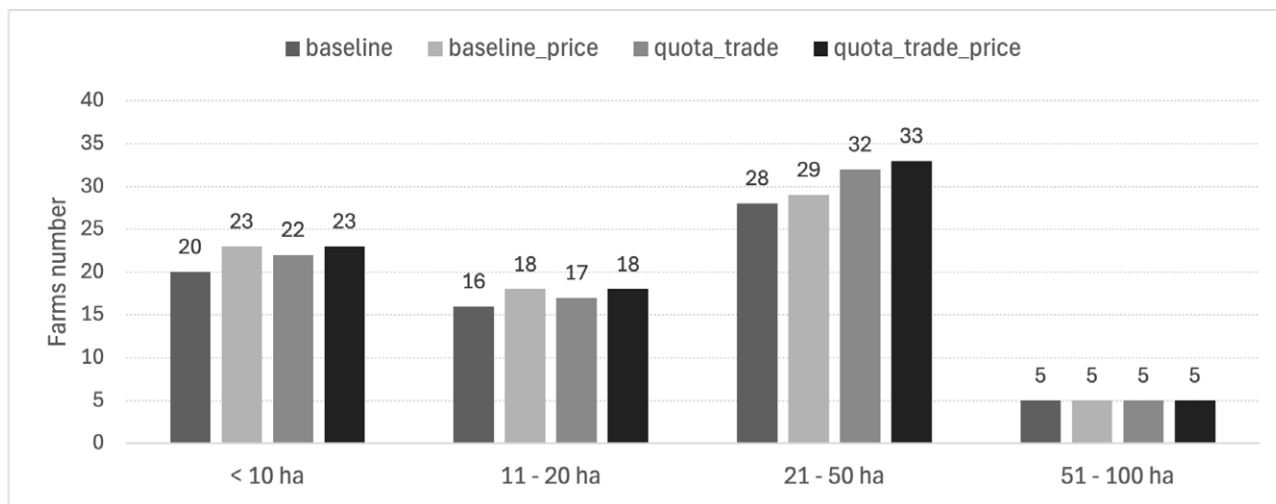


Figure 4. Dynamic number of farms per UAA class and policy scenario. Source: own elaborations on simulation results.

greater extent than the increase in milk price alone, simulated in baseline_price.

Environmental outcomes are displayed in Figure 6. Results show that the policy is not very effective in reducing total greenhouse gases (GHG) emissions. However, when milk price rises, emissions increase by a lower degree than in the absence of quotas.

5. DISCUSSION

After analyzing the key findings on the implementation of the PR production plan, this study aims to evaluate the actual economic, structural, and environmental

impacts of milk supply management under the policy framework implemented by the PRG.

From a policy perspective, the main concern is the establishment of new farm assets associated with the right to produce milk for PR cheese, which expanded farms' production capacity and economic dimensions (Table 5). The quotas policy fostered the conditions for production growth; in fact, it is not strictly binding, but farms can exceed their allocated production threshold and pursue economies of scale by trading milk quotas. In the scenarios, while a higher milk production is incentivized in all areas (mountain, hill, and plain) when quotas are in place, the market becomes much less reactive to price changes (Figure 1 and Table 4). Moreover, this

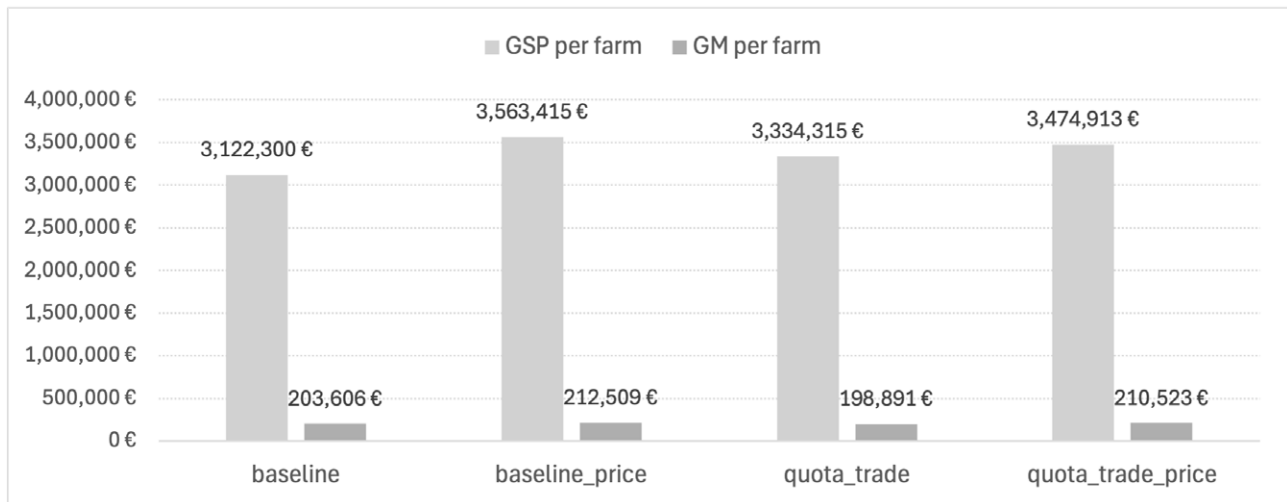


Figure 5. Economic results per policy scenario. Source: own elaborations on simulation results.

Table 5. Farms productivity per policy scenario.

Scenarios	Cows number	Cows per farm	Tons of milk per cow
baseline	2,346	34	5.01
baseline_price	3,111	41	5.38
quota_trade	2,832	37	5.19
quota_trade_price	3,214	41	5.35

Source: own elaborations on simulation results.

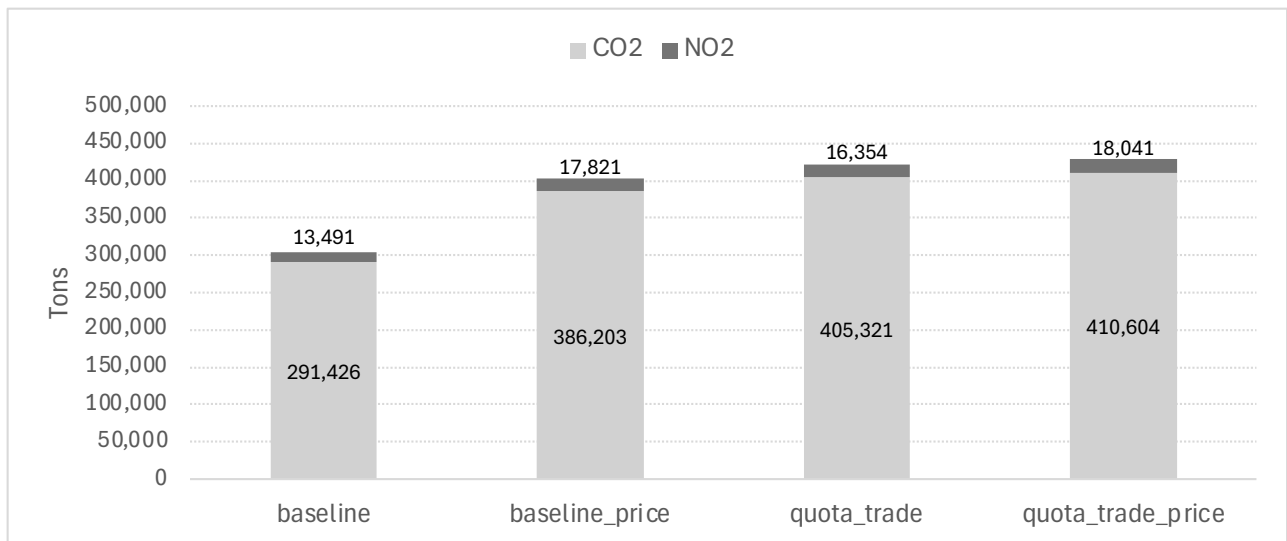


Figure 6. GHG emission levels (CO2 and NO2) per policy scenario. Source: own elaborations on simulation results.

mechanism does not constitute a strong entry barrier, as there are more farms in the market than the baseline scenarios (Figure 2); additionally, the rule establishing

that quotas cannot be traded between different agrarian regions prevents plain and hill farms – characterized by a much higher production capacity – from competing with

mountain farms, thus supporting production and development in such LFAs. However, since quotas represent an additional cost for farmers who want to expand their production, an increase in productivity is not followed by an improved economic efficiency: although farms intensify their production in an attempt to cover their costs (Table 5), thereby also generating a higher GSP, gross margins in absolute terms remain on average lower compared to those generated in the free market (Figure 5). This aligns with Bouamra-Mechemache *et al.* (2008), where it is stated how production quotas are attributable to decreases in farmers' gross margins (which are even stronger when production grows). This means that gains from higher production quantities are not able to fully compensate for investments in quotas, and further price increases would be needed to achieve the same profits. Indeed, in *quota_trade_price* they rise by a slightly greater extent in percentage terms, but the result is still worse than in *baseline_price*. While the existing literature agrees on the positive effects of quotas on profitability, here it is highlighted how, in a supply chain with different and stricter cost structures typical of GI products, enhanced productivity does not necessarily come with better economic results. On the contrary, the expansion of costs generated by the quotas scheme is not offset by the current price premium guaranteed to farmers. Bigger farms, with stronger capital bases, may absorb these costs more easily, while smaller activities might experience sharper constraints, which in the long term could reinforce structural inequalities within the sector. Therefore, even if quotas do not seem to stop farmers from entering the market, they can hamper competitiveness when economic margins are systematically eroded. Indeed, looking at the social dimension, even though both small farms and activities in marginal areas are preserved as they do not exit the market, there is a slight tendency to concentrate production towards larger farms when quotas are traded (Table 5). A limitation of the model lies in the absence of dynamic elements, which prevents us from considering how this dimension would evolve across multiple years. However, the empirical evidence (Tables S.2-S.3) confirms that the concentration observed in the simulations, when comparing the baseline and *quota_trade* scenarios, is bound to become increasingly exacerbated. While this may represent an advantage when it strengthens farmers' ability to invest in more efficient production technologies, it simultaneously undermines social sustainability, as it excludes small farmers from the supply chain – those very actors that GIs are, by definition, meant to support.

At the same time, the policy does not improve the environmental outcomes, since GHG emissions are at the lowest level in the baseline scenario (Figure 6). This

stems from the fact that, as mentioned above, the quotas are not strictly binding and an expansion in land allocated to forage production and livestock is observed, so that environmental impacts are not curbed either. On the other hand, accordingly to the analysis of Baldock *et al.* (2008), the policy as implemented by the PR Consortium is actually effective in preserving marginal mountain areas, which, in an overly competitive context, would otherwise be abandoned with negative consequences for soil and ecosystems. In this regard, the environmental issue is particularly relevant in light of the Art. 7 of Regulation (EU) 1143/2024, allowing GI groups to draft sustainability reports on their production system.

6. CONCLUSIONS OF THE STUDY

From a methodological perspective, the PMP approach is employed to calibrate model parameters and assess production costs, replicating observed practices and outcomes. ABMs complement this approach by enabling the social characterization of individual agents and their interactions within the economic environment through rule-based asset exchanges. The integration of PMP and ABM enables broader, more realistic scenario simulations by accounting for economic and non-economic parameters. The overall result is a more detailed analysis of impacts, ranging from sectoral to regional scales, and an improved understanding of the phenomena observed as individual policy measures vary.

In summary, with respect to the research question stated in the study's introduction, the findings suggest that milk quotas have mixed effects on the sustainability dimensions of the PR cheese rural system, thereby allowing for the evaluation of both the pros and cons of the policy. In particular: i) farmers' profits (economic aspect) are slightly eroded, ii) activities in marginal areas (social aspect) are preserved, but there is a general tendency of polarization towards larger farms, and iii) GHG emission levels (environmental aspect) are not reduced, but the increased number of farms operating in mountain areas has a positive role on the preservation of ecosystems and landscapes.

When drawing conclusions, it has to be acknowledged that PMP and ABMs, like any other economic modelling approach, imply simplifications and assumptions on agents' behaviors and market dynamics. In the first place, even though the behavioral assumptions are realistic and supported by the literature, they remain quite simplistic with respect to reality; the decision on whether to participate or not in quotas investments may depend not only on age and future business prospects,

but also on risk aversion, “myopic” or long term planning, access to market information, and volatility of milk price. However, such data cannot be incorporated into the model because it is not currently available in either national or regional databases. Thus, future research may improve the model by enriching it with additional elements from behavioral economics theories. Further studies may also focus on creating recursive structures capable of modelling individual agents for several years, with the aim of studying the evolution of the system at a high level of detail over time.

As a closing remark, the supply control system for EU GIs is a significant tool for safeguarding farmers’ incomes; nevertheless, its application extends beyond PDO and PGI systems’ management, influencing rural development dynamics toward selecting commercial activities based on market competitiveness and impacting the relationship between agriculture and the environment. Therefore, it is crucial to understand the effects of these supply chain management tools and transform them into effective tools for production, social and environmental planning at the territorial level. This development should occur through collaborations between local stakeholders in coordination with the Rural Development Program.

REFERENCES

- AllevaWEB (2025). Parmigiano Reggiano 2016-2024 (e oltre): la filiera raccontata dai suoi numeri. Available at: <https://allevaweb.it/parmigiano-reggiano-la-filiera-raccontata-dai-suoi-numeri/>. Last accessed: October 2025.
- Arfini, F., Donati, M., Petriccione, G. and Solazzo, R. (2008). An impact assessment of the CAP reform health check on the Italian tomato sector. European Association of Agricultural Economists, 109th Seminar, November 20.21, 2008, Viterbo, Italy.
- Arfini, F., Donati, M., and Zuppiroli, M. (2005). AGRISP, un modello di simulazione regionale per valutare gli effetti per l’Italia di modifiche alle politiche agricole. In *La riforma delle politiche agricole dell’UE ed il negoziato WTO: Il contributo di alcune ricerche quantitative alla valutazione dei loro effetti sull’agricoltura italiana*, pages 81–128. Franco Angeli (ed.).
- Baldi, L., Arfini, F., Calzolari, S., and Donati, M. (2023). An Impact Assessment of GHG Taxation on Emilia-Romagna Dairy Farms through an Agent-Based Model Based on PMP. *Land*, 12(7):1409.
- Baldi, L., Calzolari, S., Arfini, F., and Donati, M. (2024). Predicting the effect of the Common Agricultural Policy post-2020 using an agent-based model based on PMP methodology. *Bio-Based and Applied Economics*, 13(4), 333–351. <https://doi.org/10.36253/bae-14592>
- Baldock, D., Bartley, J., Burrell, A. M., Colman, D., Hart, K., Pointereau, P., and Silcock, P. (2008). Evaluation of the environmental impact of milk quotas. Technical report, European Commission, DG AGRI.
- Baptiste, L., Vincent, C., and Karine, D. (2012). Fin des quotas laitiers, contractualisation et stratégies productives: enseignements d’une modélisation bioéconomique. *Productions Animales*, 25:67–76.
- Barbero, G., Bergmann, D., Bublot, G., Koester, U., Larsen, A., Mahé, L., Marsh, J., Ritson, C., Sarris, A., Tangermann, S., and Tarditi, S. (1984). The Siena memorandum on ‘*The reform of the Common Agricultural Policy*’. *European Review of Agricultural Economics*, 11:255–259.
- Bertolini, P. and Giovannetti, E. (2020). L’evoluzione del sistema locale del Parmigiano Reggiano. Working Paper, DEMB WORKING PAPER SERIES, Dipartimento di Economia Marco Biagi – Università degli Studi di Modena e Reggio Emilia. https://doi.org/10.25341/11380_1212582.
- Boere, E., Peerlings, J., Reinhard, S., and Heijman, W. (2015). The dynamics of dairy land use change with respect to the milk quota regime. *European Review of Agricultural Economics*, 42(4):651–674.
- Bouamra-Mechemache, Z., Jongeneel, R., and Réquillart, V. (2008). Impact of a gradual increase in milk quotas on the EU dairy sector. *European Review of Agricultural Economics*, 35:461–491.
- Bórawski, P., Pawlewicz, A., Parzonko, A., Harper, J. K., and Holden, L. (2020). Factors shaping cow’s milk production in the EU. *Sustainability*, 12:420.
- Campiotti, M. (2024). Costi, redditività, bilancio: per il Parmigiano Reggiano, cambia lo scenario di produzione del latte. Alleva-WEB.
- Carletti, E. and Giangiulio, D. (1998). Il problema delle quote latte: quale equilibrio tra regolamentazione e concorrenza? *Meridiana*, pages 233–262.
- Chiodini, G. (2016). La regolazione dell’offerta dei formaggi a denominazione di origine come strumento di politica agraria. *Agriregionieuropa*.
- CLAL (2025a). Italia: Produzioni di Formaggio Parmigiano Reggiano. Available at: https://www.clal.it/?section=produzioni_parmigiano. Last accessed: July 2025.
- CLAL (2025b). Prezzi del Latte crudo alla stalla, Lombardia. Available at: <https://www.clal.it/index>.

- php?section=latte_lombardia. Last accessed: October 2025.
- CLAL (2025c). Reggio Emilia - Prezzo del latte per la produzione di Parmigiano Reggiano. Available at: https://www.clal.it/index.php?section=latte_reggio_emilia. Last accessed: October 2025.
- Corbett, D. (1992). Milk quotas – benefit or constraint? why a Common Agricultural Policy? *British Food Journal*, 94(5):38–40.
- Cortignani, R. and Dono, G. (2020). Greening and legume-supported crop rotations: An impacts assessment on Italian arable farms. *Science of the Total Environment*, 734:139464.
- Deserti, R. and Bertolini, C. (2021). La trasformazione della base allevatoria: meno stalle, ma con struttura più omogenea e competitiva. *Informatore Zootecnico*.
- Donati, M., Bodini, D., Arfini, F., & Zezza, A. (2013). An integrated PMP model to assess the development of agro-energy crops and the effect on water requirements. *Bio-Based and Applied Economics*, 2(3):301–321. <https://doi.org/10.13128/BAE-12987>
- Donati, M., Wilkinson, A., Veneziani, M., Antonioli, F., Arfini, F., Bodini, A., Amilien, V., Csillag, P., Ferrer-Pérez, H., Gkatsikos, A., Gauvrit, L., Gil, J., Hoang, V., Steinnes, K., Lila-vanichakul, A., Mattas, K., Napsintuwong, O., Nguyen, A., Nguyen, M., and Bellassen, V. (2020). Economic spill-over of food quality schemes on their territory. *Journal of Agricultural Food Industrial Organization*, 1.
- Dongo, D. (2022). Parmigiano Reggiano, Grana Padano and production quotas. *GIFT (Great Italian Food Trade)*.
- European Commission (2013). CAP Reform: an explanation of the main elements. Available at: https://ec.europa.eu/commission/presscorner/detail/en/memo_13_621.
- Gigante, R., Arfini, F. and Donati, M. (2014). Assessment of CAP reform 2014-2020 in the Emilia-Romagna region. In: Constantin Zopounidis, Nikos Kalogeras, Konstadinos Mattas, Gert Dijk and George Baourakis (ed.), *Agricultural Cooperative Management and Policy*, edition 127, pages 371-388, Springer.
- Jongeneel, R., Gonzalez-Martinez, A., Donnellan, T., Thorne, F., Dillon, E., and Loughrey, J. (2023). Research for Agri Committee – development of milk production in the EU after the end of milk quotas. Technical report, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.
- Lips, M. and Rieder, P. (2005). Abolition of Raw Milk Quota in the European Union: A CGE Analysis at the Member Country Level. *Journal of Agricultural Economics*, 56(1):1–17.
- Läpple, D., Carter, C. A., and Buckley, C. (2022). EU milk quota abolition, dairy expansion, and greenhouse gas emissions. *Agricultural Economics*, 53: 125–142.
- Madau, F. A., Furesi, R., and Pulina, P. (2017). Technical efficiency and total factor productivity changes in European dairy farm sectors. *Agric Econ*, 5:17.
- Markus, K., Peter, W., Ignacio, P., Torbjörn, J., and Paolo, S. (2011). Economic and environmental impacts of milk quota reform in Europe. *Journal of Policy Modeling*, 33(1):29–52. Special Issue: Impact assessment of agri-food policies in Europe: Methods, tools and applications.
- Náglóva, Z., Kotyza, P., Slaboch, J., Hálóvá, P., Czech, K., Wielechowski, M., and Cherevyk, D. (2021). Dairy processing industry in the European Union: Country-group clustering in pre- and post-milk quota abolishment periods. *Journal of Central European Agriculture*, 23.
- Oskam, A. J., Meester, G., and Silvis, H. J. (2010). EU policy for agriculture, food and rural areas. Wageningen Academic Publishers.
- Paris, Q. and Arfini, F. (2000). Frontier cost functions, self-selection, price risk, PMP, and Agenda 2000. *Rivista di Economia Agraria*, 211-242.
- Paris, Q. and Howitt, R. E. (1998). An analysis of ill-posed production problems using maximum entropy. *American Journal of Agricultural Economics*, 80(1):124–138.
- Petit, M. (1987). Agricultural policy formation in the European community the birth of milk quotas and CAP reform. Elsevier.
- Philippidis, G. and Waschik, R. (2019). Melitz Meets Milk: The Impact of Quota Abolition on EU Dairy Export Competitiveness. *Journal of Agricultural Economics*, 70(1):44–61.
- Pieri, R. and Rama, D. (2017). Dalla fine delle quote latte alle organizzazioni dei produttori: come cambia il settore lattiero-caseario in Italia? *Agriregionieuropa*.
- PRG (2014). Piano Regolazione Offerta del Parmigiano Reggiano Triennio 2014-2016 ai sensi del Reg. (UE) n. 1234/2007 e del D.M. 15164 del 12/10/2012.
- PRG (2022). Piano Regolazione Offerta del Parmigiano Reggiano Triennio 2023-2025 - Versione deliberata dal Consiglio di Amministrazione in data 26 gennaio 2022 Ai sensi del Reg. (UE) n. 1308/2013 e dei D.M. n. 15164 del 12 ottobre 2012, e n. 1813 del 15 febbraio 2019.
- PRG (2023). Alla ricerca della base genetica per la vacca da Parmigiano Reggiano: la genotipizzazione delle mille è cominciata. *Alleva-WEB*. Available at: <https://>

allevaweb.it/la-genotipizzazione-delle-mille-e-cominciata/

- PRG (2025a). Disciplinare di Produzione della Denominazione di Origine Protetta “Parmigiano Reggiano”. Available at: https://backend.parmigianoreggiano.com/uploads/Disciplinare_Parmigiano_Reggiano_1a92c5e19a.pdf. Last accessed: October 2025.
- PRG (2025b). Registro Quote Latte. Available at: <https://registro.parmigianoreggiano.it/qlpr/home.do>. Last accessed: October 2025.
- Solazzo, R., Donati, M., Arfini, F. and Petriccione, G. (2014). A PMP model for the impact assessment of the Common Agricultural Policy Reform 2014-2020 on the Italian Tomato Sector. *New Medit.* XIII. 9-19.
- Solazzo, R., Donati, M., Tomasi, L. and Arfini, F. (2016). How effective is greening policy in reducing GHG emissions from agriculture? Evidence from Italy. *Science of The Total Environment*, 573:1115–1124.



Citation: Grazini, C., Guarini, G. & Sturla, A. (2026). The role of Biodistricts in enhancing farms' labour productivity: a Post-Keynesian analysis. *Bio-based and Applied Economics* 15(3): 29-41. doi: 10.36253/bae-18332

Received: July 28, 2025

Accepted: May 21 2026

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Fabio Bartolini

Associated Editor: Matteo Zavalloni

ORCID

GC: 0000-0002-7305-4945

GG: 0000-0002-9159-3360

AS: 0000-0001-5117-5933

The role of Biodistricts in enhancing farms' labour productivity: a Post-Keynesian analysis

CHIARA GRAZINI^{1,*}, GIULIO GUARINI¹, ALBERTO STURLA²

¹ Economics, engineering, society, business organization Department, University of Tuscia, Viterbo, Italy

² Council for agricultural research and Economics, Centre for policies and bioeconomy (CREA PB), Italy

*Corresponding author. E-mail: c.grazini@unitus.it

Abstract. Biodistricts (BDs) leverage the “significant local presence” of organic farming and its supply chain to reach farmers' economic and environmental viability. Despite growing policy recognition in European strategies, empirical evidence of their effectiveness on farms' competitiveness remains limited. Using Italian FADN data and a post-Keynesian econometric model with dynamic panel data, this paper explores the BDs' impact on farm labour productivity growth, capturing innovation processes and competitiveness. Results suggest BD membership significantly enhances labour productivity growth, highlighting the role of territorial specialisation and collaborative networks. These benefits extend beyond organic farms, as the district's “industrial atmosphere” facilitates broader knowledge spillovers. Findings call for policies to strengthen social capital and promote sustainable farming practices, leveraging BDs as a strategy for enhancing farms' labour productivity and sustainability through agglomeration externalities, whereby the farms' spatial concentration facilitates knowledge sharing, joint resource use, and coordinated practice.

Keywords: biodistricts, labour productivity, agglomeration externalities, local sustainable development.

1. INTRODUCTION

Biodistricts (BDs), or “Eco-Regions”, represent a novel approach to Local Food Systems (LFSs), intended as geographically concentrated and specialized local production systems comprising farms, connected businesses, services and institutions engaged in producing and marketing local food (Sanz-Cañada & Muchnik, 2016). BDs enrich LAFS approach by rooting food system development in organic farming principles. A ‘Biodistrict’ is a geographical area where farmers, the public, tourist operators, associations and public authorities enter into an agreement for the sustainable management of local resources, based on organic principles and practices (COM (2021)¹ 141

¹ European Commission's Communication on an action plan for the development of organic production, available at [https://eur-lex.europa.eu/legal-content/IT/TXT/HTML/?uri=CELEX:52021DC0141R\(01\)](https://eur-lex.europa.eu/legal-content/IT/TXT/HTML/?uri=CELEX:52021DC0141R(01))

final/2, p. 15). Strengthening local organic supply chains drives multi-stakeholder development of the food sector and wider community, linking territorial organic production with tourism, crafts, environment, and local societal interactions (Assiri et al., 2021). Beyond the territorial concentration of farms and related actors, BDs are distinguished by the embeddedness of production within the local socio-economic context through relationships with local communities, their know-how, dietary practices, and institutions (Muchnik et al., 2007). They foster place-based approaches to sustainable local development (Stotten & Froning, 2023) and economic viability of local food production, and support horizontal and vertical cooperation networks (Duarte et al., 2025). Due to these abilities, BDs are receiving growing policy attention, as reflected in their recognition under the Italian² Law No. 23/2022. Moreover, both the EU Action Plan for the Development of Organic Production³ (COM(2021) 141 final) and the EU's long-term vision for rural areas⁴: towards stronger, connected, resilient and prosperous rural areas by 2040 (COM(2021) 345 final) identify BDs as effective instruments for maximising the economic and socio-cultural potential of territories.

Given these peculiarities, BDs can be studied through the economic literature on industrial districts and economies of scale. According to Marshall (1920), territorial concentration enhances local firms' efficiency by activating external economies of scale. Building on Marshall's work, Porter (1990) posits that geographic concentrations of interconnected companies, specialised suppliers, service providers, and institutions can enhance competitiveness and drive innovation by raising labour productivity, supply chain coordination, knowledge spillovers and specialised human and technical resources, thereby strengthening firms' competitive advantage (David & Rosenbloom, 1990). These mechanisms are particularly relevant in LFSSs, where small farms benefit from cooperation, vertical integration and

collective production and marketing approaches (Mantino & Vanni, 2018). Consistent with Porter's cluster theory, BDs exhibit institutional and strategic arrangements for enhancing competition in local organic farming (Zanasi et al., 2020) and can represent an innovative approach to sustainable, integrated and participatory territorial development⁵. However, while the literature has extensively discussed the externalities of spatial concentration, quantitative evidence remains limited and mixed, despite offering valuable qualitative insights (Sturla et al., 2024). Truant et al. (2019) find no particular economic benefits for organic farmers associated with BD membership, contrary to expectations from localisation economics. Instead, studies based on self-evaluation of farmers in BDs through FAO's CAET assessment framework (Mottet et al., 2020) show that high "efficiency" scores are driven by higher productive autonomy, reduced reliance on external inputs, and lower use of chemical inputs, leading to cost reduction and higher net income (Passaro & Randelli, 2022b). While efficiency is thus attributed to technical choices, these studies describe the existence of producer networks and knowledge-sharing within BDs, enabling economies of scale for better economic performance (Sciurano et al., 2024).

There's limited evidence on the contribution of BDs to farm labour productivity. To fill this gap, empirically assessing whether clustering processes in BDs enhance competitive advantages is highly relevant for policymaking, as this paper contributes to the effectiveness of territorial approaches to organic supply chains by examining labour productivity dynamics, which are closely linked to socio-economic outcomes such as unemployment and inequality (Wu et al., 2020), as well as to process and production innovation. The econometric model is based on the post-Keynesian framework, whereby labour productivity growth depends on the value-added dynamic (the so-called Smith effect or Kaldor-Verdoorn Law (see Sylos Labini, 2006)), thanks to division of labour and static and dynamic economies of scale, and on the capital intensity growth rate, according to Kaldor's technical progress function (Garofalo & Guarini, 2018). Using the System Generalized Method of Moments (GMM-SYS) estimator on a dynamic panel of farms from the Italian FADN, this paper estimates how the labour productivity growth rate is impacted by local productive specialisation in BDs. Since this is not measured directly, the presence of a BD is used as its proxy, justified by the BD's definition as homogeneous territories with a relevant concentration of organic production.

² Italian law No. 23/2022 defines BDs by combining their double nature of production systems characterised by productive specialisation and territorially embedded socio-economic configurations, as follows: "Territories with a strong agricultural vocation in which there is a significant presence of organic productions, in compliance with the regulations, where organic farmers, processors, consumer associations or local authorities collaborate, on the basis of formal agreements, collaborate for the local uptake of organic farming, for the dissemination of its values and for the support and enhancement of sustainability of local economic activities other than agriculture" (Art. 13). So, BDs aim at promoting both the local uptake of organic farming and its supply chain, and the multifunctionality of agriculture, including integration with tourism (e.g., agritourism and social agriculture) and environmental protection (Pomponi et al., 2026).

³ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021DC0141>

⁴ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021DC0345>

⁵ <https://openknowledge.fao.org/server/api/core/bitstreams/be3a420b-37c0-4805-98c1-6d91783c9e4f/content>

The remainder of the paper is organised as follows. Section 2 presents a literature review on industrial districts, territorial economies of scale and open eco-innovation, with a focus on food systems and BDs. Section 3 describes the database and the econometric model. Section 4 discusses results, while Section 5 concludes.

2. LITERATURE REVIEW

Becattini (1991) defines the industrial district as a socio-territorial construct combining a community of individuals and a concentration of enterprises within a geographically and historically delimited area, predominantly operating in the same sector. Marshall's (1920) agglomeration advantages arise from three key factors: a) the ability to support specialised suppliers; b) a geographically concentrated industry allows for labour market pooling; c) a geographically concentrated industry promotes knowledge spillovers. Rabelotti (1995) observes four sources of competitive advantage in industrial districts: 1- spatial concentration and sectoral specialization of small and medium-sized enterprises (SMEs); 2- the existence of forward and backwards linkages, involving market and non-market exchanges of goods, information, and personnel; 3- a shared socio-cultural foundation connecting and shaping implicit but occasionally explicit actors' behavioural code; 4- the presence of local public and private institutional network supporting the cluster activities. These advantages can be interpreted as Marshallian external economies, manifesting statically as reducing production costs, and dynamically, encompassing education, workforce training, and the collective accumulation of tacit knowledge. Learning by doing and informal learning processes within districts foster innovation, leading to collective improvements in labour productivity (Bellandi & Caloffi, 2008), faster technological adoption (Foster & Rosenzweig, 1995), and the development of local learning communities (Volpentesta & Ammirato, 2013).

Becattini and Coltorti (2004) highlight that labour productivity growth depends on the interaction between the local community and the productive system, whose environment and human values and knowledge permeate the productive apparatus, while intra-district competition lowers the transaction costs in the local market (Becattini, 1991). The role of geographical concentration has been further developed in economic theory: Porter (1990), drawing on the Italian geographic clustering concentration and on the case of Sassuolo's industrial district (Sforzi, 2008), equates industrial districts as a specific form of industrial clusters within the broader cluster

concept. Early-stage cluster development may intensify local competition, stimulating innovation and the continuous renewal of competitive dynamics (Pouder & St. John, 1996). Clusters enhance firms' productivity incentives through intense competitive pressure, continuous benchmarking, shared local conditions (e.g., labour costs and market access), and geographical proximity-driven differentiation among firms (Porter, 2000). The strong formulation of the Porter hypothesis, instead, posits that environmental regulation can induce eco-innovation, improving competitiveness by reducing costs and increasing productivity (Porter & Van der Linde, 1995).

Productivity growth is typically attributed to endogenous knowledge diffusion, promoted by firms' spatial proximity (Gustavsson, 2003). Synergistic mechanisms, including imitation, stakeholder collaboration, public-private partnerships, research-industry linkages, and supplier-customer interactions, strengthen regional innovation capacity (Rabelotti, 1995). Especially, industrial districts act as engines of economic development due to their flexibility and innovation capacity, as the "industrial atmosphere" sustains continuous grassroots innovation; however, global flows of knowledge and labour and the increasing integration of science into production challenge local identities and tacit capabilities, prompting both traditional and emerging districts to adopt the *open innovation mode* (Bellandi & De Propris, 2017). Under this approach, firms rely on external sources of knowledge, combining diverse competences and codified knowledge (Fabrizi et al., 2018). Indeed, the existence of a "*knowledge relations spiral*" within districts facilitates an ongoing circulation of tacit and codified knowledge among internal and external actors (de Felice et al., 2019), making knowledge accumulation and exchange a key source of sustained competitive advantage at both firm and district levels.

Despite manufacturing sector has received predominant attention due to its significant socio-economic implications associated with labour productivity growth, agglomeration can activate technology and knowledge spillovers, enhance competition in the agricultural industry, and mature factor markets through stronger upstream-downstream linkages (Wang et al., 2022). Structural changes in the food industry (for instance, increased vertical integration, greater network coordination, and growing demands for "localities") parallel those in other sectors (Carbone, 2017), with evidence of output growth in downstream segments of food supply chains and territorial proximity-drive spillover effects. Specifically, the local clustering of wholesalers, retailers, food service providers, and concentrated agricultural production enhances firm revenues, with effects

varying with urbanisation and non-linear agglomeration dynamics in rural areas (Schmit & Hall, 2013). However, empirical evidence on farm-level labour productivity in relation to territorial agglomeration remains limited. Garrone et al. (2019) examine how EU decoupled subsidies support labour productivity growth in agriculture, while coupled payments actually hinder it, although geographical factors are not fully accounted for. Instead, consistent with the Marshallian perspective, proximity and density improve farms' technical efficiency through knowledge exchange and spillovers (Hailu & James Deaton, 2016; Lakner et al., 2012).

Following the decline of mass production in the 1970s, nationally specific forms of geographic concentration gave rise to "Italian industrial districts", defined by clusters of SMEs specialising in consumer goods and related equipment (Sforzi, 2008), embedded in shared cultural contexts, local development dynamics, and dense inter-firm collaborations. This tradition progressively reframed Italian agricultural systems not only in spatial or environmental terms but also as places of social and economic relationships (Becattini, 2017), fostering the identification of geographically bounded agro-industrial systems shaped by local knowledge, territorial conformation and local traditions about techniques and agricultural products (Cavallo & Marino, 2014; Montresor, 2000). Organic farming – given its systemic nature and its environmental, social, and educational objectives – lends itself to district organisation, providing the foundation for the BDs' development and a conceptual link with the industrial district and territorial economies of scale literature.

The integrated territorial approach emphasises agri-food systems' ability to leverage their embeddedness and social networks, recognising their interdependence with local resources and proximity-based social relations (Kristensen et al., 2016). BDs can function as intermediate territorial entities, promoting the transition toward more sustainable food systems (Passaro & Randelli, 2022a). Although quantitative evidence remains limited, the literature situates BDs within Marshallian and Porterian frameworks of agglomeration externalities. By activating external economies of scale, BDs provide institutional and strategic arrangements for enhancing competition in local organic farming (Zanasi et al., 2020). In BDs, organic farming serves as a cohesive element around which actors coordinate and share goals and activities (Favilli et al., 2015), enabling the development of collective institutional arrangements, knowledge networks and market coordination that foster knowledge exchange, peer learning, and cooperative practices in input procurement and product distribution, thereby

enhancing farm competitiveness (Saenz et al., 2024; Stotten et al., 2017).

BDs coordinate local farmers in adopting agro-ecological and organic practices, often involving eco-innovation aimed at environmental preservation and the sustainability of food systems (Canwat & Onakuse, 2022). Although eco-innovations improve process efficiency, labour productivity, and environmental performance, they require greater technological complexity and depend more on codified, heterogeneous knowledge than in other agricultural districts (Barbieri et al., 2020). BD provides a place-based agency for innovation grounded in shared knowledge fostered by social and geographical proximity (Chaminade & Randelli, 2020). However, SMEs' limited capabilities to develop eco-innovations can be mitigated through external knowledge and collaboration, as the open eco-innovation paradigm emphasises the role of external knowledge sources, responsible partnerships, and integration into eco-innovation systems in overcoming internal constraints and accessing diverse expertise through collaborative networks (Ghisetti et al., 2015). Although locally embedded, BDs benefit from engagement with national and international networks (e.g., the International Network of Eco-Regions), which support knowledge exchange and the diffusion of best practices (Belliggiano et al., 2020).

Since eco-innovations require more heterogeneous knowledge, the effectiveness of innovation capabilities depends on the cooperation among heterogeneous stakeholders to facilitate efficient, low-cost knowledge integration (Fritsch & Schwirten, 1999). The Quintuple Helix model frames innovation as emerging from interactions between universities, industry, institutions, civil society and the "society's natural environments" (Carayannis et al., 2022), and clusters embody such multi-actor configurations (Porter, 2000). Although geographically extensive districts are gaining importance, they can complement localised relationships, fostering knowledge creation and diffusion, especially via strong university–industry linkages and civil society engagement, enabling multi-stakeholder innovation hubs. BDs, bringing together farmers, public authorities, civil society, and economic actors, can be interpreted as locally coordinated Quintuple Helix systems, where multi-level collaboration and environmental embeddedness foster knowledge accumulation, supply-chain specialisation, and farm-productivity gains (Donati et al., 2023).

3. DATA AND ECONOMETRIC MODEL

This study investigates the impact of BDs on farms' labour productivity growth rate using an unbalanced

dynamic panel from the Italian FADN database, covering over 122,000 farms⁶ between 2008 and 2021.

In post-Keynesian thought, the labour productivity growth rate is a crucial variable for economic development, capturing innovation, competitiveness and efficiency improvements. The output growth rate and the capital accumulation process can endogenously determine it. The former concerns the so-called Smith effect (Sylos Labini, 2006): the market expansion stimulates the horizontal and vertical division of labour, fostering technical and organisational innovations and, consequently, labour productivity gains. This effect is also called the Kaldor-Verdoorn law (Thirlwall, 1983), which links labour productivity growth to value-added growth rate via static decreasing fixed unit costs for the enlargement of the production scale and dynamic increasing returns or economies of scale for learning by doing, learning by using and learning by networking (Hein & Tarasow, 2010). The latter corresponds to the mechanisation effect expressed by Kaldor's technical progress function concerning the innovation processes for labour saving (Antenucci et al., 2020). Increases in capital per worker enhance labour productivity growth, as technological progress is embodied in new capital equipment, enabling the adoption of more advanced methods, with consequent higher labour productivity (Kaldor, 1961). Therefore, the econometric strategy is specified as follows (see Supplementary material for detailed description of Italian BDs in Fig. S.1 and Table S.1, summary statistics in Table S.3 and robustness check in Tables S.4 and S.5):

$$dPROD_{it} = \alpha_0 + \alpha_1 dPROD_{it-1} + \alpha_2 dVA_{it} + \alpha_3 dKL_{it} + \alpha_4 BD + \alpha_5 \sum_{i=1}^n FARM_CHAR_i + \gamma_{ij} + \mu_t + c_i + u_{it} \quad (1)$$

$$dPROD_{it} = \beta_0 + \beta_1 dPROD_{it-1} + \beta_2 dVA_{it} + \beta_3 dKL_{it} + \beta_4 \sum_{i=1}^n BD_CHAR + \beta_5 \sum_{i=1}^n FARM_CHAR_i + \gamma_{ij} + \mu_t + c_i + u_{it} \quad (2)$$

Where for farms $i = 1, \dots, 122000$ and the reference year $t = 2008, \dots, 2021$. The terms γ_{ij} , μ_t , c_i and u_{it} are regional dummies, year dummies, the idiosyncratic individual and time-invariant firm fixed effects and a white noise residual, respectively.

In equations (1) and (2), the dependent variable is the farm's labour productivity growth rate ($dPROD_{it}$), calculated as the first difference of the logarithm of the ratio between value-added and Agricultural Working Unit (AWU). All models include the lagged depend-

ent variable ($dPROD_{it-1}$), the capital intensity growth rate (dKL_{it}) given by the logarithm of the ratio between tangible assets and the number of employees, the value added growth rate (dVA_{it}) measured as the logarithm of deflated value added. All models control for important farm characteristics ($FARM_CHAR$): $LEGAL_FORM$ dummies⁷ based on the farm's legal form from the registration to the Chamber of Commerce; $MANAG_SYS$ dummies, which indicate the management system of farms, depending on the type of labour is used; OTE_CODE dummies⁸, controlling for the type of farming as defined by REG (EC) No. 1242/2008 and implemented in the FADN survey to identify the type of agricultural holding according to its main production activity; UAA is the logarithm of the utilised agricultural area.

Equation (1) includes the independent variable BD , a dummy representing whether the farm lies in a Municipality inside a biodistrict used as a proxy for agglomeration effects and potential economies of scale generated by biodistricts. Equation (2) controls for a set of territorial and farmer characteristics that interact with BD membership (BD_CHAR): a) if the farm within a BD exhibit positive growth in renewable energy use (BD_rin), to account the energy-related technical efficiency; b) if the farm belongs to a BD that is not located in Less Favoured Areas (LFAs)⁹ (BD_nozsva); c) if the BD is located in the North-Central regions (BD_CN) or in the South and Sicily (BD_MZ); d) if the farm within a BD is managed by a young farmer under 40 (BD_young) for testing the role of younger farmers in fostering innovation and sectoral sustainability, as they introduce novel perspectives, drive innovation, and inject vitality (Goulas & Papachatzis, 2024); e) the BD experience and the accumulated tacit knowledge (Exp), measured as the logarithm of the difference between the year of observation and the year of its establishment.

⁷ The legal forms in the FADN dataset are: 1) Sole proprietorship; 2) Simple partnership; 3) General partnership (s.n.c.); 4) Limited partnership (s.a.s.); 5) Joint-stock company (s.p.a.); 6) Limited liability company (s.r.l.); 7) Partnership limited by shares (s.a.p.a.); 8) Cooperatives (with limited or unlimited liability); 9) Social cooperative; 10) Producers' association; 11) Other recognized or unrecognized association; 12) Public entity; 13) Other profit-oriented legal form (Consortium); 14) Other non-profit legal form (Foundation); 15) Common ownership or collective lease; 16) Other type.

⁸ The farming Code in FADN dataset are: 1 = Specialist field crops; 2 = Specialist horticulture; 3 = Specialist permanent crops; 4 = Specialist grazing livestock; 5 = Specialist granivores; 6 = Mixed cropping; 7 = Mixed livestock holdings; 8 = Mixed crops-livestock.

⁹ LFAs are classified, according to EU Regulation No. 950/97 (Articles 22–24) in: 1) no disadvantaged; 2) partially disadvantaged by natural conditions; 3) totally disadvantaged by natural conditions; 4) partially disadvantaged for socio-economic inequalities; 5) totally disadvantaged for socio-economic inequalities.

⁶ Farms located in the regions of Sardinia and Marche were excluded from the sample to prevent potential bias due to the presence of BDs covering the entire regional territory, which would compromise estimates based on inside-outside geographical comparisons

Estimating the agglomeration effects on labour productivity requires addressing endogeneity arising from potential reverse causality (Graham et al., 2010). To address this problem, this empirical analysis employs the system generalised method of moments (GMM-SYS) approach (Blundell & Bond, 1998), which accounts for individual fixed effects and the past dependency of the dependent variable, as well as the potential endogeneity resulting from reverse causality between regressors and the dependent variable (Garofalo et al., 2020). All continuous covariates and BD are treated as potentially endogenous and instrumented using the lagged covariates and dummies related to the farm's characteristics, regions and years as instruments. This GMM-SYS is particularly suitable for unbalanced panel data, enhancing efficiency through an expanded instrument set (Roodman, 2009).

4. RESULTS AND DISCUSSION

4.1. Main results

This section shows and discusses the empirical evidence regarding the impact of BD location on farm labour productivity dynamics (see Table 1), and further examines this effect in relation to specific characteristics of BDs and farms (see Table 2).

In Table 1, columns 1 and 4 show the baseline model without and with the biodistrict (BD) dummy, respectively, estimated on the whole sample of farms. Columns 2 and 3 present the baseline model estimated on subsamples of farms located outside and inside BDs, respectively. Column 5 replicates the specification in column 4, treating BD membership as potentially endogenous to account for the unobserved factors that connect farmers' participation in a BD and higher productivity rates. The baseline model is confirmed in all the equations, both for the whole sample as well as for "inside" and "outside" BD subsamples (see columns 1-3 of Table 1). The overall negative and significant coefficient of the lagged variable $dPROD_{it-1}$ shows a negative dependence of labour productivity dynamics on the past. Consistent with the post-Keynesian literature, the Value Added growth rate (dVA_{it}) shows a positive and significant coefficient at 1% (5% in column 2), suggesting the positive effect of economies of scale for labour productivity in agriculture. The significant (at 1%) and positive coefficients of dKL_{it} support the validity of the mechanisation effect also for the agricultural sector, although its significance decreases to 10% in column 3.

Table 1 reveals that BD participation positively impacts farm-level labour productivity, as indicated by the significant at 5% positive coefficient of the BD dummy in column 4. In column 3 (*farms inside BDs*),

variable UAA_{itis} significant (5%) with a negative coefficient, consistent with the inverse relationship between innovation capacity and land size typically observed in more traditional farms with a lower propensity to innovate (Helfand & Taylor, 2021). Since BDs primarily target farms that benefit most from cooperation initiatives (RRN, 2019), this evidence, together with the positive and significant coefficient of "being in a BD" in column 4, suggests that the observed productivity gains are driven by agglomeration (Marshallian) externalities associated with spatial proximity. When BD participation is treated as potentially endogenous (column 5), its coefficient remains positive and statistically significant, confirming the robustness of the BD-productivity relationship to endogeneity bias.

Table 2 expands the analysis by interacting BD membership with farm and territorial characteristics to explore sources of the competitive advantage (treating BD dummy as endogenous). While baseline model is confirmed in all equations with consistent effects, the interaction variables reveal a mutually reinforcing impact of farms and territorial characteristics and BD presence on labour productivity dynamics. Although the coefficient of UAA_{it} remains insignificant, its inclusion strengthens model robustness as a key control. Column 1 reports the interaction of BD membership with the adoption by farmers of renewable energy (BD_{rin}), representing eco-innovations. The positive and significant at 5% coefficient of BD_{rin} suggests that BD environments foster conditions conducive to sustainable innovation; since renewable resources are widely available within the farm sector, effective energy-efficient practices and on-farm renewable energy sources can reduce farmers' energy costs.

In column 2, the positive and significance (5%) coefficient of BD_{nozsva} indicates that the competitive advantage from BD participation is not driven by marginality because it focuses on municipalities without physical or social disadvantage (Reg EC No. 950/97). Columns 3 and 4 report the coefficients of the interactions between BD membership and the geographical area: Centre-Northern (CN) and Southern (MZ) Italy, whose coefficients are both positive and significant at 10% and 5%, respectively. Both variables capture the interaction between BD and territorial features not captured by other covariates, suggesting that BD's action depends on the local socio-economic context. While organic farming and cooperation are prevalent in Southern Italy, some Centre-Northern regions have introduced specific regional legislation¹⁰ regulating BDs, eventually providing for financial support (Assiri et al., 2021).

¹⁰ Liguria (L.R. 66/2009); Lazio (L.R. 22/2019) and Toscana (L.R. 16/2014).

Table 1. The impact of BD participation on a farm's labour productivity.

	(1) <i>dPROD_{it}</i> <i>All farms</i>	(2) <i>dPROD_{it}</i> <i>Farms outside BD</i>	(3) <i>dPROD_{it}</i> <i>Farms inside BD</i>	(4) <i>dPROD_{it}</i> <i>All farms (Exogenous BD)</i>	(5) <i>dPROD_{it}</i> <i>All farms</i>
<i>dPROD_{it-1}</i>	-0.104*** (-3.02)	-0.0339 (-0.28)	-0.174*** (-5.29)	-0.0832* (-1.94)	-0.0832* (-1.93)
<i>dVA_{it}</i>	0.604*** (4.46)	1.309** (2.18)	0.689*** (4.07)	0.618*** (3.48)	0.593*** (3.35)
<i>dKL_{it}</i>	3.627*** (3.02)	7.585*** (2.98)	1.517* (1.74)	3.965*** (2.79)	3.926*** (2.76)
BD				5.550** (2.27)	3.689** (2.09)
UAA _{it}	0.168 (0.57)	0.109 (0.47)	-0.830** (-2.54)	-0.00634 (-0.03)	0.0763 (0.34)
Constant	1.646* (1.68)	-0.191 (-0.37)	2.242*** (3.09)	-0.561 (-0.82)	-0.527 (-0.82)
<i>LEGAL_FORM Dummies</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>MANAG_SYS Dummies</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>OTE_CODE Dummies</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional Dummies</i>	<i>Yes</i>	<i>yes</i>	<i>yes</i>	<i>yes</i>	<i>yes</i>
<i>Year Dummies</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Observations	62777	52125	10652	62777	62777
Hansen test (p-value)	0.522	0.428	0.681	0.236	0.242
AR (1) (p-value)	0.00000219	0.00000115	2.71e-13	0.0000273	0.0000277
AR (2) (p-value)	0.392	0.0759	0.522	0.199	0.200

Note: t statistics in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

Column 5 evaluates the interaction between BD membership and the young farmer status. The significant at 5% and positive coefficient of *BD_young* variable indicates that younger farmers' greater propensity for innovation contributes to labour productivity growth, reflecting their higher openness to new initiatives and stronger inclination toward organic agriculture and participation in biodistricts (Mazzocchi et al., 2020). Lastly, column 6 reports a positive and significant at 5% impact of BDs' experience (*Exp*) on labour productivity, supporting the presence of a "district effect" in agriculture.

4.2. Discussion of results

Evidence from Tables 1 and 2 suggests that the competitive advantages derived from BD membership could stem from its place-based development approach, which activates external economies of scale. Consistent with the post-Keynesian literature (e.g., Blecker & Setterfield, 2019), findings confirm the key role of economies of scale in enhancing labour productivity in agriculture. As output increases, average costs decline, improv-

ing efficiency and supporting farm labour productivity growth through innovation and specialisation. Empirical evidence from a group of farms in the Salzburg region specialising in milk production shows that the pursuit of economies of scale increases production intensity, labour productivity, and reduces production costs. In addition, the mechanisation effect aligns with previous studies, describing how mechanisation in labour-intensive agriculture enhances labour productivity by complementing labour (De Roest et al., 2018).

Cooperation and knowledge sharing, either formal or informal, are central in BD strategies (Passaro & Randelli, 2022b). Results suggest how the territorial clustering of specialised farms generates agglomeration advantages, lowering per-unit costs and intensifying regional specialisations, as observed in other agricultural districts. While this supports a competitive advantage from BDs, its exact source remains difficult to identify. It may reflect the activation of aggregation economies and the emergence of dynamic increasing returns and learning processes related to cooperation initiatives. However, the presence of economies of scope due to diversification

Table 2. The impact of biodistricts' characteristics on labour productivity.

	(1) $dPROD_{it}$	(2) $dPROD_{it}$	(3) $dPROD_{it}$	(4) $dPROD_{it}$	(5) $dPROD_{it}$	(6) $dPROD_{it}$
$dPROD_{it-1}$	-0.0837* (-1.94)	-0.0814* (-1.88)	-0.0818* (-1.89)	-0.0832* (-1.93)	-0.0932** (-2.19)	-0.169* (-1.83)
dVA_{it}	0.596*** (3.37)	0.650*** (3.48)	0.625*** (3.48)	0.593*** (3.35)	0.587*** (2.95)	0.522 (0.99)
dKL_{it}	3.927*** (2.77)	3.953*** (2.83)	4.014*** (2.80)	3.926*** (2.76)	3.580** (2.56)	3.106*** (3.49)
BD_rin	3.909** (2.25)					
BD_nozsva		4.763** (2.10)				
BD_CN			4.336* (1.75)			
BD_MZ				3.689** (2.09)		
BD_young					1.190** (1.96)	
Exp_{it}						0.359** (1.99)
UAA_{it}	0.0630 (0.28)	0.0653 (0.29)	0.0760 (0.33)	0.0763 (0.34)	0.362 (1.08)	
Constant	-0.521 (-0.83)	-0.240 (-0.43)	-0.573 (-0.79)	-0.527 (-0.82)	1.648 (1.46)	-0.0843 (-0.43)
LEGAL_FORM Dummies	Yes	Yes	Yes	Yes	Yes	No
MANAG_SYS Dummies	Yes	Yes	Yes	Yes	Yes	No
OTE_CODE Dummies	Yes	Yes	Yes	Yes	Yes	No
Regional Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62777	62777	62777	62777	62777	2584
Hansen test (p-value)	0.291	0.165	0.0823	0.242	0.930	0.0732
AR(1) (p-value)	0.0000276	0.0000292	0.0000290	0.0000277	0.00000910	0.00676
AR(2) (p-value)	0.200	0.197	0.196	0.200	0.394	0.744

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0$.

cannot be excluded, as highlighted in similar experiences (De Roest et al., 2018).

A further contribution of the empirical study is that positive impacts on BDs' participation also extend to conventional farmers, reflecting the "industrial atmosphere" generated by specialisation, which benefits not just organic farmers (Becattini, 1991). The Biovallee case in France shows that BD's atmosphere supports the adoption of environmentally friendly practices by local conventional farmers. Consistent with the open eco-innovation mode, complementarities between standard and new institutional innovations, such as BDs conceived as "instruments of knowledge" (Stefanovic & Agbolosoo-Mensah, 2023), generate knowledge spillovers and economies of scope. This context is characterised

by trust, networking, and institutional arrangements, reflecting the embeddedness of local economic activities (Granovetter, 1985).

Rising concerns over climate change and industrial sustainability have intensified focus on environmental performance, particularly on energy efficiency due to its link to innovation and competitiveness (Tripathy et al., 2024). This connection is particularly evident in agriculture, where energy productivity remains volatile, indicating limited farmers' ability to optimise energy use through technological upgrading and energy-saving practices (Ball et al., 2015). Findings suggest that BDs can activate inter-organisational networks and innovative governance for greater productivity and sustainability, driving improvements in energy efficiency and circu-

lar-economy initiatives (Poconi et al., 2021), consistent with Law 23/2022's call for "*pursuing resource-conserving development*" (Art 13). Indeed, BDs actively promote networks for rational and sustainable energy use with the double objective of curbing CO₂ emissions while lowering production costs (Lasorella, 2024).

Consistent with existing literature, yet at odds with the perceived mission of BDs, the association between BD-related competitive advantages and territorial marginality suggests that benefits tend to concentrate in municipalities lacking significant physical or social disadvantages, despite BDs being intended as instruments for rural revitalisation. Therefore, the BD effectiveness seems closely conditioned by the local socio-economic context, particularly the availability of supporting services and infrastructure (Assiri et al., 2021). Furthermore, the long-standing experience of BDs can stimulate alternatives to mainstream agricultural regimes by enabling new business models and organisational routines, thereby enhancing the attractiveness of rural areas for younger farmers, who are more likely to adopt innovative practices, undertaking higher levels of risk for establishing and expanding their enterprises (May et al., 2019). The Val di Vara biodistrict exemplifies this dynamic: sustained collective action in organic farming has restructured local meat and dairy supply chains, increasing employment opportunities and areas' appeal to younger farmers (Viganò & Sturla, 2013).

By bridging the industrial district and agricultural economics literature, this study shows that a "district effect" on labour productivity emerges once BD activity becomes significant, typically over the medium term. Time is crucial for the development of the district atmosphere and the activation of external economies. Technological progress is a cumulative learning process, underpinning the knowledge accumulation and the emergence of innovation (Winter et al., 2000). Accordingly, regions with a longer history of specialisation tend to endow firms with greater stocks of intangible assets, such as tacit knowledge and institutional capabilities, than less developed regions (Gustavsson, 2003).

5. CONCLUSIONS

This paper estimates the effects of BDs on farm labour productivity growth using a dynamic panel GMM model on the Italian FADN dataset. Findings highlight that BD membership positively affects innovation and competitiveness, supporting the economic viability of sustainability-oriented networking. By framing BDs within a post-Keynesian framework, the BDs'

impact on labour productivity is interpreted as arising from their intrinsic nature, whereby development processes involve civil society and sustainability principles generate competitive advantages, indicating their capacity to activate dynamic returns to scale as a key mechanism shaping local growth.

Findings support integrating a territorial perspective into post-Keynesian economics by combining the economies of scale analyses (dynamic increasing returns, learning by doing, network externalities) with place-based drivers and barriers, concerning institutional, geographical and social dimensions, and the evolutionary path of local economic and technological relations. In line with the quintuple helix model, considering BDs as institutional innovation where science, business, policy, society, and nature interact underscores their nature as collective innovation, in which local demand sustains labour productivity and collective action generates spillovers diffusing sustainable farming practices (Kreft et al., 2023).

Empirical analysis provides interesting policy implications. From the lens of Porter's strong hypothesis, organic farming principles can act as institutional drivers of efficiency and product diversification. Evidence from BD practices supports this view: municipalities within the *Biodistretto della Via Amerina e delle Forre* issued regulations limiting pesticide use in hazelnut orchards, alongside technical support - provided in collaboration with regional authorities - to facilitate compliance among conventional farmers¹¹. Findings suggest that BD initiatives generate indirect benefits for conventional farms. BDs' policies should aim to stimulate at least the adoption of sustainable practices by conventional farms because strengthening the 'district atmosphere' through enhanced social capital and knowledge diffusion can foster their uptake of sustainable practices. As in the Parma Biodistrict (Guareschi et al., 2023), progressive labelling or participatory certification systems could be supportive.

Findings show that BDs can be conceptualised as territorial systems in which labour productivity benefits from governance structures reinforcing environmental policies (such as incentives for renewable energy adoption) through the cooperative and knowledge-sharing dynamics typical of the district approach, as observed in local food systems. Nevertheless, this "district effect" rises in non-marginalised areas, underscoring the role of rural-urban interaction in fostering innovation (Packer & Zanasi, 2023) and the influence of socio-territorial factors partly beyond BDs' control. This needs to com-

¹¹ <https://biodistrettoamerina.com/pan-pesticidi/>.

plement BD initiatives with policies aimed at reducing territorial disparities. Consistent with the 2025 European Commission's "A Vision for Agriculture and Food"¹², the positive impact of the Common Agricultural Policy must be complemented with cohesion policies supporting economic diversification, infrastructure and services provision.

The study's limitations provide avenues for future research. The main constraint concerns the absence of explicit consideration of spatial interactions, which could generate spillovers and spatial dependence, thereby limiting agglomeration dynamics' analysis. This limit stems from the nature and size of the data, which preclude robust spatial regression analysis. Approximately 20% of observations are not georeferenced, leading to an information loss in the GMM model, and only a small share of farms in the FADN dataset are located in municipalities within BDs, weakening the identification of meaningful spatial linkages. Moreover, the unbalanced panel, covering nearly 100,000 farms, pose significant computational challenges for a spatial regression. Future research will develop datasets suitable to measure potential BDs' spatial spillovers. The analysis does not differentiate between organic and conventional farms, preventing the assessment of heterogeneity in BD effects. While this does not undermine the research question, since BD-related benefits appear to extend to conventional farms, likely through district "atmosphere" effects, "physical" endowments (such as local specialisation, supply chain infrastructures, knowledge spillovers emerging within districts, and access to the shared networks), establishing a stronger relationship between labour productivity enhancement and spillovers between organic and conventional farms remains necessary. Finally, the dataset prevents identifying BD membership among organic farms. As members' farms benefit from dedicated market arrangements, technical assistance, marketing initiatives and cooperation projects, distinguishing membership status would allow a more robust assessment of differential impacts between 'inside' and 'outside' BDs.

REFERENCES

- Antenucci, F., Deleidi, M., & Paternesi Meloni, W. (2020). Kaldor 3.0: An empirical investigation of the Verdoorn-augmented technical progress function. *Review of Political Economy*, 32(1), 49–76.
- Assiri, M., Barone, V., Silvestri, F., & Tassinari, M. (2021). Planning sustainable development of local productive systems: A methodological approach for the analytical identification of Ecoregions. *Journal of Cleaner Production*, 287, 125006.
- Ball, V. E., Färe, R., Grosskopf, S., & Margaritis, D. (2015). The role of energy productivity in US agriculture. *Energy Economics*, 49, 460–471.
- Barbieri, N., Marzucchi, A., & Rizzo, U. (2020). Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones? *Research Policy*, 49(2), 103901.
- Becattini, G. (1991). Italian industrial districts: problems and perspectives. *International Studies of Management & Organization*, 21(1), 83–90.
- Becattini, G. (2017). The Marshallian industrial district as a socio-economic notion. *Revue d'économie Industrielle*, 157, 13–32.
- Becattini, G., & Coltorti, F. (2004). Aree di grande impresa ed aree distrettuali nello sviluppo post-bellico dell'Italia: un'esplorazione preliminare. *Rivista Italiana Degli Economisti*, 9(1), 61–102.
- Bellandi, M., & Caloffi, A. (2008). District internationalisation and trans-local development. *Entrepreneurship and Regional Development*, 20(6), 517–532.
- Bellandi, M., & De Propriis, L. (2017). New forms of industrial districts. *Economia e Politica Industriale*, 44(4), 411–427.
- Belliggiano, A., Sturla, A., Vassallo, M., & Viganò, L. (2020). Neo-endogenous rural development in favor of organic farming: Two case studies from Italian fragile areas. *European Countryside*, 12(1), 1–29.
- Blecker, R. A., & Setterfield, M. (2019). *Heterodox Macroeconomics: Models of Demand, Distribution and Growth*. Edward Elgar Pub.
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115–143.
- Canwat, V., & Onakuse, S. (2022). Organic agriculture: A fountain of alternative innovations for social, economic, and environmental challenges of conventional agriculture in a developing country context. *Cleaner and Circular Bioeconomy*, 3, 100025.
- Carayannis, E. G., Campbell, D. F. J., & Grigoroudis, E. (2022). Helix trilogy: The triple, quadruple, and quintuple innovation helices from a theory, policy, and practice set of perspectives. *Journal of the Knowledge Economy*, 13(3), 2272–2301.
- Carbone, A. (2017). Food supply chains: coordination governance and other shaping forces. *Agricultural and Food Economics*, 5(1), 3.
- Cavallo, A., & Marino, D. (2014). L'analisi della dimensione territoriale dell'agricoltura: una proposta di lettura. *Scienze Del Territorio*, 2, 159–178.

¹² https://agriculture.ec.europa.eu/overview-vision-agriculture-food/vision-agriculture-and-food_en

- Chaminade, C., & Randelli, F. (2020). The role of territorially embedded innovation ecosystems accelerating sustainability transformations: a case study of the transformation to organic wine production in Tuscany (Italy). *Sustainability*, 12(11), 4621.
- David, P. A., & Rosenbloom, J. L. (1990). Marshallian factor market externalities and the dynamics of industrial localization. *Journal of Urban Economics*, 28(3), 349–370.
- de Felice, A., Martucci, I., & Scaglioni, C. (2019). «Relations at Work» in a Modern Industrial District: A Pathway to Innovation. *L'industria*, 40(3), 437–462.
- De Roest, K., Ferrari, P., & Knickel, K. (2018). Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies*, 59, 222–231.
- Donati, L., Stefani, G., & Bellandi, M. (2023). The evolutionary emergence of quintuple helix coalitions: A case study of place-based sustainability transition. *Triple Helix*, 10(1), 125–155.
- Duarte, L. A. P., Méndez, M. R., & Muñoz-Rojas, J. (2025). Territorial embeddedness of sustainable agro-food systems: A systematic review. *Agroecology and Sustainable Food Systems*, 49(6), 948–988.
- Fabrizi, A., Guarini, G., & Meliciani, V. (2018). Green patents, regulatory policies and research network policies. *Research Policy*, 47(6), 1018–1031.
- Favilli, E., Rossi, A., & Brunori, G. (2015). Food networks: collective action and local development. The role of organic farming as boundary object. *Organic Agriculture*, 5, 235–243. <https://doi.org/10.1007/s13165-015-0118-2>
- Foster, A. D., & Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of Political Economy*, 103(6), 1176–1209.
- Fritsch, M., & Schwirten, C. (1999). Enterprise-university co-operation and the role of public research institutions in regional innovation systems. *Industry and Innovation*, 6(1), 69–83.
- Garofalo, G., & Guarini, G. (2018). Reti D'Impresa Ambientali E Sviluppo Eco-Sostenibile a Livello Regionale (Environmental Business Networks and Eco-Sustainable Development at Regional Level). *Moneta e Credito*, 71(281).
- Garofalo, G., Guarini, G., & Chiaccherini, C. (2020). Le piccole e medie imprese italiane nella riflessione di Francesco Parrillo e nel contesto dell'economia italiana del III millennio: un percorso di ricerca sul capitalismo italiano con una verifica empirica. *Rivista bancaria*.
- Garrone, M., Emmers, D., Lee, H., Olper, A., & Swinnen, J. (2019). Subsidies and agricultural productivity in the EU. *Agricultural Economics*, 50(6), 803–817.
- Ghisetti, C., Marzocchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, 44(5), 1080–1093.
- Goulas, A., & Papachatzis, A. (2024). Young farmers, small farms and entrepreneurship under the new European Union green deal. *Annals of the University of Craiova, Biology, Horticulture, Food Products Processing Technology, Environmental Engineering*, 29(65).
- Graham, D. J., Melo, P. S., Jiwattanakulpaisarn, P., & Noland, R. B. (2010). Testing for causality between productivity and agglomeration economies. *Journal of Regional Science*, 50(5), 935–951.
- Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91(3), 481–510.
- Guareschi, M., Mancini, M. C., Lottici, C., & Arfini, F. (2023). Strategies for the valorization of sustainable productions through an organic district model. *Agroecology and Sustainable Food Systems*, 47(1), 100–125.
- Guarini, G. (2015). Complementarity between environmental efficiency and labour productivity in a cumulative growth process. *PSL Quarterly Review*, 68(272).
- Gustavsson, R. (2003). Industrial growth and dynamic externalities: the case of Sweden. *Journal of Economic Integration*, 607–625.
- Hailu, G., & James Deaton, B. (2016). Agglomeration effects in Ontario's dairy farming. *American Journal of Agricultural Economics*, 98(4), 1055–1073.
- Hein, E., & Tarassow, A. (2010). Distribution, aggregate demand and productivity growth: theory and empirical results for six OECD countries based on a post-Kaleckian model. *Cambridge Journal of Economics*, 34(4), 727–754.
- Helfand, S. M., & Taylor, M. P. H. (2021). The inverse relationship between farm size and productivity: Refocusing the debate. *Food Policy*, 99, 101977.
- Kaldor, N. (1961). Capital accumulation and economic growth. *The Theory of Capital: Proceedings of a Conference Held by the International Economic Association*, 177–222.
- Kreft, C., Angst, M., Huber, R., & Finger, R. (2023). Farmers' social networks and regional spillover effects in agricultural climate change mitigation. *Climatic Change*, 176(2), 8.
- Kristensen, D. K., Kjeldsen, C., & Thorsøe, M. H. (2016). Enabling sustainable agro-food futures: exploring

- fault lines and synergies between the integrated territorial paradigm, rural eco-economy and circular economy. *Journal of Agricultural and Environmental Ethics*, 29(5), 749–765.
- Lakner, S., von Cramon-Taubadel, S., & Brümmer, B. (2012). Technical efficiency of organic pasture farming in Germany: The role of location economics and of specific knowledge. *Renewable Agriculture and Food Systems*, 27(3), 228–241.
- Mantino, F., & Vanni, F. (2018). The role of localized agri-food systems in the provision of environmental and social benefits in peripheral areas: Evidence from two case studies in Italy. *Agriculture*, 8(8), 120.
- Marshall, A. (1920). Principles of economics. In *Macmillan and Co.*
- May, D., Arancibia, S., Behrendt, K., & Adams, J. (2019). Preventing young farmers from leaving the farm: Investigating the effectiveness of the young farmer payment using a behavioural approach. *Land Use Policy*, 82, 317–327.
- Mazzocchi, C., Orsi, L., Ferrazzi, G., & Corsi, S. (2020). The dimensions of agricultural diversification: a spatial analysis of Italian municipalities. *Rural Sociology*, 85(2), 316–345.
- Montesor, E. (2000). I sistemi locali di produzione agroalimentare. In *L'agricoltura tra locale e globale. Distretti e filiere* (Vol. 2). CNEL.
- Mottet, A., Bicksler, A., Lucantoni, D., De Rosa, F., Scherf, B., Scopel, E., López-Ridaura, S., Gemmil-Herren, B., Bezner Kerr, R., & Sourisseau, J.-M. (2020). Assessing transitions to sustainable agricultural and food systems: a tool for agroecology performance evaluation (TAPE). *Frontiers in Sustainable Food Systems*, 4, 579154.
- Muchnik, J., Requier-Desjardins, D., Sautier, D., & Touzard, J.-M. (2007). Introduction: les systèmes agroalimentaires localisés (SYAL). *Économies et Sociétés. Systèmes Agroalimentaires (AG)*, 41(929), 1465–1484.
- Packer, G., & Zanasi, C. (2023). Comparing social sustainability assessment indicators and tools for biodistricts: building an analytical framework. *Frontiers in Sustainable Food Systems*, 7, 1229505.
- Passaro, A., & Randelli, F. (2022a). *Spaces of Governance for Sustainable Transformation of Local Food Systems: the Case of 8 biodistricts in Tuscany*. DISEI, Università degli Studi di Firenze.
- Passaro, A., & Randelli, F. (2022b). Spaces of sustainable transformation at territorial level: an analysis of biodistricts and their role for agroecological transitions. *Agroecology and Sustainable Food Systems*, 46(8), 1198–1223.
- Pomponi, T., Carillo, F., Henke, R., Sturla, A., Del Giudice, T., & Sorrentino, A. (2026). Biodistricts as social innovation: Territorial implications in Italy. *Journal of Rural Studies*, 121, 103926.
- Porter, M. E. (1990). *The Competitive Advantage of Nation*. The Free Press.
- Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, 14(1), 15–34.
- Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97–118.
- Pouder, R., & St. John, C. H. (1996). Hot spots and blind spots: Geographical clusters of firms and innovation. *Academy of Management Review*, 21(4), 1192–1225.
- Rabellotti, R. (1995). Is there an “industrial district model”? Footwear districts in Italy and Mexico compared. *World Development*, 23(1), 29–41.
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal*, 9(1), 86–136.
- RRN. (2019). *L'agricoltura biologica per lo sviluppo territoriale: l'esperienza dei distretti biologici*.
- Saenz, J., Aramburu, N., Alcalde-Heras, H., & Buenechea-Elberdin, M. (2024). Technical knowledge acquisition modes and environmental sustainability in Spanish organic farms. *Journal of Rural Studies*, 109, 103338.
- Sanz-Cañada, J., & Muchnik, J. (2016). Geographies of origin and proximity: Approaches to local agro-food systems. *Culture and History Digital Journal*, 5(1), 1–19.
- Schmit, T. M., & Hall, J. S. (2013). Implications of agglomeration economies and market access for firm growth in food manufacturing. *Agribusiness*, 29(3), 306–324.
- Sciurano, J. P., Arfini, F., & Maccari, M. (2024). A methodological approach to upscale organic and agroecological-local agrifood systems: the case of the Pampa Organica Norte group in Argentina. *Frontiers in Sustainable Food Systems*, 8, 1304558.
- Setterfield, M. (2006). Thirlwall's law and Palley's pitfalls: a reconsideration. *Growth and Economic Development: Essays in Honour of AP Thirlwall*, 47–59.
- Sforzi, F. (2008). The industrial district: from Marshall to Becattini. *Il Pensiero Economico Italiano*, a. XVI, 2, 71–80.
- Stefanovic, L., & Agbolosoo-Mensah, O. A. (2023). Biodistricts as a tool to revitalize rural territories and communities: insights from the biodistrict Cilento. *Frontiers in Sustainable Food Systems*, 7, 1267985.

- Stotten, R., Bui, S., Pugliese, P., Schermer, M., & Lamine, C. (2017). Organic values-based supply chains as a tool for territorial development: a comparative analysis of three European organic regions. *International Journal of Sociology of Agriculture and Food*, 24(1).
- Stotten, R., & Froning, P. (2023). Territorial rural development strategies based on organic agriculture: the example of Valposchiavo, Switzerland. *Frontiers in Sustainable Food Systems*, 7, 1182993.
- Sturla, A., Viganò, L., Vassallo, M., & Belliggiano, A. (2024). Mission,(self)-perception and role in localized food systems of Italian biodistricts: insights from a Delphi survey. *Frontiers in Sustainable Food Systems*, 8, 1433261.
- Sylos Labini, P. (2001). *Underdevelopment: a strategy for reform*. Cambridge University Press.
- Sylos Labini, P. (2006). *Torniamo ai classici: produttività del lavoro, progresso tecnico e sviluppo economico*. Laterza.
- Thirlwall, A. P. (1983). A plain man's guide to Kaldor's growth laws. *Journal of Post Keynesian Economics*, 5(3), 345–358.
- Tripathy, P., Jena, P. K., & Mishra, B. R. (2024). Systematic literature review and bibliometric analysis of energy efficiency. *Renewable and Sustainable Energy Reviews*, 200, 114583.
- Truant, E., Broccardo, L., & Zicari, A. (2019). Organic companies' business models: emerging profiles in Italian bio-districts. *British Food Journal*, 121(9), 2067–2085.
- Viganò, L., & Sturla, A. (2013). La sostenibilità delle filiere biologiche: il caso di Varese Ligure. *INEA: Rome, Italy*, 317–341.
- Volpentesta, A. P., & Ammirato, S. (2013). Alternative agrifood networks in a regional area: a case study. *International Journal of Computer Integrated Manufacturing*, 26(1–2), 55–66.
- Wang, J., Sun, F., Lv, K., & Wang, L. (2022). Industrial agglomeration and firm energy intensity: how important is spatial proximity? *Energy Economics*, 112, 106155.
- Winter, S. G., Kaniovski, Y. M., & Dosi, G. (2000). Modeling industrial dynamics with innovative entrants. *Structural Change and Economic Dynamics*, 11(3), 255–293.
- Wu, J., Ge, Z., Han, S., Xing, L., Zhu, M., Zhang, J., & Liu, J. (2020). Impacts of agricultural industrial agglomeration on China's agricultural energy efficiency: A spatial econometrics analysis. *Journal of Cleaner Production*, 260, 121011.
- Zanasi, C., Basile, S., Paoletti, F., Pugliese, P., & Rota, C. (2020). Design of a Monitoring Tool for eco-regions. *Frontiers in Sustainable Food Systems*, 4, 536392.



Citation: Borgia, R., Tiboldo, G. & Castellari, E. (2026). Investigating the relationship between family environments and children's adoption of obesity-related behaviours in Italy. *Bio-based and Applied Economics* 15(3): 43-54. doi: 10.36253/bae-18178

Received: July 10, 2025

Accepted: July 17, 2026

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Fabio Bartolini

Associated Editor: Oriana Gava

ORCID

RB: 0000-0002-8853-276X

GT: 0000-0002-5599-9750

EC: 0000-0002-5012-7574

Investigating the relationship between family environments and children's adoption of obesity-related behaviours in Italy

RICCARDO BORGIA¹, GIULIA TIBOLDO^{2*}, ELENA CASTELLARI²

¹ University of Bologna, Department of Agricultural and Food Sciences, Viale Fanin 50, Bologna, 40127, Italy

² Università Cattolica del Sacro Cuore, Dipartimento di Economia Agro-alimentare, Via Emilia Parmense 84, 29122, Piacenza, Italy

*Corresponding author. E-mail: giulia.tiboldo@unicatt.it

Abstract. This study investigates the association between family-environment and children's adoption of four obesity-related behaviours: regular physical activity, adequate fruit and vegetable (FV) consumption, having an adequate breakfast and daily snack consumption. We perform a cross-sectional analysis using a nationally representative sample of Italian households with children (45,333 children from 30,228 households) collected by ISTAT over the period 2013-2023. Two sets of logit models are estimated to investigate the relationship between children's adoption of the four behaviours under analysis and household characteristics (household models), as well as paternal and maternal habits (parental models). Our results show a statistically significant correlation exists between the adoption of obesity-related behaviours in adults and children within the same household. Moreover, this relationship is found to be stronger for relatively unhealthy behaviours (e.g., snacking) than for healthy ones (e.g., FV consumption) and when maternal behaviour is accounted for.

Keywords: children, obesity-related behaviours, family environment, parental model.

INTRODUCTION

Although Italy has the lowest percentage of adults with obesity in Europe (Eurostat, 2022), childhood overweight and obesity rates are among the highest among the European Union (EU) Member States. In detail, 39% of boys and 29% of girls in Italy are overweight, compared to the European average of 36% and 23%, respectively (WHO, 2025). Childhood obesity leads to a higher risk of poor health during adolescence and adulthood (Rolland-Cachera et al., 2006; Stettler et al., 2002) and lifelong health problems, such as cardiovascular diseases, diabetes, and hypertension (MacMahon et al., 2009; Park et al., 2012; Pulgarón, 2013; Rankin et al., 2016). Further, childhood obesity can increase the likelihood of experiencing behavioural and emotional difficulties, sometimes leading to stigmatization, poor socialization,

and reduced educational attainment (Cunningham et al., 2014; Pulgarón, 2013; WHO, 2017). Therefore, understanding the key determinants of childhood overweight and obesity is crucial for the development of effective measures to contain one of today's most urgent public health challenges (Lobstein et al., 2004).

Maintaining a correct balance between energy intake and energy expenditure is at the basis of body weight regulation (Lustig, 2001). Indeed, scientific literature suggests that children engaging in less physical activity (PA) (Andersen et al., 1998, Hernández et al., 1999) are more likely to be overweight and obese (Janssen, 2007). On the other hand, children with a high energy intake and poor diet quality – e.g., low fruit and vegetable consumption (Arcan et al., 2007; Pearson et al., 2009), breakfast skipping (Hallström et al., 2013) and high snack consumption (Jahns et al., 2001) – are at greater risk of becoming obese and overweight. Therefore, identifying the drivers of such obesity-related behaviours is crucial for designing public health measures aimed at mitigating their adoption.

An informative approach to understanding the mechanisms behind obesity-related habits during childhood is the analysis of children's environments. According to the *ANalysis Grid for Environments Linked to Obesity* (ANGELO) framework developed by Swinburn et al. (1999) and Ferreira et al. (2006) such environments can be primarily categorized in two classes: micro-environments (e.g., family/household, school, workplace, neighbourhood, etc.) and macro-environments (e.g., city/municipality/region, infrastructures, healthcare system, etc.). Each environment can be further classified in four types: physical, socio-cultural, economic, and political. Some previous research has explored how the broader school environment can shape children's eating habits and dietary behaviours (Castellari & Berning, 2016; Castellari et al., 2018; Sogari et al., 2024; Vitali et al., 2023). The present paper specifically focuses on the family micro-environment, since its influence on childhood behaviour adoption is widely recognized in previous scientific studies (Cerroni et al., 2019; Pickard et al., 2024; Wang et al., 2011; Maestri & Macchioni, 2021). Moreover, several studies show that, within the above-mentioned environments, socio-economic status (SES) and the modelling role played by parents are the most frequent aspects investigated within familial settings (Beydoun and Wang, 2009; Ferreira et al., 2006). However, to the best of our knowledge, the individual and combined relevance of the two parents' habits with these behaviours have not been deeply investigated (Ferreira et al., 2006; Goldman et al., 2012; Wang et al., 2011). The observation of only one parent at a time can hide some

behavioural interactions and be a potential source of miscomprehension of such familial dynamics (Hart et al., 2010; Kueppers et al., 2018; Ng et al., 2025).

This study extends the existing literature on childhood overweight/obesity and health-related behaviours in several important ways. While previous research has consistently documented the association between family environments and children's health outcomes (Pickard et al., 2024; Wang et al., 2011), much of the evidence has focused on obesity prevalence or body mass index (BMI) as outcome measures, rather than on the specific behavioural pathways through which obesity risk is transmitted across generations. This study provides a more nuanced understanding of the mechanisms linking family environments to children's obesity risk by examining four key obesity-related behaviours, namely: regular practice of physical activity (PA-practice), adequate fruit and vegetables consumption (FV-consumption) (Arcan et al., 2007; Pearson et al., 2009), having breakfast (Breakfast-consumption), and daily consumption of savoury snacks (Snacks-consumption) (Jahns et al., 2001). Furthermore, much of the existing literature relies on relatively small samples, regional populations, or data from single countries and time periods, limiting the generalisability of findings. Using a large, nationally representative sample of Italian households collected over the period 2013–2023, this paper offers robust and up-to-date evidence on children's health behaviours in Italy. The large sample size (45,333 children belonging to 30,228 households) also enables a more detailed investigation of behavioural patterns within households. To the best of our knowledge, results of the Italian *Multipurpose Survey on Households Daily Life Aspects* (MHDLA) (ISTAT, 2018, 2021) have not been employed before to investigate the mechanisms behind the adoption of obesity-related habits among children. While prior studies have frequently focused on parental influences as a whole or have primarily examined maternal effects (Hart et al., 2010; Kueppers et al., 2018; Ng et al., 2025), this paper contributes to the growing literature on intergenerational transmission of health behaviours by separately analysing maternal and paternal habits, providing further insight into the gendered dimensions of health behaviour transmission within families. Finally, the study contributes novel evidence by demonstrating that parent-child associations are stronger for unhealthy behaviours, such as snack consumption, than for healthy behaviours, such as fruit and vegetable intake. This finding suggests that the transmission of health behaviours within families may be asymmetric, a dimension that has received limited attention in previous research. By highlighting differences in the intergenerational transmission of healthy and unhealthy

behaviours, the study offers important implications for the design of family-based interventions aimed at preventing childhood obesity.

The rest of the paper is organized as follows: section 2 illustrates materials and methods, section 3 and 4 describe the key results of the analysis, section 5 concludes.

2. MATERIALS AND METHODS

2.1. Sample selection

The study is performed using secondary data from the MHDLA conducted by ISTAT (2018, 2021). The survey annually covers a large sample of Italian households (about 50,000 individuals from 20,000 households every year) and collects individual self-reported information on several aspects of daily life and behaviours, including food consumption patterns and other health-related behaviours. We combine eleven years (2013-2023) of MHDLA data in a unique repeated cross-sectional dataset. Only households with children and both parents are considered, resulting in a final dataset of 45,333 children and 30,228 households, with children being identified as individuals younger than 18.

2.2. Variables and measures

As diet and physical activity are recognized as key factors in affecting the risk of developing overweight and obesity since early childhood (Lustig, 2001), we develop four key indicators of obesity-related behaviours in children using secondary data collected from the MHDLA survey (ISTAT, 2018, 2021). In doing so, we contrast two sets of behaviours based on their potential effect on childhood obesity risk. The first one includes relatively healthy behaviours that may reduce obesity risk, namely PA-practice, Breakfast-consumption and FV-consumption, while the second one captures a potentially obesogenic behaviour, that is, Snacks-consumption (Lustig, 2001)¹.

Based on the MHDLA survey, each of these behaviours is captured by a binary variable. *PA-practice* takes the value of 1 for respondents who report regularly

practising one or more sports throughout the year, and 0 otherwise. *FV-consumption* is constructed using information on the daily number of portions of fruit and vegetables consumed and takes the value of 1 for respondents consuming at least five portions per day, in line with nutritional guidelines (CREA, 2019), and 0 otherwise. *Breakfast-consumption* takes the value of 1 for respondents who report consuming a complete breakfast, while it equals 0 for those who skip breakfast or only drink coffee or tea without eating any food. Finally, *Snacks-consumption* takes the value of 1 for respondents who consume savoury snacks, such as potato chips or popcorn, at least once a day, and 0 for those consuming them less frequently. A detailed description of variable definitions and the original MHDLA questions used to construct them are reported in Supplementary Materials, in Section A and Table S1, respectively.

2.3. Statistical analysis

To explore the relationship between the adoption of obesity-related behaviours by adults and children within the same household, we estimate two sets of logit models, namely *household models* and *parental models* (Cramer, 2003). The first set of models – *household models* – investigates the association between the adoption of obesity-related behaviours by children and overall household characteristics. The second set of models – *parental models* – evaluates separately the relationship between the adoption of obesity-related behaviours by children and by their mothers and fathers, respectively.

More specifically, the *household models* study the association between presence of the identified children's behaviours and the characteristics of the household from a socio-economic, health (i.e., presence of adults with overweight/obesity) and behavioural perspective. Considering the scientific literature on the role of the family socio-economic status (SES) in influencing children's dietary behaviours (Fernández-Alvira et al., 2015; Hallström et al., 2012), the following variables are employed as socio-economic proxies: level of education (*Education*) and employment (*Employment*) of the head of the household; number of children living in the household (*Children number*); and geographical area of residence (*Geographical*). To capture the health status of the household's components, we include the presence of adults with overweight/obesity within the family nucleus as a regressor (Lauria et al., 2015) (*Overweight/obese*). Moreover, a specific variable indicating the adoption of the investigated obesity-related behaviour at the household level is also accounted for (*Adults' behaviour*). Lastly, in line with previous literature (e.g., O'Loughlin

¹ These four habits have been selected considering their widely recognised relevance in scientific literature in affecting the likelihood of incurring overweight and obesity, especially among children (Jahns et al., 2001; Arcan et al., 2007; Pearson et al., 2009; Hallström et al., 2013). Indeed, observing the consumption of other food items, as eggs, meat, and dairy products, would have turned the interpretation of the results less univocal against the scope of this study. Other obesity-related behaviours as smoking and alcohol consumption, are not suitable for a children-centred study.

et al., (1999), Story et al. (2002), and Videon & Manning (2003)), children's characteristics such as age (*Age*) and gender (*Gender*) are included as regressors, together with dummy variables accounting for the survey year (*Year*).

The *parental models* also account for the parental relationship in explaining childhood obesity/overweight. In these models, for each of the two parents – father and mother – we control for the level of education (*Father education*; *Mother education*), employment (*Father employment*; *Mother employment*), and weight status (*Father with overweight/obesity*; *Mother with overweight/obesity*), as well as the adoption of the four targeted behaviours (*Father behaviour*; *Mother behaviour*). The rest of the control variables are unchanged with respect to the *household models*. The summary statistics of the key variables used in this analysis are reported in the Supplementary Materials, section B (Table S2-S4).

Given the dichotomous nature of the dependent variables of these models, we estimate the relationship between children's adoption of each of the four obesity-related behaviours of interest and household level (*household models*) and parental (*parental models*) engagement in these behaviours through a multivariate logistic regression approach (Cramer, 2003). The probability of each child *i* adopting a certain obesity-related

behaviour *j* ($y_i \neq 0$) given all the explanatory variables included in the *Household* and in the *Parental models*, X_i 's, can be expressed as follows:

$$P(y_i \neq 0 | X_i) = \frac{\exp(X_i \beta)}{1 + \exp(X_i \beta)} \quad (1)$$

where β 's are the estimated coefficients of interest (Pindyck and Rubinfeld, 1998).

3. HOUSEHOLD AND PARENTAL MODELS' ESTIMATION RESULTS

Tables 1 and 2 report the estimated marginal effects from the logistic regression of the *household* and *parental models*. The estimated coefficients from the corresponding logistic regressions are reported in the Supplementary Materials, Section C (Table S5 and Table S6). Sections 3.1, 3.2 and 3.3 illustrate the key findings of the current analysis focusing on the association between obesity-related behaviours and children's and household characteristics (sections 3.1 and 3.2, respectively), as well as adults' behaviours (section 3.3) referring to the results of both the *household* (Table 1) and the *parental* model (Table 2).

Table 1. *Household models*: Discrete marginal effect of the explanatory variables expressed as absolute percentage change (n = 45,333).

Variables (Reference class in brackets)	Classes	Investigated children's behaviours			
		Breakfast-consumption	PA-practice	Snacks-consumption	FV-consumption
Age (3-5 y)	6-10 y	-0.55	36.62***	3.63***	0.69***
	11-13 y	-8.39***	39.09***	6.40***	0.95***
	14-17 y	-13.90***	30.41***	5.50***	1.99***
Gender (Male)	Female	-3.09***	-7.70***	-0.89***	0.38**
Overweight/obese (No one)	At least one	-0.16	-0.89*	1.37***	-0.34**
	All	-1.17**	-2.43***	1.43***	-0.33*
Education (Elementary school license or lower)	Secondary school license	-2.01**	11.47***	-1.33*	-0.63
	High school diploma	-1.04	19.52***	-4.33***	-0.50
	University degree or higher	1.17	27.11***	-8.39***	0.27
Employment (Unemployed)	Employed	0.80*	6.23***	-1.19***	0.23
Geographical (Northern Italy)	Central Italy	-0.61	0.49	-1.28***	-0.23
	Southern Italy and Isles	-1.86***	-11.93***	3.22***	-1.58***
Children number (1)	2	0.28	-0.65	0.36	-0.13
	3 or more	0.09	-7.68***	1.11***	0.36
Adults' behaviour (No one)	At least one	9.08***	14.96***	16.59***	4.98***
	All	17.41***	25.37***	28.72***	8.67***
<i>Goodness of fit statistics</i>					
Pseudo R ²		0.073	0.153	0.084	0.143
Likelihood χ^2 ratio test p-value		0.000	0.000	0.000	0.000

*** p < 0.01; ** p < 0.05; * p < 0.1.

Table 2 *Parental models*: Discrete marginal effect of the explanatory variables expressed as absolute percentage change (n=45,333).â

Variables (Reference class in brackets)	Classes	Investigated children's behaviours			
		Breakfast-consumption	PA-practice	Snacks-consumption	FV-consumption
Age (3-5 y)	6-10 y	-0.47	36.55***	3.58***	0.71***
	11-13 y	-8.26***	39.25***	6.26***	0.99***
	14-17 y	-13.75***	30.85***	5.24***	2.04***
Gender (Male)	Female	-3.12***	-7.80***	-0.88***	0.37**
Father with overweight/obesity (No)	Yes	0.34	-0.15	0.80**	-0.15
Mother with overweight/obesity (No)	Yes	-1.63***	-1.56***	0.38	-0.20
Father education (Elementary school license or lower)	Secondary school license	-0.67	6.91***	-0.99	-0.77
	High school diploma	0.41	10.85***	-2.56***	-0.71
	University degree or higher	1.85	14.01***	-4.89***	-0.52
Mother education (Elementary school license or lower)	Secondary school license	-2.99***	4.52	-0.31	0.46
	High school diploma	-3.25**	11.88***	-2.64***	0.40
	University degree or higher	-1.67	16.82***	-5.59***	1.27**
Father employment (Unemployed)	Employed	1.13**	5.37***	-0.65	0.40
Mother employment (Unemployed)	Employed	-1.19***	6.27***	-0.86***	0.04
Geographical (Northern Italy)	Central Italy	-0.66	0.74	-1.37***	-0.25
	Southern Italy and Isles	-2.19***	-10.13***	2.85***	-1.57***
Children number (1)	2	0.19	-0.98*	0.52	-0.15
	3 or more	-0.13	-7.03***	0.97**	0.34
Father behaviour (Not present)	Present	6.68***	10.81***	13.20***	3.88***
Mother behaviour (Not present)	Present	10.80***	14.85***	17.61***	4.96***
<i>Goodness of fit statistics</i>					
Pseudo R ²		0.075	0.164	0.088	0.144
Likelihood χ^2 ratio test pvalue		0.000	0.000	0.000	0.000

*** p < 0.01; ** p < 0.05; * p < 0.1.

3.1. Associations between obesity-related behaviours and children's characteristics

Age

Our results show that the likelihood of incurring obesity-related behaviours generally increases with children's age. Children aged 11-13 years have lower probability of Breakfast-consumption and are more likely to have daily Snacks-consumption compared to children aged 6-10 years. Our findings also suggest that children increase PA-practice starting from the age of 5, while this habit reduces from the age of 14 (Table 1 and Table 2). In contrast, FV-consumption is positively associated with age. Furthermore, children aged 14-17-year-olds are 13.9% less likely to have adequate Breakfast-consumption than 3-5-year-old children. However, comparing the same age classes, the likelihood of Snack-consumption or FV-consumption increases by 5.5%, and by 1.99%, respectively.

Gender

Our results also show the existence of gender differences regarding the presence of obesity-related behaviours among children. Females are less likely to have an adequate Breakfast-consumption and regular PA-practice. On the other hand, females show higher FV-consumption and lower occurrence of daily Snacks-consumption (Table 1 and Table 2).

3.2. Associations between obesity-related behaviours and household characteristics

Geographical area of residence

Children from southern Italy and Italian isles are more at risk of adopting obesity-related behaviours than those living in Northern Italy. This tendency is particularly pronounced for low PA-practice and high Snacks-consumption, while it is less evident for low FV-consumption (Tables 1 and 2).

Number of children in the household

The number of children in the household is not related to the probability of Breakfast- and FV-consumption, though its relationship with Snacks-consumption is slightly positive. Conversely, the probability of PA-practice seems to be negatively associated with the number of children in the household, although this relationship is only statistically significant for households with three or more children (Table 1 and 2).

3.3. Associations between obesity-related behaviours and adults/parents' characteristics

Weight status

Overall, our results show that children living in households with adults who are affected by overweight/obesity are more likely to engage in obesity-related behaviours (Table 1). Focusing on the results from the *parental models*, we find that children with a mother with overweight/obesity are less likely to regularly engage in PA-practice or adequate Breakfast-consumption but are slightly more prone to Snacks-consumption in the case of a father experiencing overweight/obesity (Table 2).

Educational level

We find that the educational level of the head of household is negatively associated with the adoption of Snacks-consumption among children, while the opposite is true for the probability of children practicing PA regularly (Table 1). Results from the *parental models* are similar: higher parental education is associated with a higher probability of children engaging in regular PA-practice and a lower probability of Snacks-consumption, although this effect is not always statistically significant (Table 5). Only mother's educational attainment is positively related with children's likelihood of FV-consumption, while negatively related with children's Breakfast-consumption.

Employment

Children are less likely to engage in obesity-related behaviours when the household head is employed, except for FV-consumption, for which no significant association is found (Table 1). The correlation between employment and children's Breakfast-consumption is weak, while it is more marked for regular PA-practice and Snacks-consumption.

Results also show that the relationship between parental employment and children's behaviour differs by parent's gender (Table 2). The presence of a working father in the household is positively associated with the probability of children's Breakfast-consumption, while maternal employment shows the opposite association. We also find strong association between parental employment and children PA-practice, with a stronger link observed for mothers' employment status. Lastly, only maternal employment appears to be negatively associated with Snacks-consumption, while FV-consumption is not significantly associated with parental employment.

Adult behaviours

As shown in Table 1, a positive correlation exists between children's and adults' adoption of the four investigated behaviours, with this relationship being the strongest when both parents engage in the same obesity-related behaviour. For instance, children living in a household where only one parent engages in daily snacking are 16.59% more likely to engage in the same behaviour than peers living in a family where neither adult exhibits this behaviour. This probability increases up to 28.72% when we look at families in which both parents engage in daily Snacks-consumption. We also find that the correlation between children's and adults' behaviours is the strongest for Snacks-consumption (i.e., larger marginal effect), followed by PA-practice and Breakfast-consumption, and the weakest for FV-consumption (Table 1). This pattern is also confirmed by the results of the *parental models* where fathers' and mothers' behaviours are considered separately (Table 2).

Table 3 reports the results of the test used to investigate whether the estimated marginal effects associated with the four investigated behaviours differ significantly between the two parents in the *parental models*. Results show that differences between the estimated mothers' and fathers' marginal effects are positive and statistically significant for the four targeted behaviours, meaning that a higher correlation exists between mothers and children in their behaviour than with fathers. For instance, children are 4.12% more likely to consume breakfast regularly when their mothers do so, than when their fathers' behaviour is considered. A similar result is found for PA practice (4.04%) and snack consumption (4.41%). On the other hand, this difference is milder when focusing on FV consumption (1.1%). This may imply that mothers have a stronger influence than fathers on children's adoption of the investigated behaviours.

Table 3. Differences between the estimated parental marginal effects for the four investigated behaviours ^a

	Coefficient	Standard Error	P-value
Breakfast-consumption	4.12***	0.59	0.000
PA-practice	4.04***	0.88	0.000
Snacks-consumption	4.41***	0.89	0.000
FV-consumption	1.08***	0.32	0.001

^a Difference between the estimated mothers' and fathers' marginal effects. ***, **, * indicates statistically significance at 1%, 5% and 10% confidence level respectively.

4. DISCUSSION

The present study confirms that the prevalence of obesity-related habits among Italian children is rather alarming. According to our sample, only a small portion of children consume the recommended portions of FV daily (2.92%), and barely half of the sample regularly practice PA (53.11%). Furthermore, not having an adequate breakfast and consuming snacks every day are relatively common habits (17.77% and 12.35%, respectively) (Table S4). This picture is largely in line with the findings of the main reports on the nutritional status of Italian children (Cavallo et al., 2016; Lauria et al., 2019; Nardone et al., 2018, 2022; Prandini, 2021).

More specifically, our results indicate that the age of children is associated with a higher adoption of obesity-related behaviours, except for FV-consumption. This result is consistent with the 4th Italian report from the Health Behaviour in School-aged Children (HBSC) study (Cavallo et al., 2016), which showed that the percentage of Italian children skipping breakfast in school days increased from 18.8 at the age of 11 to 30.1 at the age of 15, while the percentage of breakfast eaters fell from 63.6 to 53.6, respectively. Moreover, the findings from the 2017/2018 HBSC survey (Inchley et al., 2020) also showed an increase in daily consumption of sweets and chocolate among Italian children, ranging from 27% at the age of 11 to 31% at the age of 13. Lastly, both the above-mentioned reports observed an age-related fall in PA-practice, with a decline starting from the age of 13 years². The increasing adoption of obesity-related behaviours with age may be related to the different educational stages of Italian children. At the beginning of junior high school (in Italy at age 11), children usually seek more autonomy and independence (Neumark-Sztainer et

al., 1999; Story et al., 2002; Videon and Manning, 2003). This desire may have implications on their food choices, resulting, for instance, in higher snack consumption that may have been previously limited by stronger parental surveillance. The beginning of senior high school (at the age of 14), instead, usually implies more time constraints in children's lifestyle. Less time available in the morning might result in a higher risk of not having an adequate breakfast, while less time available in the afternoon implies limited opportunities for PA-practice. In addition, O'Loughlin et al. (1999), Edwards et al. (2015), Farooq et al. (2018) and Marquet et al. (2018) hypothesized that the availability, accessibility, and appeal of free playground activities decline with age. On the other hand, our findings show that FV-consumption is positively related with children's age. This result is consistent with the HBSC study reporting a similar age-related increase in FV consumption among Italian children. Moreover, in line with the HBSC study, we find that the likelihood of Breakfast-consumption decreases to a higher extent with age than FV-consumption. One explanation for these findings could be that unhealthy habits are easier to adopt than healthy ones (Dolgoplova et al., 2022; Kachwaha et al., 2024; Swinburn et al., 2011).

In line with the findings from the Italian national surveillance system (Lauria et al., 2015), our results show that females are less likely to have an adequate breakfast-consumption and engage in regular PA-practice³. These results are in line with previous studies showing that a gender gap exists regarding physical activity, with females tending to be less physically active than males both in childhood and adulthood. Moreover, our results confirm the existence of a North-South gap in terms of obesity-related behaviours: children from the South of Italy and Italian Isles are more at risk of irregular PA-practice, inadequate FV-consumption and daily Snacks-consumption compared to peers from the North or the Centre of Italy (Lauria et al., 2015).

As in Fogelholm et al. (1999), the results of the *parental models* also show that the presence of overweight mothers is highly correlated with the uptake of obesity-related behaviours among children, in line with our observations on regular PA practice. In accordance with our findings, Lauria et al. (2015) reported that Italian children aged 8-9 years old with a mother with overweight/obesity were more inclined to skip breakfast and to practice less PA, while the mother's weight status is not correlated with children's FV-consumption (Lauria et al., 2015).

² Differently from MHDLA, the HBSC sample (around 65.000 children) includes only 11-, 13- and 15-year-old students attending public schools.

³ Lauria et al. (2015) refers to a sample ($n=46.300$) of 8-9-years-old children.

Our results also suggest that the level of education of the household head is positively associated with regular PA-practice and lower Snacks-consumption. Moreover, measuring the correlation of each parents' characteristics on children's behaviour (i.e., *parental models*) allows us to also appreciate that children's FV-consumption is significantly associated only with maternal education – as also observed by Nardone et al. (2018), Lauria et al. (2015) and Hanson and Chen (2007).

This analysis also finds significant correlation between adults' employment status and children's adoption of obesity-related habits. Specifically, the employment status of the household heads is associated with lower presence of children's obesity-related habits. Some key differences emerge when differentiating between parents' employment status. For instance, the likelihood of children's adequate Breakfast-consumption is positively associated with paternal employment. This might reflect the effect of higher familial SES and, hence, greater affordability of healthier dietary choices (Fernández-Alvira et al., 2015). On the other hand, the negative association between Breakfast-consumption and maternal employment may be explained by working mothers having less time to take care of children's breakfast in the morning, a role that tends to be gendered (Lauria et al., 2015). For the other investigated behaviours, the role of parental employment moves in the same direction with different intensity. For example, we find stronger association between children PA-practice and maternal rather than paternal employment. This result may suggest that maternal employment triggers a greater leap in the familial SES, resulting in a more evident adoption of this behaviour by children (O'Loughlin et al., 1999).

In line with O'Loughlin et al. (1999) and Goldman et al. (2012), our analysis confirms adults' household habits are significantly associated with children's adoption of obesity-related behaviours, with mothers and fathers exhibiting different degrees of modelling influence. In detail, children's daily Snacks-consumption is the habit most related to parents' behaviour, while the weakest relationship is found with the adequacy of FV-consumption. Moreover, in line with Vereecken et al. (2004) that found children with a daily-snacking mother were more at risk of adopting the same habit, our results show a higher likelihood of children's Snacks-consumption when this habit is also exhibited by mothers. We also find a stronger correlation between children's habits and those of mothers compared with fathers with respect to positive behaviours namely, PA-practice, Breakfast-and FV-consumption. Similar results were also reported in Fogelholm et al. (1999) and other studies showing that children's overweight and obesity issues are more

strongly associated with maternal than paternal weight (Whitaker et al., 2010). In agreement with Goldman et al. (2012) and Vereecken et al. (2004), we also find a positive association between parental and children FV-consumption, with the mother-child association being stronger than the father's one. Furthermore, the parental daily consumption of FV is the habit with the weakest marginal effect on children's behaviours. However, it is also important to point out that FV-consumption is the least adopted behaviour in our sample (2.92% of children, 3.51% of fathers and 5.44% of mothers). Therefore, the low emulation of this behaviour by children may reflect a more general difficulty of adopting it. Other unhealthy behaviours, such as daily Snacks-consumption, instead, tend to be more easily imitated, evidenced by the stronger correlation found in the analysis. A possible interpretation might be that the influence that parents play as models is stronger on unhealthy behaviours than on healthy ones. Vereecken et al. (2004) reported a similar finding in their study: the likelihood of children imitating maternal behaviour was higher for the consumption of soft drinks than for the FV-consumption. A similar dynamic was also reported by Fogelholm et al. (1999) who found that the probability of children's practicing of PA is more influenced by parental inactivity rather than activity.

5. CONCLUSIONS, LIMITATIONS, AND FURTHER DEVELOPMENTS

This study explores the interconnection between children's and adults' adoption of obesity-related behaviours. In line with previous literature (Cavallo et al., 2016; Steinbeck, 2001), the modelling role of mothers being stronger than fathers suggests the importance of engaging mothers in health promotion interventions. Furthermore, we find a strong correlation between parental behaviours and children's Snacks-consumption, suggesting strong interconnections among family members in the adoption of unhealthy behaviours and highlighting the importance of extending interventions to other contexts, such as schools.

Based on the results of this analysis, indications can be drawn about children's age groups who are more at risk of adopting specific obesity-related behaviours, therefore suggesting at which educational stage these habits should be addressed as a priority. In details, we find that Italian children in junior secondary school (age 11-13 years) are more inclined to increase the consumption of snacks, while in senior high school (age 14-17 years) they tend to reduce the practice of PA. The con-

sumption of an adequate breakfast, instead, appears to decrease over time from elementary to high school.

Our study also identifies priority targets of intervention regarding children's gender, indicating that girls are at higher risk of inadequate breakfast consumption and low PA, while boys have a higher risk of Snack and low FV consumption. Furthermore, our results show a higher presence of obesity-related behaviours among children from larger families, with low-educated and/or unemployed adults, thus reinforcing the recommendation of promoting healthy habits also in extra-familial environments, which are less influenced by the household SES. Indeed, the results of this analysis confirm the importance of strengthening impactful initiatives such as "*Okkio alla Salute*", which promotes physical activity and healthy diets within the school setting (Nardone et al., 2018), as well as the *EU School Schemes*, which allocates resources from the Common Agricultural Policy to support the distribution of milk, fruit and vegetables to children from nurseries to secondary schools (European Commission, 2020). In accordance with previous studies (Cavallo et al., 2016; Lauria et al., 2019; Nardone et al., 2018), this study also highlights the importance of prioritizing the South of Italy and Italian Isles in the implementation of health promotion policies among children. In these territories, as well as in the rest of Italy, it would be crucial to leverage health promotion initiatives implemented at local level, including those financed by targeted community funding opportunities such as the LEADER approach (*Liaison Entre Actions de Développement de l'Economie Rurale*), supporting the development of school canteens fed by shorter food supply chains and promoting vegetable gardens at schools (European Commission, 2006).

An important strength of this research is the employment of a large secondary dataset, including 45,333 children belonging to 30,228 households and eleven years of observations from the Italian MHDLA (ISTAT, 2018, 2021). To the best of our knowledge, this secondary data source has never been employed before to investigate children's adoption of obesity-related behaviours. This study therefore contributes to the literature by shedding lights on the mechanism underlying the adoption of obesity-related habits among children, with a specific focus on the familial environment.

Nevertheless, this study has some limitations, mostly related to the nature of the dataset. First, the Italian MHDLA is based on self-reported measures and, therefore, respondents' answers may be affected by their comprehension, memory and by social desirability (Hebert et al., 1995). Moreover, it is possible that parents complete the survey on behalf of their children. Then, for privacy reasons, information related to child's weight status is

omitted, limiting our ability to investigate the association between family environment and childhood obesity and overweight. It should also be recognised that, although unlikely, there is no formal rule preventing the re-selection of the same household across years (ISTAT 2018, 2021). Lastly, the use of a secondary dataset limited our ability to include some variables relevant to this study, such as those addressing the parental role in household/childcare tasks or family income. We therefore rely on the most suitable variables available in the MHDLA data, which are recognized in the literature as valid proxies for these variables, such as the employment status and level of education.

Many aspects of this analysis warrant further investigation. Future studies could examine how habits within a household are formed and transferred to children, considering the interdependence of behaviours. A deeper understanding of household behavioural interactions could provide useful insights for the design of public policies targeting the family environment. As suggested by O'Loughlin et al. (1999), the potential gender-specific modelling role of parents regarding children's obesity-related behaviours deserves further investigation. Moreover, widening the range of investigated habits might enable to generalize the hypothesized dynamics regarding the contrast between healthy and unhealthy behaviours. Future research could further explore the role of the primary caregiver responsible for household and childcare tasks, as well as the co-occurrence of the investigated behaviours, rather than investigating them individually as in the current analysis.

ACKNOWLEDGEMENTS

This work was partially supported by the Doctoral School in Agri-food System (Agrisystem) of Università Cattolica del Sacro Cuore (Italy).

AUTHORSHIP

Riccardo Borgia: Conceptualization, Methodology, Formal analysis, Writing – Original draft; Giulia Tiboldo: Data curation, Formal analysis, Supervision, Writing – Review & Editing; Elena Castellari: Conceptualization, Methodology, Supervision, Writing – Review & Editing.

ETHICAL STANDARDS DISCLOSURE

This study analyses secondary data and thus obtaining ethical approval is not needed. Data employed in

the study are publicly available in the dedicated section of the ISTAT website: <https://www.istat.it/en/archive/129934>.

DATA AVAILABILITY STATEMENT

The original data used in this study are publicly available from the Italian National Institute of Statistics (Istat) through the dataset “Aspetti della vita quotidiana: file per la ricerca” available at <https://www.istat.it/microdati/multiscopo-sulle-famiglie-aspetti-della-vita-quotidiana/>.

REFERENCES

- Andersen, R. E., Crespo, C. J., Bartlett, S. J., Cheskin, L. J., and Pratt, M. (1998). Relationship of Physical Activity and Television Watching With Body Weight and Level of Fatness Among Children Results From the Third National Health and Nutrition Examination Survey. *Journal of the American Medical Association* 279: 938–942.
- Arcan, C., Neumark-Sztainer, D., Hannan, P., Van Den Berg, P., Story, M., and Larson, N. (2007). Parental eating behaviours, home food environment and adolescent intakes of fruits, vegetables and dairy foods: Longitudinal findings from Project EAT. *Public Health Nutrition* 10: 1257–1265.
- Beydoun, M. A., and Wang, Y. (2009). Parent-child dietary intake resemblance in the United States: evidence from a large representative survey. *Social Science & Medicine* (1982) 68: 2137–2144.
- Castellari, E., & Berning, J. P. (2016). *Can providing a morning healthy snack help to reduce hunger during school time? Experimental evidence from an elementary school in Connecticut*. *Appetite*, 106: 70–77.
- Castellari, E., Marette, S., Moro, D., & Sckokai, P. (2018). Can menu labeling affect away-from-home dietary choices? *Bio-based and Applied Economics*, 7(3): 249–263.
- Cavallo, F., Lemma, P., Dalmasso, P., Vieno, A., Lazzeri, G., and Galeone, D. (2016). *4° Rapporto sui dati italiani dello studio internazionale HBSC*. Torino: Dipartimento di Scienze della Sanità Pubblica e Pediatriche, 118.
- Centro di Ricerca Alimenti e Nutrizione (CREA) (2019). *Linee Guida per Una Sana Alimentazione Revisione 2018*. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2915_allegato.pdf (accessed on 04/02/2024).
- Cerroni S, Watson V & Macdiarmid JI (2019) Consumers' rationality and home-grown values for healthy and environmentally sustainable food. *Bio-based and Applied Economics* 8, 101–132.
- Cramer, J. S. (2003). The standard multinomial logit model. In *Logit Models from Economics and Other Fields*. Cambridge University Press, 104–125.
- Cunningham, S. A., Kramer, M. R., Narayan, K. M. V., and Venkat Narayan, K. M. (2014). Incidence of childhood obesity in the United States. *New England Journal of Medicine* 370: 403–411.
- Dolgoplova I, Li B, Pirhonen H, et al. (2022) The effect of attribute framing on consumers' attitudes and intentions toward food: A Meta-analysis. *Bio-based and Applied Economics* 10, 253–264.
- European Commission. (2006). THE LEADER APPROACH A basic guide. *Office for Official Publications of the European Communities*.
- European Commission. (2020). *School scheme explained*. European Commission https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/market-measures/school-fruit-vegetables-and-milk-scheme/school-scheme-explained_en, (accessed on 12/20/2020).
- Eurostat. (2022). *Overweight and obesity - BMI statistics*. Statistics Explained - Eurostat.
- Fernández-Alvira, J. M., Börnhorst, C., Bammann, K., Gwozdz, W., Krogh, V., Hebestreit, A., Barba, G., Reisch, L., Eiben, G., Iglesia, I., Veidebaum, T., Kourides, Y. A., Kovacs, E., Huybrechts, I., Pigeot, I., and Moreno, L. A. (2015). Prospective associations between socio-economic status and dietary patterns in European children: The Identification and Prevention of Dietary- And Lifestyle-induced Health Effects in Children and Infants (IDEFICS) study. *British Journal of Nutrition* 113: 517–525.
- Ferreira, I., Van Der Horst, K., Wendel-Vos, W., Kremers, S., Van Lenthe, F. J., and Brug, J. (2006). Environmental correlates of physical activity in youth - A review and update. *Obesity Reviews* 8: 129–154.
- Fogelholm, M., Nuutinen, O., Pasanen, M., Myöhänen, E., and Säätelä, T. (1999). Parent-child relationship of physical activity patterns and obesity. *International Journal of Obesity* 23: 1262–1268.
- Goldman, R. L., Radnitz, C. L., and McGrath, R. E. (2012). The role of family variables in fruit and vegetable consumption in preschool children. *Journal of Public Health Research* 1: 143–148.
- Hallström, L., Vereecken, C. A., Labayen, I., Ruiz, J. R., Le Donne, C., García, M. C., Gilbert, C. C., Martínez, S. G., Grammatikaki, E., Huybrechts, I., Kafatos, A., Kersting, M., Manios, Y., Molnár, D., Patterson, E., Widhalm, K., De Vriendt, T., Moreno, L. A., and Sjöström, M. (2012). Breakfast habits among Euro-

- pean adolescents and their association with sociodemographic factors: The HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. *Public Health Nutrition* 15: 1879–1889.
- Hallström, L., Vereecken, C. A., Labayen, I., Ruiz, J. R., Le Donne, C., García, M. C., Gilbert, C. C., Martínez, S. G., Grammatikaki, E., Huybrechts, I., Kafatos, A., Kersting, M., Manios, Y., Molnár, D., Patterson, E., Widhalm, K., De Vriendt, T., Moreno, L. A., Sjöström, M., ... Sjöström, M. (2013). Breakfast consumption and CVD risk factors in European adolescents: The HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. *Public Health Nutrition* 16: 1296–1305.
- Hanson, M. D., and Chen, E. (2007). Socioeconomic status and health behaviors in adolescence: A review of the literature. *Journal of Behavioral Medicine* 30: 263–285.
- Hart, C. N., Raynor, H. A., Jelalian, E., and Drotar, D. (2010). The association of maternal food intake and infants' and toddlers' food intake. *Child: Care, Health and Development* 36: 396–403.
- Hebert, J. R., Clemow, L., Pbert, L., Ockene, I. S., and Ockene, J. K. (1995). Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. *International Journal of Epidemiology* 24: 389–398.
- Hernández, B., Gortmaker, S. L., Colditz, G. A., Peterson, K. E., Laird, N. M., and Parra-Cabrera, S. (1999). Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *International Journal of Obesity* 23: 845–854.
- Inchley, J., Currie, D., Budisavljevic, S., Torsheim, T., Jåstad, A., Cosma, A., Kelly, C., Samdal, O., and Arnarsson, Á. M. (2020). *Spotlight on adolescent health and well-being. Findings from the 2017/2018 Health Behaviour in School-aged Children (HBSC) survey in Europe and Canada. International report. Volume 2. Key data.* Copenhagen: WHO Regional Office for Europe, 144.
- ISTAT. (2018). *Aspetti della vita quotidiana. Periodo di riferimento: anno 2016. Aspetti metodologici dell'indagine.* Roma: ISTAT, 21.
- ISTAT. (2021). *Multipurpose Survey on Households: Aspects of Daily Life - Microdata for research purposes.* ISTAT. <https://www.istat.it/en/archive/129934> (accessed on 04/24/2021).
- Jahns, L., Siega-Riz, A. M., and Popkin, B. M. (2001). The increasing prevalence of snacking among US children from 1977 to 1996. *Journal of Pediatrics* 138: 493–498.
- Janssen, I. (2007). Guidelines for physical activity in children and young people. *Applied Physiology, Nutrition and Metabolism* 32: S122–S135.
- Kachwaha, S., Kim, S. S., Das, J. K., Rasheed, S., Gavaravarapu, S. M., Pandey Rana, P., and Menon, P. (2024). Behavior Change Interventions to Address Unhealthy Food Consumption: A Scoping Review. *Current Developments in Nutrition* 8: 102104.
- Kueppers, J., Stein, K. F., Groth, S., and Fernandez, I. D. (2018). Maternal and child dietary intake: The role of maternal healthy-eater self-schema. *Appetite* 125: 527–536.
- Lauria, L., Spinelli, A., Buoncristiano, M., and Nardone, P. (2019). Decline of childhood overweight and obesity in Italy from 2008 to 2016: Results from 5 rounds of the population-based surveillance system. *BMC Public Health* 19: 1–9.
- Lauria, L., Spinelli, A., Cairella, G., Censi, L., Nardone, P., and Buoncristiano, M. (2015). Dietary habits among children aged 8-9 years in Italy. *Annali Dell'Istituto Superiore Di Sanita* 51: 371–381.
- Lobstein, T., Baur, L., and Uauy, R. (2004). Obesity in children and young people: A crisis in public health. *Obesity Reviews, Supplement 5*: 4–104.
- Lustig, R. H. (2001). The neuroendocrinology of childhood obesity. *Pediatric Clinics of North America* 48: 909–930.
- MacMahon, S., Baigent, C., Duffy, S., Rodgers, A., Tomi-naga, S., Chambless, L., De Backer, G., De Bacquer, D., Kornitzer, M., Whincup, P., Wannamethee, S. G., Morris, R., Wald, N., Morris, J., Law, M., Knuiman, M., Bartholomew, H., Davey Smith, G., Sweetnam, P., ... Whitlock, G. (2009). Body-mass index and cause-specific mortality in 900 000 adults: Collaborative analyses of 57 prospective studies. *The Lancet* 373: 1083–1096.
- Maestri, G., Macchioni, E. (2021) La cultura del cibo tra genitorialità e stili di vita. Legami e semantiche familiari. In: Prandini, R., Maestri, G., Bassi, A. (a cura di) *Cibo, stili di vita, salute. Un'indagine empirica nel territorio della ASL di Reggio-Emilia.* Franco Angeli Editore, Milano.
- Nardone, P., Spinelli, A., Buoncristiano, M., Lauria, L., Pierannunzio, D., and Galeone, D. (2018). *Il Sistema di sorveglianza OKkio alla SALUTE: risultati 2016.* Roma: Istituto Superiore di Sanità, 83.
- Nardone, P., Spinelli, A., Ciardullo, S., Salvatore, M. A., Andreozzi, S., and Galeone, D. (2022). *Obesità e stili di vita dei bambini: OKkio alla SALUTE 2019.* Rapporti ISTISAN 22/27. Roma.
- Neumark-Sztainer, D., Story, M., Perry, C., and Casey, M. A. (1999). Factors influencing food choices of adolescents: Findings from focus- group discussions with

- adolescents. *Journal of the American Dietetic Association* 99: 929–937.
- Ng, N. B. H., Ng, J. Q. X., Shen, L., and Shorey, S. (2025). Redefining Roles—Fathers Play a Crucial Role in Shaping Children's Healthy Eating Behaviors: Cross-Sectional Observational Study. *Nutrients* 17.
- O'Loughlin, J., Paradis, G., Kishchuk, N., Barnett, T., and Renaud, L. (1999). Prevalence and correlates of physical activity behaviors among elementary schoolchildren in multiethnic, low income, inner-city neighborhoods in Montreal, Canada. *Annals of Epidemiology* 9: 397–407.
- Park, M. H., Falconer, C., Viner, R. M., and Kinra, S. (2012). The impact of childhood obesity on morbidity and mortality in adulthood: A systematic review. *Obesity Reviews* 13: 985–1000.
- Pearson, N., Biddle, S. J. H., and Gorely, T. (2009). Family correlates of fruit and vegetable consumption in children and adolescents: A systematic review. *Public Health Nutrition* 12: 267–283.
- Pickard, A., Farrow, C., Haycraft, E., Herle, M., Edwards, K., Llewellyn, C., Croker, H., and Blissett, J. (2024). Associations between parent and child latent eating profiles and the role of parental feeding practices. *Appetite* 201: 107589.
- Pindyck, S., and Rubinfeld, L. (1998). *Econometric models and economic forecasts*. United States of America, McGraw-Hill, Inc.
- Prandini, R., Mastri, G., Bassi, A. (2021). *Cibo, stili di vita, salute. Un'indagine empirica nel territorio della ASL di Reggio-Emilia*. Milano.
- Pulgarón, E. R. (2013). Childhood Obesity: A Review of Increased Risk for Physical and Psychological Comorbidities. *Clinical Therapeutics* 35: A18–A32.
- Rankin, J., Matthews, L., Cobley, S., Han, A., Sanders, R., Wiltshire, H. D., and Baker, J. S. (2016). Psychological consequences of childhood obesity: psychiatric comorbidity and prevention. *Adolescent Health, Medicine and Therapeutics* 7: 125–146.
- Rolland-Cachera, M. F., Deheeger, M., Maillot, M., and Bellisle, F. (2006). Early adiposity rebound: Causes and consequences for obesity in children and adults. *International Journal of Obesity* 30: S11–S17.
- Sogari, G., Wongprawmas, R., Andreani, G., Lefebvre, M., Pellegrini, N., Gómez, M. I., Mora, C., & Menozzi, D. (2024). Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing. *Bio-Based and Applied Economics*, 13(3): 301–316.
- Steinbeck, K. S. (2001). The importance of physical activity in the prevention of overweight and obesity in childhood: A review and an opinion. *Obesity Reviews* 2: 117–130.
- Stettler, N., Zemel, B. S., Kumanyika, S., and Stallings, V. A. (2002). Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics* 109: 194–199.
- Story, M., Neumark-Sztainer, D., and French, S. (2002). Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association* 102: S40–S51.
- Swinburn, B., Egger, G., and Raza, F. (1999). Dissecting obesogenic environments: The development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine* 29: 563–570.
- Swinburn, B., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., and Gortmaker, S. L. (2011). The global obesity pandemic: shaped by global drivers and local environments. *The Lancet* 378: 804–814.
- Vereecken, C. A., Keukelier, E., and Maes, L. (2004). Influence of mother's educational level on food parenting practices and food habits of young children. *Appetite* 43: 93–103.
- Videon, T. M., and Manning, C. K. (2003). Influences on adolescent eating patterns: The importance of family meals. *Journal of Adolescent Health* 32: 365–373.
- Vitali, V., Tiboldo, G., Castellari, E., & Meshkovska, B. (2023). *Teachers' perspectives on the EU Fruit and Vegetable Scheme implementation in Italy*. *Health Education Journal*, 82(8), 907–921.
- Wang, Y., Beydoun, M. A., Li, J., Liu, Y., and Moreno, L. A. (2011). Do children and their parents eat a similar diet? Resemblance in child and parental dietary intake: Systematic review and meta-analysis. *Journal of Epidemiology and Community Health* 65: 177–189.
- Whitaker, K. L., Jarvis, M. J., Beeken, R. J., Boniface, D., and Wardle, J. (2010). Comparing maternal and paternal intergenerational transmission of obesity risk in a large population-based sample. *The American Journal of Clinical Nutrition* 91: 1560–1567.
- WHO. (2025). *WHO European Childhood Obesity Surveillance Initiative (COSI): report on the sixth round of data collection, 2022– 2024*. Copenhagen: WHO (<https://iris.who.int/server/api/core/bitstreams/8ee17a15-aa52-421e-94d1-892c3cf191e8/content>, accessed on 05/30/2026).
- WHO. (2017). Report of the Commission on Ending Childhood Obesity. In *Implementation Plan: Executive summary*. Geneva: WHO.



Citation: Strusi, V. & Balestri, S. (2026). Land, women and development: A systematic review of causal evidence. *Bio-based and Applied Economics* 15(3): 55-75. doi: 10.36253/bae-17846

Received: May 15, 2025

Accepted: October 27, 2025

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Silvia Coderoni

Associated Editor: Donato Romano

ORCID

VS: 0009-0007-0077-0792

SB: 0000-0002-4070-4665

Land, women and development: A systematic review of causal evidence

VALERIA STRUSI^{1*}, SARA BALESTRI²

¹ Department of International Economics, Institutions and Development (DISEIS), Università Cattolica del Sacro Cuore, Largo Gemelli, 1, Milan, 20123, Italy

² Department of Economics, University of Perugia, Perugia, Italy

*Corresponding author. E-mail address: valeria.strusi@gmail.com

Abstract. This article systematically reviews the causal literature on the impacts of women's land rights on development in the Global South, asking how they affect different development outcomes, and what patterns emerge across types of rights, geographies, and methodological approaches. Following the PRISMA protocol, we screen over 800 records and retain 96 studies, covering 46 countries and 202 effects classified in 11 outcomes. Findings show consistently positive effects on *empowerment*, *education*, and *health*, though the latter are less studied. Evidence on *investment*, *financial inclusion*, and *welfare* is more ambiguous, while *natural resource management* and *intra-household dynamics* remain too underexplored for meaningful conclusions. Most research focuses on formal ownership, overlooking the broader 'bundle' of rights; regions outside Africa and South Asia are critically underrepresented. By mapping causal patterns and gaps, this review establishes a systematic evidence map and guides future evaluations addressing thematic and geographic blind spots.

Keywords: land, land rights, women, development, systematic review, PRISMA.

1. INTRODUCTION

Gender-based discrimination in land access is a well-documented issue in the empirical literature. Women often have inferior rights to natural resources (Otsuka & Place, 2001), and when they do hold rights to land, these often apply to smaller or lower-quality plots than those allocated to men (FAO, 2011). This disparity arises not only from discrimination in the allocation of agricultural land but also from unequal access to complementary inputs such as fertilizer, pesticides, and extension services (Burke et al., 2018; Burke & Jayne, 2021; Chu et al., 2023).

Even with formal landownership, effective access and use can be limited by weak institutions that fail to enforce rights. For poor rural women, pursuing justice entails both financial and social costs, especially when family or clan dependence discourages challenging these power structures (Polavara-pu, 2020).

Women's land claims often remain weak despite access to formal justice, due to poor enforcement of statutory rights, elite-driven land dispossession, and overlapping legal systems. Customary courts – the main dispute-resolution venues in developing countries – often reflect patriarchal norms that discriminate against women and reinforce gender inequalities (Behrman et al., 2012; Dell'Angelo et al., 2017; Polavarapu, 2020). Legal discrimination at the intersection of land, marriage, and inheritance laws further limits women's rights as their claims often depend on relationships with men, leaving them vulnerable when these ties change or dissolve.

Economic theory and empirical case studies suggest that land access can reduce the gender asset gap, strengthening women's economic security and social status (Bhaumik et al., 2016) and contributing to broader household and community development (Agarwal, 1995; Doss, 2006; Duflo & Udry, 2004; Luke & Munshi, 2011; Quisumbing & Maluccio, 2003). More recently, land rights (LRs) have also been linked to improved climate adaptation and societal resilience (Laura et al., 2023). Yet, the relationship between land access, women's agency, and development remains poorly understood. Empirical findings are heterogeneous across geographies, outcomes and research designs, and much of the discourse continues to rely on fragmented case studies rather than systematic evidence. Consequently, generalized claims – such as the portrayal of land access as a 'panacea for household welfare problems' (Bhaumik et al., 2016, p. 249) – risk overstating the case in the absence of a comprehensive appraisal of the scientific literature.

In this context, a systematic review is both timely and necessary. As global development agendas increasingly prioritize gender equality, LRs, and climate resilience, there is an urgent need for a rigorous synthesis of causal evidence to inform policy and future research. To our knowledge, this is the first systematic review on the land-women-development nexus that applies a standardized protocol of analysis as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021), ensuring transparency and methodological consistency.

A natural point of reference to this work is the earlier review of Meinzen-Dick et al. (2019), which mapped 11 pathways linking women's land rights (WLRs) to poverty reduction, and narratively synthesized the qualitative and quantitative evidence up to 2017. Building on that foundation – but restricting inclusion to studies adopting inferential methods – this review also innovates by: (1) documenting geographic, temporal and methodological trends in the literature, (2) introducing a typology of LRs to assess how different forms of access

are explored in the empirical literature, and (3) including publications through late 2024, thereby broadening the temporal coverage of Meinzen-Dick et al. (2019).

Methodologically, our approach also aligns with Lawry et al. (2017) in (1) prioritizing causal identification through quantitative studies that go beyond descriptive analysis, (2) organizing outcomes in ten classes that partly overlap with ours (i.e., investment, productivity, access to credit, consumption, gender equality), and (3) emphasizing effect heterogeneity across countries and regions. Our review, however, differs in three respects. First, gender is the central organizing principle rather than a subgroup dimension: we restrict inclusion to studies identifying effects of WLRs and track outcomes directly tied to women's agency in households and communities (e.g., *empowerment, health, education*). Second, we introduce a typology of LRs, an angle not systematically pursued by Lawry et al. (2017). Finally, to provide a full picture of the evidence base, we also include carefully controlled observational designs, while acknowledging the tradeoffs for internal validity (see Section 4.4).

Therefore, by cutting through the complexity and fragmentation of the existing evidence, this review provides a solid grounding for advancing scholarly understanding and policy debates around WLRs and their development implications.

2. THEORETICAL PERSPECTIVES ON SECURING WLRs

Along the traditional measurement of the gender asset gap, awareness of its implications for development has gradually emerged, with scholars and policymakers linking its reduction to poverty alleviation (de Janvry & Sadoulet, 2016; Meinzen-Dick et al., 2019). Rooted in institutional theory, this idea highlights the role of property rights in economic development. When farmers enjoy secure property rights and ownership protection, they invest more in their land, enhancing agricultural productivity, natural resource management (NRM), access to credit, and, ultimately, long-term growth in output and income (de Janvry & Sadoulet, 2016). Recognized rights also allow land rental or sales to more efficient users, potentially generating gains from trade. Additionally, better rights make it easier to collateralize land, further enabling investment (de Soto, 2000; Besley, 1995). Several influential studies provide empirical evidence for these claims, particularly in Africa (Goldstein & Udry, 2008; Ali et al., 2011; Deininger et al., 2008).

Although early property rights theory established a connection between landownership and development, it

did not incorporate an explicit gender perspective. Yet, it already recognized that a ‘male monopoly over property’ (Folbre, 1996, p.10) undermines efficiency by limiting women’s full participation in economic activities.

During the mid-2000s, policymakers’ early enthusiasm for formal, individual land titles (de Soto, 2000) shifted toward recognizing informal and communal rights (Ostrom, 1990) as more effective tools for protecting vulnerable groups from ‘land grabs’ (De Schutter, 2015). At the same time, many economists moved away from the unitary model of the household (Becker, 1974), which treats the family as a single utility-maximizing entity, in favor of collective frameworks (Chiappori, 1992), particularly intra-household bargaining models (Agarwal, 1997a), which acknowledge that intra-household inequality and different preferences – often gender-based – shape household spending and resource allocation.

Within a bargaining framework, Agarwal (1994) presents three arguments for why WLRs matter for development: efficiency, empowerment and welfare. Efficiency refers to the productive use of land: in line with property rights theory, women with secure land access tend to invest more in productive and sustainable agricultural practices (Goldstein & Udry, 2008) and freely decide what to grow, consume or sell, enhancing food security (Duflo & Udry, 2004; FAO, 2011). Empowerment involves enhancing ‘women’s agency and voice’ (Sen, 1999, p. 193). Land, as a source of wealth and social status (de Janvry & Sadoulet, 2016), can enhance women’s bargaining power and lessen dependence on male relatives. Economic independence, in turn, can mitigate the risk of gender-based violence (Polavarapu, 2020), decrease reliance on transactional sex, and improve women’s ability to negotiate safer sex, helping prevent STIs (Conrad & Doss, 2008). These benefits extend to household and community welfare: landownership increases women’s influence over nutrition, education and healthcare (Agarwal, 1995) and serves as collateral for such expenses (Menon et al., 2014; Agarwal, 2003). Critics of the unitary model (Ward-Batts, 2008; Lundberg et al., 1997; Armand et al., 2020; Alderman et al., 1995) show that family expenditure patterns depend on who controls assets: women typically allocate resources more equitably and with long-term perspective (Udry, 1996; Deininger et al., 2013; Burrone & Giannelli, 2023; Thomas, 1990; McElroy, 1990), benefiting children’s well-being and especially girls’ human capital.

Access to land is also expected to encourage women’s participation in collective action at local and broader societal levels, potentially enhancing institutional inclusivity. Their involvement in managing village commons, in particular, can strengthen social equity and commu-

nity resilience, while gender-equitable management of common-pool resources can prevent resource conflict and the ‘tragedy of the commons’ (Meinzen-Dick et al., 1997; Pandolfelli et al., 2008; Ratner et al., 2013).

Recent research explores how different LR typologies influence development. Moving beyond traditional ‘ownership,’ scholars increasingly refer to a ‘bundle of rights,’ a continuum of land-related actions held jointly or individually (Schlager & Ostrom, 1992)¹. Women rarely enjoy a complete ‘bundle,’ and different rights affect outcomes differently.

Emerging approaches also highlight the distinction between individual and joint rights as a key measure of women’s land autonomy (Bhatla et al., 2010). Individual rights, particularly those backed by formal titles, are often more empowering (Agarwal, 2003), as they reduce dependence on others. However, since empowerment depends on what is culturally perceived as legitimate and appropriate (Jackson, 2003), individual ownership can disrupt power relations, triggering conflict and ‘male backlash’ as predicted by the relative resource theory of domestic violence (Atkinson et al., 2005).

3. RESEARCH AIM AND METHODS

Building on such theoretical arguments, a growing body of empirical research has tested the land-women-development nexus, yet causal relationships remain inconclusive. Findings vary significantly across regions, types of rights, and methodological approaches. While development practitioners promote land tenure security, there is still limited understanding of its broader benefits and the contextual factors, such as gender norms and intra-household dynamics, that mediate its impact (Higgins et al., 2018; Lawry et al., 2017).

We therefore propose a systematic review to take stock of such empirical evidence. Specifically, we asked: “How do WLRs affect development outcomes, and what patterns emerge across different types of rights, geographical contexts, and methodological approaches?” This research question guided our effort to synthesize findings, identify evidence gaps, and trace the evolution of research in this domain. We identified well-studied and underexplored outcomes from a gender perspective, and evaluated the direction, consistency, and geographical distribution of findings as well as the methods used to estimate causal effects. Additionally, we examined

¹ Schlager & Ostrom (1992) identify rights of access, withdrawal, management, exclusion and alienation. Empirical studies have adapted this framework to fit case studies, often mapping them into access, use and ownership/control (Meinzen-Dick et al., 2019).

the extent to which empirical literature distinguishes between (1) individual and joint rights, and (2) different rights within Schlager & Ostrom (1992)'s 'bundle'.

This review applied the PRISMA 2020 statement, renowned for setting standards for transparent and reproducible systematic reviews (Page et al., 2021).² Our protocol incorporated strategies from seminal works (e.g., Pickering & Byrne, 2014) on systematic reviews in social sciences and was preregistered online³. While systematic reviews have been widely applied to land research, they rarely adopt a gender perspective, which we instead propose in this review.⁴

3.1. Eligibility criteria

We included peer-reviewed articles or reputable working papers in English that provided causal evidence through observational (with at least multivariate regression), quasi-experimental, or experimental approaches.

Further criteria were inspired by the PICO framework. Eligible studies focused on populations (P) from low- to upper-middle-income countries. In (quasi-)experimental studies, interventions (I) encompassed laws, policies, and land-use changes affecting women's ability to benefit from land. In observational studies, outcome comparisons based on the presence/absence of rights or varying levels of tenure security for women were used as interventions. Comparisons (C) required baseline groups where women lacked rights or had insecure tenure (using temporal, spatial, or between-group designs). Outcomes (O) were not predefined, to capture the full range of potential impacts as they naturally emerged from the review (Page et al., 2021).

3.2. Search strategy

We searched Web of Science, Scopus, and EconLit, recognized for their coverage of peer-reviewed development research. We applied a stepwise refinement approach to progressively narrow the search queries (Figure S1.1). The final query focused on three core themes: land, rights, and women, with minor adjustments to align with databases' search syntax (Figure 1).

Database	Search query	Limitations
EconLit	NOFT(wom?n OR gender* OR female)	Peer reviewed
	AND NOFT("land rights" OR "land tenure" OR "property rights" OR "ownership rights" OR "access rights" OR "use rights" OR "tenure rights" OR "inherit" rights" OR "tenure security" OR "management rights" OR "control rights")	Article
	AND NOFT(land) AND DTYPE("Article") AND PEER(yes) AND LA(English)	English
Scopus	TITLE-ABS-KEY (wom?n OR gender* OR female)	
	AND TITLE-ABS-KEY ("land rights" OR "land tenure" OR "property rights" OR "ownership rights" OR "access rights" OR "use rights" OR "tenure rights" OR "inherit" rights" OR "tenure security" OR "management rights" OR "control rights")	Article
	AND TITLE-ABS-KEY (land)	Social Sciences Economics
Web of Science Core Collection	AND (LIMIT-TO (SUBJAREA, "SOCT")	
	OR LIMIT-TO (SUBJAREA, "ECON")	English
	AND (LIMIT-TO(DOCTYPE,"ar"))	
Web of Science Core Collection	AND (LIMIT-TO(LANGUAGE, "English"))	
	(wom?n OR gender* OR female)	
	AND ("land rights" OR "land tenure" OR "property rights" OR "ownership rights" OR "access rights" OR "use rights" OR "tenure rights" OR "inherit" rights" OR "tenure security" OR "management rights" OR "control rights")	Article Early Access
Web of Science Core Collection	AND land (Topic)	Economics Development Studies
	AND Article or Early Access (Document Types)	
	AND Economics or Development Studies (Categories)	English
Web of Science Core Collection	AND English (Languages)	

Source: Authors' elaboration.

Figure 1. Search query.

In line with the strategy outlined in Section 3, it avoided mentioning specific outcomes (e.g., 'education').

Additionally, we manually screened the reference lists of retrieved studies to identify relevant publications not captured by the initial queries⁵. As a result, we included 14 additional publications (Table S2.1), which underwent the same eligibility screening and data extraction procedures as those retrieved from the original search.

Since studies often report multiple effects across countries and outcomes, we treated effects as units of analysis rather than entire articles, following the approach adopted by Higgins et al. (2018). Effects were recorded in a spreadsheet with their corresponding attributes (e.g., country, statistical significance) (Pickering & Byrne, 2014; Ogundari, 2022). Multiple estimates for the same effect – derived from different model specifications, robustness checks or heterogeneity analyses – were consolidated based on reviewers' judgment.

The PRISMA flowchart (Figure 2) illustrates the workflow of screening, retrieving, and selecting articles, resulting in 96 studies and 202 effects after snowballing (Table S3.1).

Although no outcomes were specified in the search query, a working definition of "development outcomes" guided screening to ensure consistency. These are understood as measurable, objective dimensions of socio-economic progress at the individual, household, or community level, including, but not limited to, agricultural productivity, household income and expenditure, health and

² The wide range of outcomes, heterogeneous indicators, and differences in WLRs coding made a formal meta-analysis unfeasible. A systematic review instead enables a structured synthesis that accommodates methodological variation.

³ See the study protocol for further methodological details (<https://doi.org/10.17605/OSF.IO/45QKB>).

⁴ See de Jong et al. (2021), Higgins et al. (2018), Lawry et al. (2017), and Murken & Gornott (2022).

⁵ While database searches remain the core of systematic reviews, PRISMA permits supplementary backward snowballing to enhance comprehensiveness, provided that its use is cautious, transparent, and reproducible (Page et al., 2021).

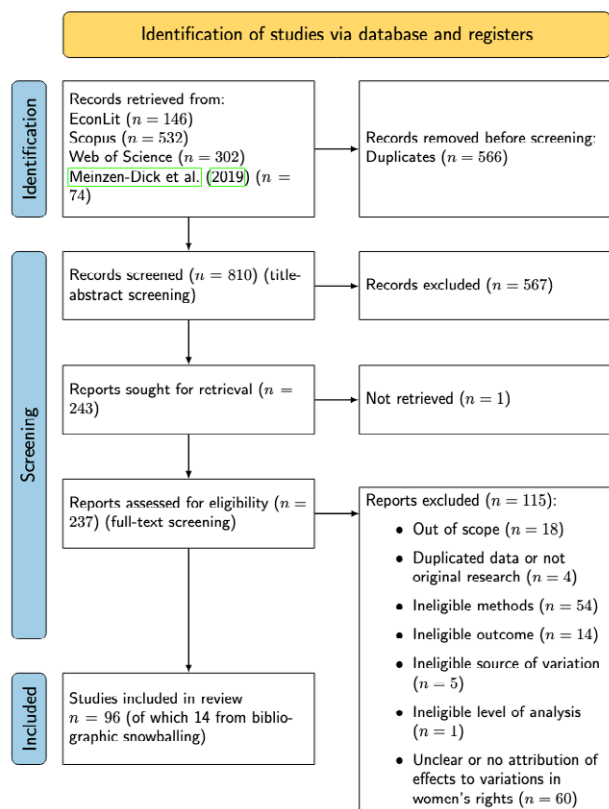


Figure 2. PRISMA flowchart. Source: Authors' elaboration based on Page et al. (2021)'s template. Note: The diagram illustrates the workflow of identifying, screening and including publications in the review.

nutrition, education, and women's empowerment. Consequently, outcomes not directly indicative of development were deemed "ineligible". For example, migration was excluded due to its ambiguity, as it may imply either an adaptation strategy or a decline in living standards⁶. Thus, the review focuses on outcomes clearly linked to development impacts attributable to WLRs.

3.3. Limitations

Given the complexity and context-specific nature of land-related impacts, especially gendered ones, we included only empirical studies that moved beyond descriptive correlations and addressed selection bias and confounding factors using inferential methods. This methodological filter ensures internal validity and supports evidence-based policy recommendations grounded in robust causal inference.

However, this choice entails limitations. Excluding purely observational or descriptive studies, which offer valuable qualitative insights or rich contextual detail, risks overlooking important dimensions of the WLR-development nexus. It may bias findings toward data-rich settings, underrepresenting marginalized groups, lesser-studied regions, and informal tenure systems. Moreover, causal studies often emphasize measurable outcomes, neglecting longer-term or intangible effects better captured by qualitative research. Therefore, while enhancing findings' internal validity, our approach may limit breadth and external validity. A fuller understanding of WLRs' impacts would benefit from complementary syntheses incorporating mixed-method and ethnographic studies to capture social norms, power dynamics, and lived experiences influencing tenure security and development.

4. MAIN FINDINGS OF THE SYSTEMATIC LITERATURE REVIEW

The final sample of 96 publications reflects the richness and fragmentation of the empirical literature on WLRs and development. Geographically, the evidence is highly concentrated in Sub-Saharan Africa and South Asia, with scattered coverage in other regions. Thematically, it spans 11 outcome areas attributable to development processes, including *women's empowerment*, *household welfare*, *agricultural productivity*, *financial inclusion*, and *health*. Methodologically, most studies rely on observational and, to a lesser extent, quasi-experimental designs, often exploiting policy changes to identify causal effects⁷.

Building on this evidence, this section presents the main findings of the systematic review, focusing on how WLRs influence various development outcomes. We first examine WLRs' operationalization in the literature, emphasizing the elements of the 'bundle' and how these distinctions shape observed effects (Section 4.1). To facilitate comparison, outcomes were grouped into broader domains reflecting the primary focus of reported effects, with empirical insights synthesized for each (Section 4.2). The analysis then considers studies' geographical and temporal coverage (Section 4.3) and, subsequently, their methods and data (Section 4.4), offering a systematic overview of not only what outcomes are affected by WLRs but also how, where, and with which methodological approaches these effects have been assessed.

⁷ See Tables S4.1 and S4.2 for the distribution of studies across regions, methods, and outcomes, together with detailed information for each included study.

⁶ See, for example, Kudo (2015).

4.1. Operationalizing the 'Bundle of Rights'

Contemporary economic theory (Schlager & Ostrom, 1992) highlights the importance of women's concrete actions regarding land. To assess whether empirical literature reflects this, we propose a preliminary classification of the LRs mentioned as explanatory variables in reviewed studies (Figure E1). Most effects (190) are explicitly associated with ownership or inheritance, typically self-reported or documented via a land title. However, authors often omit details on the specific claims these rights entail or how they were validated in surveys. Although ownership is often assumed to grant the complete 'bundle of rights,' even titling does not ensure women can exercise any or all rights. Shwachman Kaminaga & Sheldon (2022, p. 1200) observe that '[t]he interplay between *de facto* and *de jure* legal systems [...] [affects] whether a title (physical or assumed) is recognized in practice.' If ownership simply reflects *de jure* rights, our understanding of *de facto* rights (and their heterogeneous impacts) is impaired. Further, studies rarely assess different rights separately, often combining them into a single explanatory variable.

Other rights in the 'bundle' are scarcely represented: alienation appears only in 25 effects; access/use rights are present in 18 effects (based on actual access or land-use certificates); management and withdrawal are evaluated in only 14 and eight effects, respectively. No studies explicitly mention exclusion rights; though five cases report women's inability to maintain exclusive land access (e.g., the fear of land loss noted in Deininger et al., 2019). This gap is notable, as Schlager & Ostrom (1992) argue that individual rights of exclusion promote investment and productivity.

Only 20 studies consider multiple dimensions of the 'bundle.' Notably, 55% are concentrated in Sub-Saharan Africa, indicating a strong regional focus that will be examined in more detail in the following sections.

4.2. Development outcomes

The analysis identified 11 outcome categories attributable to development processes. Among these, *women's empowerment* emerged as the most investigated one. Others derived from the theoretical literature (*investment and environmental sustainability, agricultural productivity, NRM, and financial inclusion*), scholars' attention to 'mediated' impacts (*welfare, health, and education*), and the latest developments in this field (*intra-household dynamics, social capital and collective action, and social stability*).

Greater consistency of findings emerges from specific areas of *empowerment* (namely, *decision-making* and *economic empowerment*), *health*, and *education*, where WLRs are connected to robust and positive impacts. More heterogeneous or scattered findings emerge on the remaining outcomes.

4.2.1. Women's empowerment

With 45 studies, *empowerment* emerges as the most examined outcome, slightly more based on observational studies (51%) and with broad country coverage, especially in South Asia and Sub-Saharan Africa. We identified four main dimensions: *decision-making, economic empowerment, family planning, and intimate partner violence (IPV)*.

Decision-making is the most popular theme in this area, with most studies confirming a positive relationship. Particularly coherent findings emerge from quasi-experimental studies, where nearly every intervention demonstrated a positive impact (Ajefu et al., 2024; Biswas et al., 2024; Grabe, 2010; Grabe, 2015; Melesse et al., 2018; Mishra & Sam, 2016; Persha et al., 2017; Santos et al., 2014; Schling & Pazos, 2024; Wiig et al., 2011). A few observational studies, however, have found insignificant effects in specific countries (Amir-ud-Din et al., 2024; Doss et al., 2014; Kumar et al., 2020; Yokying & Lambrecht, 2020).

Decision-making power is usually measured in the *household*, except for Grabe (2015) on women's participation in community meetings. Thresholds for considering a woman 'empowered' vary widely, from having (some) input in (key) family decisions, to full independence.

Findings on '*economic empowerment*'⁸ are largely positive, particularly on employment and earnings in Sub-Saharan Africa (Ajefu et al., 2024; Peterman, 2011; Efobi et al., 2019) and Vietnam (Menon et al., 2017). Nevertheless, negative effects on employment were identified in India's patrilineal societies (Bahrami-Rad, 2021), where the combination of property inheritance and social stigma against women working outside the home reduced their economic participation, particularly in agriculture. Similarly, in China, reforms granting land leasing rights increased men's off-farm employment more than women's, leaving them with greater household and childcare responsibilities (Shi et al., 2024).

WLRs were also found to increase household expenditure/savings on healthcare, education and women's and girls' goods, and to decrease those in traditional

⁸ *Economic empowerment* includes employment, entrepreneurship, influence on household expenditure, and similar outcomes.

men's goods (Brulé, 2010; Muchomba, 2017; Nguyen & Le, 2023; Quisumbing & Maluccio, 2003).

Four studies on India's inheritance reform, however, reveal troubling family-planning outcomes: landed women were more likely to marry paternal cousins to keep property within male lineages (Bahrami-Rad, 2021) and showed a stronger preference for male offspring (Bose & Das, 2024). Related evidence indicates increased female foeticide (Bhalotra et al., 2020) and child mortality (Rosenblum, 2015). Overall, these findings suggest that – despite pro-women land reform – social norms adapt to preserve traditional inheritance patterns, as households seek more sons to maintain male control over family assets.

A small evidence base explores women's experiences with IPV, with mixed findings. While some studies show protective effects of WLRs (Biswas et al., 2024; Muchomba et al., 2014; Panda & Agarwal, 2005), others report increased IPV under specific conditions (Peterman et al., 2017; Shwachman Kaminaga & Sheldon, 2022; Ward & Harlow, 2021), particularly in South Asia (Anderson & Genicot, 2015; Murshid, 2017).

4.2.2. Investment and environmental sustainability

The review identified 19 studies on investment and environmental sustainability⁹, mainly concentrated on Sub-Saharan Africa (80%) and mostly based on observational evidence.

One experimental study – the only randomized-controlled trial (RCT) in this review – found that land formalization in Benin promoted long-term investments, with particularly strong effects among female-headed households (Goldstein et al., 2018).

Quasi-experimental studies show mixed findings. In Rwanda, land regularization increased soil conservation, particularly among female-headed households (Ali et al., 2014). Similarly, in Zambia, widows' inability to inherit land reduced fertilizer use, fallowing and intensive tillage (Dillon & Voena, 2018). In India, adding women's names to land titles boosted agricultural investment and the use of higher-quality inputs (Santos et al., 2014). Nevertheless, other studies found no significant effects. In Nicaragua, for example, titling alone had no effect, suggesting the need for complementary support for vulnerable groups (De La O Campos et al., 2023).

Observational studies present similarly mixed findings, though most support a positive relation. For

example, in Ghana, insecure WLRs reduced fallowing (Goldstein & Udry, 2008), while in Kenya, tenure insecurity under patrilineal inheritance systems discouraged long-term investments among male heirs in male-headed households (though this effect did not extend to women) (Linkow, 2019). Likewise, in Malawi, stronger women's tenure security in uxori-local communities promoted investment (Benjamin, 2020), but reduced men's tenure security, discouraging their long-term investments (Lovo, 2016).

Interestingly, several studies explored how different rights across the 'bundle' shape investment. For example, in Ghana, alienation reduced investments in female-owned plots, while other rights showed no significant effects (Aikins et al., 2021). Conversely, in Malawi, alienation was linked to increased investment in organic manure, whereas other rights were not (Deininger et al., 2021). Adoption of climate-smart agriculture was more likely when management rights aligned with ownership and economic rights, although results varied across countries, right types, and land managers' gender (Teklewold, 2023).

These mixed results could be explained by variations in how investments are defined and measured, or by their nature and timeframe (short-term or long-term), which, carrying different risks, are likely to elicit different responses to varying levels of tenure security.

4.2.3. Agricultural productivity

The review identified 13 studies on *agricultural productivity*, mainly concentrated on Sub-Saharan Africa (84%) and based on observational studies (61%).

An experimental approach found that Benin's land demarcation increased long-term investment among female-headed households but did not improve agricultural yields in the short term, suggesting that productivity benefits may take longer to materialize (Goldstein et al., 2018).

Some quasi-experimental studies evaluated the productivity impacts of government land policies. In Ethiopia, land certification correlated positively with higher agricultural output value, particularly for female-headed households (Bezabih et al., 2016; Holden & Ghebru, 2011). Likewise, in Vietnam, individual and joint land-use certificates improved rice yields (Newman et al., 2015). However, in Malawi, redistribution only improved productivity among male-headed households (Mendola & Simtowe, 2015).

Observational studies particularly show the relationship between women's tenure security and productivity. In Malawi, for instance, the fear of land loss only

⁹ These outcomes were grouped as the reviewed investments involve adopting sustainable fuels or agriculture, often with conservation measures.

reduced productivity among female farmers, but not among their male counterparts (Deininger et al., 2019). Similarly, in Ghana, women's lower productivity was attributed to insecurity over retaining land while it lay fallow (Goldstein & Udry, 2008). In Kenya, women farmers with titles were more productive than those without (Owoo & Boakye-Yiadom, 2015).

Further, in Nigeria, access and ownership rights were associated with higher productivity (Daudu et al., 2022), while in Rwanda, the ability to sell or collateralize land increased productivity, especially for households that acquired farmland through purchase, loans or leases (Kamande & Bahati, 2019). This aligns with findings from Ethiopia, where rental market participation increased productivity among female-headed households (Bezabih et al., 2016; Holden & Ghebru, 2011).

Studies employed various measures of productivity, including physical yields (e.g., per hectare/acre) (Benjamin, 2020; Daudu et al., 2022; Mendola & Simtowe, 2015; Owoo & Boakye-Yiadom, 2015), and monetary measures, such as revenue (Bezabih et al., 2016; Deininger et al., 2019; Goldstein et al., 2018; Holden & Ghebru, 2011) and profits (Goldstein & Udry, 2008; Mastereson, 2007).

4.2.4. Natural resources management

The review identified only three studies on *NRM*. All of them focus on Ethiopia and investigate a single aspect (land rental decisions), providing preliminary support for the positive effects of WLRs.

Akpalu & Bezabih (2015) show that female farmers often avoid renting out their land due to fears of losing it to male tenants. Together with findings on *productivity*, this evidence suggests that improving institutional support for WLRs and dispute resolution could make land markets more efficient.

Quasi-experimental evidence reinforces this point. Specifically, Holden & Ghebru (2011) found that paper-based certificates increased the likelihood that female-headed households would rent out their land. However, upgrading to digitized certificates had little additional effect (Persha et al., 2017).

Future research should extend beyond Ethiopia, whose land laws differ from those in most other developing countries and even within Sub-Saharan Africa, limiting findings' generalizability. For instance, land sales and collateralization are illegal, and in some areas, non-residents risk losing their LR (Stevens et al., 2020). Thus, pro-women land policies in more typical land markets could yield different *NRM* outcomes.

4.2.5. Financial inclusion

The review identified eight studies on *financial inclusion*. The evidence is limited but evenly distributed across regions and across observational and quasi-experimental designs (50% each).

Findings point to a generally positive relationship, supported by four studies (Balasubramanian et al., 2019; Nguyen & Le, 2023; Persha et al., 2017; Santos et al., 2014). In Vietnam, for instance, land-use certificates allowed women to collateralize their land, reducing dependence on costly informal credit markets (Nguyen & Le, 2023). Access to credit also enabled investment in education and health, generating spill-over effects. Notably, this study is one of the few in the broader literature on LRs to identify clear impacts on *financial inclusion* (Deininger et al., 2019).

Nevertheless, benefits may depend on men's involvement. For instance, while landed women are more likely to have formal savings and accounts, they are also more likely to obtain credit when owning land *jointly* with a male relative (Balasubramanian et al., 2019). Furthermore, land interventions may not benefit women's financial inclusion as much as men's. In Ethiopia, for example, digitized certificates increased credit-based business transactions, but gains were smaller among female-headed households (Persha et al., 2017).

Not all studies observed significant effects. In Nicaragua, titling had no significant impact on credit (De La O Campos et al., 2023). In Peru, the relationship between landownership and 'credit resources' was also insignificant (Schling & Pazos, 2024). Similarly, in Tanzania, women living in communities with stronger property and inheritance rights were no more likely to own a savings account (Peterman et al., 2017).

Indicators of *financial inclusion* vary from access to formal credit and microcredit to bank account ownership and reliance on informal loans. Some aspects of *financial inclusion* remain unexplored, such as access to digital payment services, remittances, and (crop) insurance.

4.2.6. Welfare

The review identified 11 studies on *welfare*¹⁰, primarily in Sub-Saharan Africa (82%) and observational (64%). Findings are mixed, with some highlighting negative impacts under specific conditions.

Quasi-experimental studies consistently demonstrate that pro-women land policies can improve welfare for

¹⁰ While these studies focus on income, consumption and savings, their authors generally use them as proxies for welfare.

both men and women. In Ethiopia, for instance, longer land certificate tenure increased consumption, particularly among female-headed households (Holden & Ghebru, 2011). Similarly, land redistribution in Malawi boosted wealth and welfare, especially in matrilineal communities (Mendola & Simtowe, 2015), while in Vietnam, women's individual certificates increased household expenditures and reduced poverty (Menon et al., 2017). Another study in Malawi (Asfaw & Maggio, 2018) found that temperature shocks reduced household consumption more severely when women managed land alone; however, these effects were weaker in matrilineal districts, where women's stronger tenure security and greater investment in agricultural technologies helped buffer the impact.

Findings from observational studies are more ambiguous. In Tanzania, for example, women in communities with strong property and inheritance rights enjoyed higher expenditures and savings (Peterman, 2011). Similarly, in Burkina Faso, women's landownership was associated with higher income among livestock-keepers (Montcho et al., 2023).

However, where women lack market access, complementary inputs, or rights enforcement, the land-welfare nexus weakens. In such contexts, welfare may even improve when men retain control over assets (Bhaumik et al., 2016). For example, in Malawi, women's landownership correlated negatively with income from high-value agriculture (Bhaumik et al., 2016). This aligns with the argument that tenure security alone cannot drive socio-economic development without institutional support and access to complementary inputs (de Janvry & Sadoulet, 2016). Similarly, Deere et al. (2004) observed that WLRs often benefit off-farm income more than farm income.

Welfare has been measured through different proxies, including consumption, income (farm/off-farm), expenditure, savings, asset value, poverty lines, and self-reported poverty status. Most studies understand welfare as access to material goods, as is traditional in economics. Future studies could explore alternative measures capturing life satisfaction and relative deprivation, such as subjective well-being, experienced preferences, and the indexes inspired by Sen (2008)'s 'capability approach'.¹¹

4.2.7. Health

The review identified 20 studies on *health*¹², evenly distributed between Sub-Saharan Africa and South

Asia and between quasi-experimental and observational methods. Findings strongly suggest that WLRs improve health outcomes, particularly for children.

Quasi-experimental studies link WLRs to improved child anthropometric measures. For example, in Nigeria, joint landownership improved women's caloric intake and reduced child stunting and underweight rates (Aderemi, 2021). In India and Kenya, inheritance reforms were associated with better child anthropometric measures (Ajefu et al., 2022, 2024) through better education and household bargaining power (Ajefu et al., 2022).

However, not all studies find direct effects. In India, Kumar et al. (2020) observed that landownership alone was insufficient to mitigate child stunting; instead, women's education and household wealth were more critical.

When women control crop choices, they prioritize food availability and dietary diversity. In Rwanda, for example, female landownership improved both (Kamande & Bahati, 2019), though the effect of joint ownership alone was inconclusive. Similarly, in Vietnam, management and use rights in *de facto* female-headed households were linked to improved food security (Bairagi et al., 2022).

Women's income and decision-making are important mediators: observational studies from Ghana (Doss, 2006) and India (Rehman et al., 2019), for instance, showed that women's asset ownership directs spending toward food, while in Nepal, women landowners had greater decision-making, which correlated with better child anthropometric measures (Allendorf, 2007).

Most studies focus on household or child-level outcomes, with only Aderemi (2021) examining women's nutrition. Indicators also vary, with most relying on anthropometric scores or caloric intake, and only two assessing nutritional diversity (Kamande & Bahati, 2019; Burrone & Giannelli, 2023).

Two studies assess health beyond nutrition-related measures. In Vietnam, female-only land-use rights led to a larger reduction in child illness rates and a greater increase in insurance coverage than male-only or jointly held rights (Menon et al., 2014), suggesting a shift toward child health expenditures as predicted by intra-household bargaining theory. In Kenya, individual landownership reduced HIV rates among those women most at risk of survival sex by providing economic security and alternatives to risky sexual behaviors (Muchomba et al., 2014).

¹¹ See, for example, the Human Development Index and the OECD's Better Life Index.

¹² Most studies (90%) focus on nutritional outcomes, typically measured through anthropometric indicators. These are categorized under the *health* domain, as stunting, wasting, or underweight rates reflect not

only food intake or security but also broader health factors (de Haen et al., 2011), including disease prevalence, sanitation, and healthcare access (FAO, 1999).

4.2.8. Education

The review identified eight studies on *education*, mainly in India (50%) and based on quasi-experimental methods.

Evidence consistently shows that WLRs improve educational outcomes, especially for women and girls. For example, in Vietnam, women's land-use certificates increased children's school enrollment (Menon et al., 2014). In India and the Philippines, pro-women inheritance reforms raised higher educational attainment for women (Bose & Das, 2017) and their daughters (Deininger et al., 2013; Roy, 2015; Quisumbing et al., 2003).

Consistent with intra-household bargaining theory, WLRs can shift household expenditure toward education. In rural Ghana, for example, households where women owned more farmland spent more on education (Doss, 2006).

Interestingly, while WLRs improve outcomes for girls, effects on boys are mixed: in India, Bose & Das (2017) found reduced attainment, while Deininger et al. (2013) (on the same Indian reform) and Quisumbing et al. (2003) (on the Philippines) found positive effects only for girls.

4.2.9. Intra-household dynamics

The review identified only one quasi-experimental study on *intra-household dynamics*¹³, limiting the empirical evidence to India.

Family conflict is often modeled through bargaining models that include separation or divorce as potential exit strategies. Anderson & Genicot (2015) extended this framework by including suicide as an extreme exit option and found that pro-women inheritance reform increased suicide rates for both sexes due to marital conflict.

Despite its robust causal design, the study's findings may not generalize beyond India, where divorce and separation are extremely rare (Anderson & Genicot, 2015). Where marriage dissolution is more accessible, WLRs may influence household dynamics differently, fostering either conflict or cooperation.

4.2.10. Social capital and collective action

The review identified three observational studies on *social capital and collective action*¹⁴, mainly in Sub-Saharan Africa.

Despite their small number, most report positive effects. As social capital cannot be directly measured (Meinzen-Dick et al., 2004), studies use proxies like participation in organizations or social events. In Uganda, WLRs increased women's involvement in coffee cooperatives and collective marketing, especially in gender-equal or joint-ownership households (Meier Zu Selhausen, 2016). In Vietnam, women's share of family land increased their (non-)production-related group membership and attendance at social events (Nguyen & Le, 2023).

However, in Ghana, Yokying & Lambrecht (2020) found no significant differences in agricultural group membership between landed and landless women.

4.2.11. Social stability

The review identified only one quasi-experimental study on *social stability*, which found no significant effects of digitized certificates on land disputes in Ethiopia (Persha et al., 2017).

Two important considerations, however, contextualize this finding. First, the study focused on the *marginal* benefits of digitized certificates over paper-based ones, rather than assessing the overall impact of certification. Second, the low incidence of disputes limited statistical power (Persha et al., 2017).

4.3. Geographic and time coverage

The review uncovered effects across 46 countries, plus two multi-country studies.¹⁵ However, evidence availability varies considerably across and within regions (Figure 3).¹⁶

Sub-Saharan Africa (123 effects, 49 articles) and South Asia (37 effects, 26 articles) dominated the literature, reflecting their high levels of rural poverty (Castañeda et al., 2018) and the substantial policy relevance of WLRs. In contrast, Europe & Central Asia (one effect) and the Middle East & North Africa (three effects, two articles) are critically underrepresented. East Asia & Pacific (19 effects, 12 articles) and Latin America & the Caribbean (17 effects, 10 articles) have a scattered evidence base, insufficient to generalize findings at the regional level.

¹³ By 'intra-household dynamics,' we refer to the ways in which WLRs affect family relationships, fostering either cooperation or conflict, particularly between spouses.

¹⁴ Collective action refers to coordinated land management through common property regimes or inter-farms collaboration (Meinzen-Dick

et al., 2004). Social capital underpins collective action, and it is often analyzed jointly (Krishna, 2004).

¹⁵ Balasubramanian et al. (2019) and Sommer et al. (2024) aggregate data from multiple developing economies.

¹⁶ The research community's engagement with WLRs has varied over time as well, with bibliometric trends revealing an acceleration that began around 2008 (Figure S5.2).

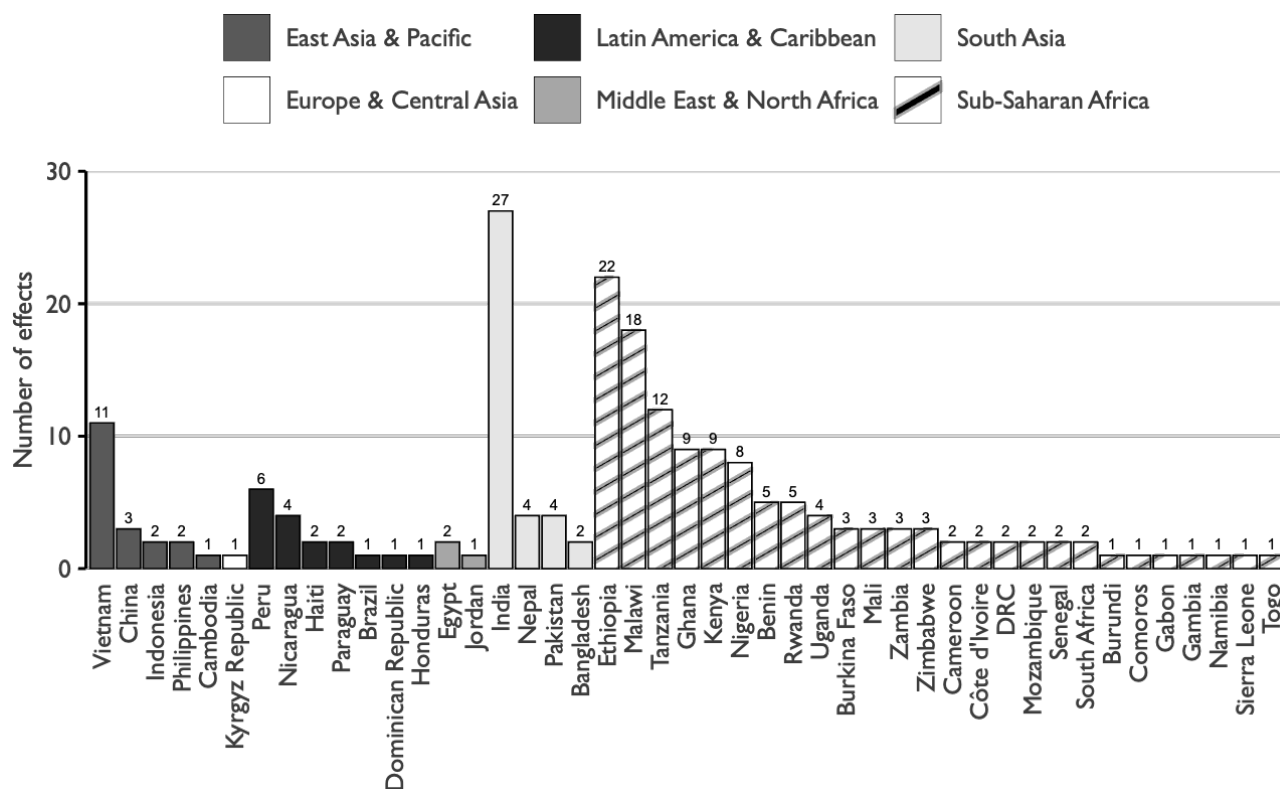


Figure 3. Distribution of effects, by country of analysis. Source: Authors' elaboration. Note: Each count represents an effect from WLR included in the review. A single article may report effects for multiple countries and development outcomes. Two studies (Balasubramanian et al., 2019; Sommer et al., 2024) are excluded from this figure because they aggregate data from several countries into a single effect.

The analysis paints a modest picture of outcomes' coverage outside the two focal regions (Figure 4). Research on *empowerment* is common to all regions but mostly concentrated in Sub-Saharan Africa, as are studies on *investment* and *productivity*. South Asia, despite ranking second in terms of geographic coverage and extensively relying on traditional agriculture, holds limited evidence on the latter two outcomes. On the other hand, *health* is well-represented in both focal areas, while receiving no attention elsewhere.

Even within well-covered regions, research concentrates on specific countries. Research in Sub-Saharan Africa focuses mostly on Tanzania, Ethiopia and Malawi, while research in South Asia appears overwhelmingly clustered on India.

This trend appears driven by data availability and the possibility of exploiting natural experiments for analysis. Countries undergoing legal or policy changes tend to attract scholarly interest since they offer unique opportunities to identify generalizable effects. Notable instances include Ethiopia's and Benin's land certification programs (started in 1998 and 1993, respectively), India's inheritance reform (2005), and Vietnam's Land Law

(1993), which serve as sources of discontinuity in multiple articles in this review.¹⁷ Broadly speaking, the main land programs covered by the reviewed studies occurred in the late 1990s and early 2000s, and were accompanied by extensive documentation and standardized data collection efforts, largely supported by the international community. Most studies draw on periodical data from the early 2000s to 2015, with no significant regional differences in temporal coverage. The most recent evidence is from Nigeria, with data extending to 2021¹⁸. The temporal distribution of data does not reveal specific patterns in terms of outcomes or geographies; however, recent studies tend to consider a broader range of rights within the 'bundle' compared to earlier research.

When examining how different rights in the 'bundle' intersect with geographical coverage, Sub-Saharan Africa and South Asia still dominate the evidence base, especially for ownership/inheritance rights. While this geographic focus carries over to other dimensions, East

¹⁷ See the Supplementary Materials (S4) for further details on programs/reforms covered in the reviewed studies.

¹⁸ See Daudu (2022).

Women's Empowerment	9	1	8	3	23	63
Investment & Environmental Sustainability			2		1	18
Agricultural Productivity	1		1			11
Natural Resources Management						3
Financial Inclusion	2		2		1	2
Welfare	1		3			9
Health	2		1		6	11
Education	3				5	3
Intra-Household Dynamics					1	
Social Capital & Collective Action	1					2
Social Stability						1
	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa

Figure 4. Distribution of effects, by region and outcome. Source: Authors' elaboration. Note: Each count represents an effect from WLR included in the review. A single article may report effects for multiple countries and development outcomes. Two studies (Balasubramanian et al., 2019; Sommer et al., 2024) are excluded from this figure because they aggregate data from several countries into a single effect.

Asia is relatively better represented in access/use and alienation rights. This suggests that, in this region, specific local contexts – such as legal frameworks and customary practices – and socio-cultural dynamics may shape WLRs in ways that differ from other regions. Data availability from major land reforms (e.g., Vietnam) likely also drives scholarly focus.

4.4. Research methods and data

Most studies adopt observational (142 effects from 57 articles) or quasi-experimental designs (57 effects from 37 articles) (Figure 5), with only two studies (three effects) employing experimental approaches. Among these, only Goldstein et al. (2018) (on Benin) used an RCT – the “gold standard” in causal inference (Higgins et al., 2018) – leveraging a major land reform in the country.

Common identification strategies include instrumental variables, differences-in-differences, and their combination with matching methods. Matching methods and inverse probability weighting are often used in observational studies to address confounding bias.

Most studies (72%) rely on cross-sectional data, single or repeated (153 effects, 69 studies)¹⁹, while only a

few use panel data (49 effects, 27 studies), largely limited to China, India, Vietnam and selected countries in Sub-Saharan Africa (Benin, Ethiopia, Ghana, Malawi, Nigeria, Rwanda and Tanzania). Longitudinal data enable the observation of long-term outcomes (e.g., *productivity*, *education*), the use of fixed-effects estimators, and the study of dynamic processes (e.g., lagged effects). However, large-scale longitudinal surveys with land modules remain rare.

Recent studies increasingly use individual- and plot-level analyses,²⁰ as already noted by Meinzen-Dick et al. (2019), enabling estimation of local effects with high internal validity. Nevertheless, studies where the parcel is the explicit unit of analysis remain relatively niche²¹. First appearing in Goldstein & Udry (2008), plot-level studies in our sample account for only 15 studies (18%), mostly on *investment* (nine studies, or 60% within this domain), *productivity* (seven studies, or 54%), *financial inclusion* and *NRM* (one study each), with mainly positive effects. Apart from De La O Campos et al. (2023), Kelly et al. (2019), and Newman et al. (2015) – on Nicaragua, Haiti and Vietnam, respectively – all plot-level analyses refer to Sub-Saharan Africa (80%).

While this focus on local-level analyses provides rich insights, it has reduced attention to ‘macro-level’ and cross-country analyses. Furthermore, few studies differentiate outcomes by women’s characteristics (e.g., marital status), except for research on family and inheritance law reforms.

Research on individual rights is predominant (61 studies), while joint rights are the explicit focus of only 11 studies. Further, comparisons of effects across individual and joint rights remain sparse (12 studies), largely due to data limitations. Even when data are available, many studies aggregate these categories to maintain statistical power, with 12 providing combined analyses. When differentiated, individual rights improved *decision-making* over joint rights in Sub-Saharan Africa (Doss et al., 2014). Both LR types were beneficial compared to landlessness; however, in India, individual rights showed no effect, and joint rights had negative effects, reflecting heterogeneous local outcomes. In Vietnam, instead, both types of rights increased women’s self-employment (Menon et al., 2017), but female-only rights improved *health* and *education* outcomes more than male-only or joint rights (Menon et al., 2014). In

²⁰ Given our focus on gendered impacts, included studies provide either individual-level data (on women) or plot-level data (with gender-specific information), even when the household is the observation unit.

²¹ Data measured at different scales can be integrated, for instance, plot-level variables analyzed at individual or household levels. Here, however, the measurement level refers specifically to the outcome variable.

¹⁹ See Table S4.1 for further details on key data sources.

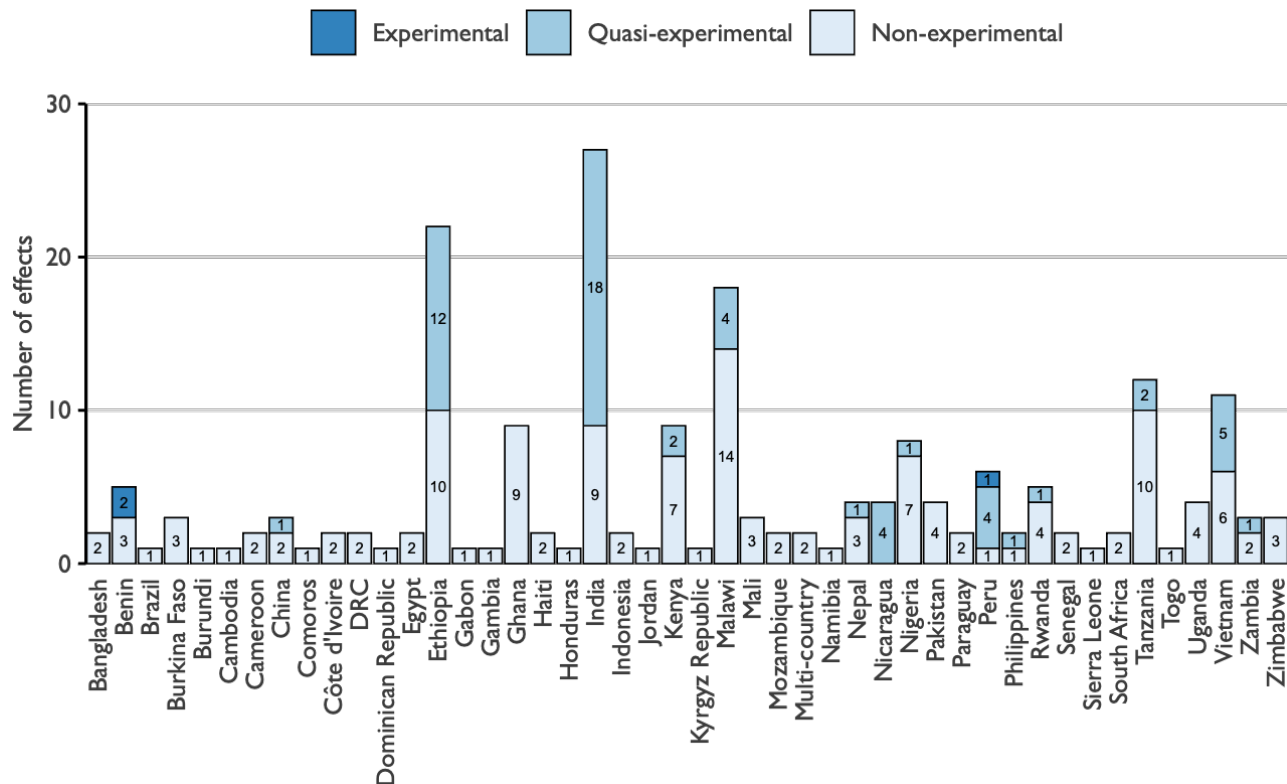


Figure 5. Distribution of effects, by country of analysis and study design. Source: Authors' elaboration. Note: Each count represents an effect from WLR included in the review. A single article may report effects for multiple countries and development outcomes. Two studies (Balasubramanian et al., 2019; Sommer et al., 2024) are excluded from this figure because they aggregate data from several countries into a single effect.

Kenya, both increased vulnerability to IPV (Ward & Harlow, 2021). Further research is needed to confirm whether individual rights are more empowering for women, as suggested by Agarwal (2003) and Bhatla et al. (2010), among others.

5. DISCUSSION OF THE MAIN FINDINGS AND RESEARCH GAPS

5.1. WLRs' effect on development outcomes

Synthesizing such a diverse literature is challenging due to the wide range of outcomes and the heterogeneity of the indicators used to measure them. To provide a structured and interpretable overview, we followed approaches similar to Higgins et al. (2018) and, partly, Lawry et al. (2017), reporting the number – and, in our case, the proportions – of positive and statistically significant effects by outcome²². This approach uncovers

outcome patterns and identifies areas of abundant or limited evidence (Figure 6).

Empirical evidence remains uneven across outcomes and geographies. It is larger in the area of *empowerment* and, to a smaller extent, *productivity*, *health*, and *investment*, whereas other outcomes warrant increased focus.

The strongest, most coherent evidence of positive effects is on *empowerment* (Figure 6). LR consistently improve women's *decision-making* and *economic empowerment*; though impacts on IPV and *family planning*, particularly in South Asia, vary. As Meinzen-Dick et al. (2019) note, there is also coherent, albeit limited, evidence of positive impacts on *productivity*, *financial inclusion*, and *social capital*.

Although limited in number, the evidence on *education* and *health* is unambiguously positive. Future research could explore potential long-term, intergenerational benefits of WLRs, such as whether children

²² The diversity of outcomes and measurement indicators, along with

multiple regressions using alternative proxies for the same outcome within individual studies, renders a meta-analysis impractical and a structured summary of effect sizes challenging to interpret.

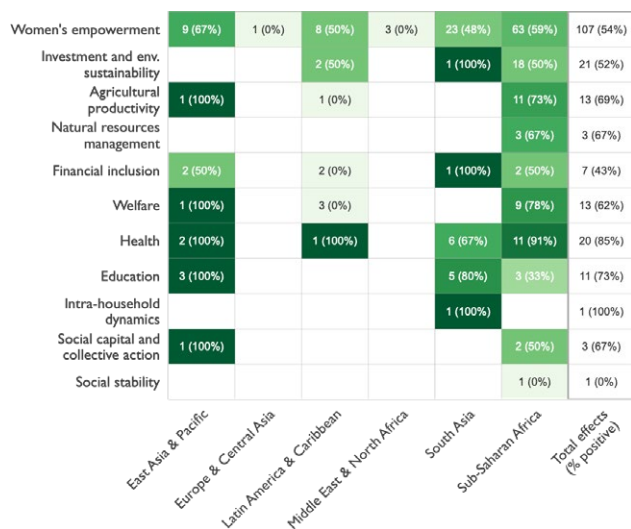


Figure 6. Proportion of positive effects, by region and development outcome. Source: Authors' elaboration. Each count represents an effect from WLR included in the review. Darker shades indicate a higher share of positive and statistically significant outcomes. Percentages are calculated over the total number of articles in that outcome category. A single article may report effects for multiple countries and development outcomes. Two studies (Balasubramanian et al., 2019; Sommer et al., 2024) are excluded from this figure because they aggregate data from several countries into a single effect.

of landed women become healthier, more productive adults, contributing to poverty reduction. Greater attention is also needed on nutritional diversity – a key but unexplored aspect of food security (FAO, 1996).

Evidence on *investment* and *welfare* is moderate but inconsistent, with some studies reporting negative effects, partly contrasting Meinzen-Dick et al. (2019), who noted a high level of agreement on 'technology adoption,' and Lawry et al. (2017), who found relatively consistent positive effects of broader LR recognition on long-term investment²³.

The evidence on *intra-household dynamics*, *NRM*, and *social stability* is insufficient to draw definitive conclusions. At the same time, discussions on climate adaptation and resilience remain largely absent from the literature, with only Asfaw & Maggio (2018) addressing them. Future research should examine how WLRs contribute to such outcomes across different climatic and institutional contexts. Further, as in Lawry et al. (2017), existing evidence on *NRM* focuses exclusively on land rental, while other practices affecting economic efficiency (e.g., use, sales, purchases, or gifting) remain unexplored.

²³ These discrepancies stem from different eligibility criteria and our inclusion of more recent studies. Lawry et al. (2017) had a broader scope, with many reviewed studies lacking a gender lens.

5.2. Progress with respect to previous reviews

While our outcome classification does not directly align with Meinzen-Dick et al. (2019)'s or Lawry et al. (2017)'s, several points are worth mentioning.

First, by extending the timeframe, this review adds over 30 recent studies,²⁴ reflecting the surge in research following transnational large-scale land acquisitions and the Russian invasion of Ukraine, which intensified land pressures in the Global South (Dell'Angelo et al., 2023).

Second, this broader scope enables inclusion of additional outcomes (*education*, *health*, *intra-household dynamics*, *social stability*, *social capital* and *collective action*) beyond those covered by previous reviews. More specifically, while Meinzen-Dick et al. (2019) recognized potential impacts on women's bargaining power and decision-making over consumption, human capital and intergenerational transfers, this review assesses the 'mediated' outcomes themselves, rather than bargaining power in these domains. It also expands the 'credit' category (present, in different capacities, in both previous reviews) to encompass broader financial inclusion indicators.

The review finds no progress in resilience and limited gains beyond *agricultural productivity*, *health*, and *investment*.

Third, this review proposes two preliminary classifications of LR typologies considered in the empirical literature. Drawing on Schlager & Ostrom (1992), the first shows an almost exclusive focus on ownership/inheritance; the second, contrasting individual and joint rights, highlights a predominant focus on individual rights or combined analyses. Therefore, despite theoretical expectations (Agarwal, 2003), studies examining heterogeneous impacts across different LR typologies remain scarce.

5.3. Further considerations

Beyond our outcome classification, no eligible studies addressed several potential outcomes suggested by economic theory (Stevens et al., 2020), theoretical frameworks (Meinzen-Dick et al., 2019), or qualitative research (Higgins et al., 2018; Lawry et al., 2017). These include displacement, extension services, democracy and governance, public infrastructure, human development, inequality, post-conflict recovery, poverty reduction, sustainable landscapes and biodiversity conservation.

²⁴ In terms of number of reviewed studies, the closest comparison is Meinzen-Dick et al. (2019), which also focused on WLRs. Lawry et al. (2017) covered broader LR recognition and is less directly comparable.

Macro-level outcomes (e.g., democracy and governance, inequality) are largely absent, likely due to authors' focus on local effects with strong internal validity. Yet, institutions influence both individual experiences and broader socio-economic systems: if rights' recognition affects women and communities, national-level impacts are also plausible. Future research should explore whether WLRs produce systemic effects.

Observed trends and gaps appear largely driven by data availability and uneven opportunities to exploit natural experiments, leading to over-representation of certain countries and outcomes, and few studies on different LR typologies. In particular, the intuitive relationship between rights and agency has enriched research on *empowerment*, but also overshadowed outcomes not directly tied to gender equality.

6. CONCLUSION

Despite recent growth in empirical studies, evidence on the land-women-development nexus remains fragmented across regions, outcomes, and methods. Building on Meinzen-Dick et al. (2019), this review advances the field by applying the PRISMA protocol and systematizing 202 causal effects from 96 publications across 46 countries. This approach enhances transparency and reproducibility, while clarifying areas of consensus, contradictions, and evidence gaps.

Specifically, the review (1) codifies effects' direction and significance, (2) proposes an original classification of 11 outcomes related to WLRs' recognition, and (3) critically synthesizes empirical evidence, identifying patterns across outcomes and geographies.

The most consistent findings concern *empowerment*, particularly *decision-making* and *economic empowerment*, with positive spillovers to *education* and *health*. These results support longstanding claims that secure LRs can strengthen women's agency and shift household investments toward human capital (Meinzen-Dick et al., 2019). However, contradictions remain: gender-equitable land reforms may improve women's bargaining power but also trigger violence 'backlash' or regressive family planning shifts, particularly under entrenched patriarchal norms. Likewise, evidence on *investment*, *productivity*, *financial inclusion*, and *welfare* is highly heterogeneous, confirming that tenure security alone is insufficient without complementary access to inputs, markets, and effective LRs enforcement (de Janvry & Sadoulet, 2016).

Important gaps remain. Research disproportionately focuses on Sub-Saharan Africa and South Asia, especially where legal or policy reforms have generated natural

experiments. Methodologically, reliance on observational and cross-sectional data limits insights into long-term impacts. Moreover, studies tend to privilege ownership and inheritance rights, with less attention to other dimensions of the 'bundle' – despite recent literature beginning to move in this direction. Neglected outcome areas include *NRM*, *social stability*, climate resilience, and broader macro-level processes like governance and inequality.

Our findings highlight clear policy priorities: land interventions can promote development and women's empowerment, but effectiveness requires policies that account for local gender norms, guard against unintended backlash, and are supported by agricultural services, financial infrastructure, and LRs' enforcement.

The research agenda should expand geographically and thematically, moving beyond *decision-making* and individual ownership to explore how women benefit from land and how these pathways affect different outcomes. Advancing this agenda requires the systematic collection of longitudinal micro-data, including the mode of acquisition (e.g., inheritance, purchase), rights' typologies (individual or joint), women's characteristics, and specific dimensions of the 'bundle.' Such efforts should follow standardized, gender-sensitive protocols and include macro-level indicators capturing local institutional settings.

Addressing these gaps will enable a more comprehensive understanding of how WLRs contribute to inclusive and sustainable development, and their role in climate adaptation and resilience at local and systemic levels.

DATA AVAILABILITY

The review protocol is accessible at <https://doi.org/10.17605/OSF.IO/45QKB>. Effects' classification is available upon request.

ACKNOWLEDGEMENTS

We are grateful to S. Beretta, F. Perali, F. Cerniglia, and two anonymous referees for their insightful comments on an earlier version of this paper. We also thank the SEEDS Annual Conference 2024 participants for their valuable feedback.

REFERENCES

- Abay, K. A., Breisinger, C., Glauber, J., Kurdi, S., Laborde, D., & Siddig, K. (2023). The Russia-Ukraine war: Implications for global and regional food security and potential policy responses. *Global Food Security*, 36, 100675. <https://doi.org/10.1016/j.gfs.2023.100675>
- Aderemi, T. A. (2021). Nutritional deficiency and women's empowerment in agriculture: Evidence from Nigeria. *African Journal of Agricultural and Resource Economics*, 16(4), 314–336. [https://doi.org/10.53936/AFJARE.2021.16\(4\).21](https://doi.org/10.53936/AFJARE.2021.16(4).21)
- Agarwal, B. (1994). Gender and command over property: A critical gap in economic analysis and policy in South Asia. *World Development*, 22(10), 1455–1478. [https://doi.org/10.1016/0305-750X\(94\)90031-0](https://doi.org/10.1016/0305-750X(94)90031-0)
- Agarwal, B. (1995). *A field of one's own: Gender and land rights in South Asia*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511522000>
- Agarwal, B. (1997a). “Bargaining” and gender relations: Within and beyond the household. *Feminist Economics*, 3(1), 1–51. <https://doi.org/10.1080/135457097338799>
- Agarwal, B. (2003). Gender and land rights revisited: Exploring new prospects via the state, family and market. *Journal of Agrarian Change*, 3(1-2), 184–224. <https://doi.org/10.1111/1471-0366.00054>
- Aikins, E., Oduro, A., & Twerefou, D. (2021). Ownership rights and investment in agricultural land in Ghana: A gender analysis. *West African Journal of Applied Ecology*, 29(1), 49–61.
- Ajefu, J., Uchenna, E., Singh, N., & Ali, S. Z. (2024). Women's inheritance rights and child health outcomes in Kenya. *Journal of Family and Economic Issues*, 45(1), 137–150. <https://doi.org/10.1007/s10834-023-09895-y>
- Ajefu, J. B., Singh, N., Ali, S., & Efobi, U. (2022). Women's inheritance rights and child health outcomes in India. *Journal of Development Studies*, 58(4), 752–767. <https://doi.org/10.1080/00220388.2021.2003333>
- Akpalu, W., & Bezabih, M. (2015). Tenure insecurity, climate variability and renting out decisions among female small-holder farmers in Ethiopia. *Sustainability*, 7(6), 7926–7941. <https://doi.org/10.3390/su7067926>
- Alderman, H., Chiappori, P.-A., Haddad, L., Hoddinott, J., & Kanbur, R. (1995). Unitary versus collective models of the household: Is it time to shift the burden of proof? *The World Bank Research Observer*, 10(1), 1–19. <https://doi.org/10.1093/wbro/10.1.1>
- Ali, D. A., Deininger, K., & Goldstein, M. (2014). Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda. *Journal of Development Economics*, 110, 262–275. <https://doi.org/10.1016/j.jdeveco.2013.12.009>
- Ali, D. A., Dercon, S., & Gautam, M. (2011). Property rights in a very poor country: Tenure insecurity and investment in Ethiopia. *Agricultural Economics*, 42(1), 75–86. <https://doi.org/10.1111/j.1574-0862.2010.00482.x>
- Allendorf, K. (2007). Do women's land rights promote empowerment and child health in Nepal? *World Development*, 35(11), 1975–1988. <https://doi.org/10.1016/j.worlddev.2006.12.005>
- Amir-ud-Din, R., Naz, L., & Ali, H. (2024). Relationship between asset ownership and women's empowerment? Evidence from DHS data from 18 developing countries. *Journal of Demographic Economics*, 90(2), 154–175. <https://doi.org/10.1017/dem.2023.17>
- Anderson, S., & Genicot, G. (2015). Suicide and property rights in India. *Journal of Development Economics*, 114, 64–78. <https://doi.org/10.1016/j.jdeveco.2014.11.004>
- Armand, A., Attanasio, O., Carneiro, P., & Lechene, V. (2020). The effect of gender-targeted conditional cash transfers on household expenditures: Evidence from a randomized experiment. *The Economic Journal*, 120(631), 1875–1897. <https://doi.org/10.1093/ej/ueaa056>
- Asfaw, S., & Maggio, G. (2018). Gender, weather shocks and welfare: Evidence from Malawi. *Journal of Development Studies*, 54(2), 271–291. <https://doi.org/10.1080/00220388.2017.1283016>
- Atkinson, M. P., Greenstein, T. N., & Monahan Lang, M. (2005). For women, breadwinning can be dangerous: Gendered resource theory and wife abuse. *Journal of Marriage and Family*, 67(5), 1137–48. <https://doi.org/10.1111/j.1741-3737.2005.00206.x>
- Bahrami-Rad, D. (2021). Keeping it in the family: Female inheritance, inmarriage, and the status of women. *Journal of Development Economics*, 153, 102714. <https://doi.org/10.1016/j.jdeveco.2021.102714>
- Balasubramanian, S. A., Kuppusamy, T., & Natarajan, T. (2019). Financial inclusion and land ownership status of women. *International Journal of Development Issues*, 18(1), 51–69. <https://doi.org/10.1108/IJDI-06-2018-0091>
- Becker, G. S. (1974). A theory of social interactions. *Journal of Political Economy*, 82(6), 1063–1093. <https://doi.org/10.1086/260265>
- Behrman, J., Meinzen-Dick, R., & Quisumbing, A. (2012). The gender implications of large-scale land deals. *Journal of Peasant Studies*, 39(1), 49–79. <https://doi.org/10.1080/03066150.2011.652621>

- Benjamin, E. O. (2020). Smallholder agricultural investment and productivity under contract farming and customary tenure system: A Malawian perspective. *Land*, 9(8), 277. <https://doi.org/10.3390/land9080277>
- Besley, T. (1995). Property rights and investment incentives: Theory and evidence from Ghana. *Journal of Political Economy*, 103(5), 903–937. <https://doi.org/10.1086/262008>
- Bezabih, M., Holden, S., & Mannberg, A. (2016). The role of land certification in reducing gaps in productivity between male- and female-owned farms in rural Ethiopia. *Journal of Development Studies*, 52(3), 360–376. <https://doi.org/10.1080/00220388.2015.1081175>
- Bhalotra, S., Brulé, R., Dhahi, N. A., & Roy, S. (2020). Women's inheritance rights reform and the preference for sons in India. *Journal of Development Economics*, 146. <https://doi.org/10.1016/j.jdeveco.2018.08.001>
- Bhatla, N., Duvvury, N., & Chakraborty, S. (2010). Women's vulnerability, risk and social protection: An exploration of links between property ownership and domestic violence in South Asia. In S. Cook & N. Kabeer (Eds.), *Social protection as development policy* (pp. 219–244). Routledge India.
- Bhaumik, S. K., Dimova, R., & Gang, I. N. (2016). Is women's ownership of land a panacea in developing countries? evidence from land-owning farm households in Malawi. *Journal of Development Studies*, 52(2), 242–253. <https://doi.org/10.1080/00220388.2015.1060314>
- Biswas, S., Das, U., & Sarkhel, P. (2024). Duration of exposure to inheritance law in India: Examining the heterogeneous effects on empowerment. *Review of Development Economics*, 28(2), 777–799. <https://doi.org/10.1111/rode.13080>
- Bose, N., & Das, S. (2017). Women's inheritance rights, household allocation, and gender bias. *American Economic Review*, 107(5), 150–153. <https://doi.org/10.1257/aer.p20171128>
- Bose, N., & Das, S. (2024). Reassessing the relationship between women's empowerment and fertility: Evidence from India. *Review of Development Economics*, 28(2), 544–573. <https://doi.org/10.1111/rode.13066>
- Brulé, R. (2010, September). *Changes in India's property rights regime and the implications for improved gender parity: Evidence from regression discontinuity analysis of panel data for 17 Indian states*. (APSA 2010 Annual Meeting Paper). <https://ssrn.com/abstract=1644357>
- Burke, W. J., & Jayne, T. (2021). Disparate access to quality land and fertilizers explain Malawi's gender yield gap. *Food Policy*, 100, 102002. <https://doi.org/10.1016/j.foodpol.2020.102002>
- Burke, W. J., Li, S., & Banda, D. (2018). Female access to fertile land and other inputs in Zambia: Why women get lower yields. *Agriculture and Human Values*, 35(4), 761–775. <https://doi.org/10.1007/s10460-018-9872-6>
- Burrone, S., & Giannelli, G. (2023, August). *Do households where women own land fare better for food security? Evidence for Tanzania*. (IZA Discussion Paper No. 16382). <https://doi.org/10.2139/ssrn.4541364>
- Castañeda, A., Doan, D., Newhouse, D., Nguyen, M. C., Uematsu, H., & Azevedo, J. P. (2018). A new profile of the global poor. *World Development*, 101, 250–267. <https://doi.org/10.1016/j.worlddev.2017.08.002>
- Chiappori, P.-A. (1992). Collective labor supply and welfare. *Journal of Political Economy*, 100(3), 437–467. <https://doi.org/10.1086/261825>
- Chu, C. C., Hsu, P.-H., & Wang, Y.-T. (2023). The gender gap in the ownership of promising land. *Proceedings of the National Academy of Sciences*, 120(24), e2300189120. <https://doi.org/10.1073/pnas.2300189120>
- Conrad, C., & Doss, C. R. (2008). The AIDS epidemic: Challenges for feminist economics. *Feminist Economics*, 14(4), 1–18. <https://doi.org/10.1080/13545700802262998>
- Daudu, A. K., Awotide, B. A., Adefalu, L. L., Kareem, O. W., & Olatinwo, L. K. (2022). Impact of land access and ownership on farm production: Empirical evidence from gender analysis in southwestern Nigeria. *African Journal on Land Policy and Geospatial Sciences*, 5(1), 889–913. <https://doi.org/10.48346/IMIST.PRSM/AJLP-GSV5I1.29079>
- de Haen, H., Klasen, S., & Qaim, M. (2011). What do we really know? Metrics for food insecurity and undernutrition. *Food Policy*, 36(6), 760–769. <https://doi.org/10.1016/j.foodpol.2011.08.003>
- de Janvry, A., & Sadoulet, E. (2016). Access to land and development. In M. Vernengo, E. Perez Caldentey, & J. Ghosh (Eds.), *The New Palgrave Dictionary of Economics* (2nd ed., pp. 1–5). Palgrave Macmillan.
- de Jong, L., De Bruin, S., Knoop, J., & van Vliet, J. (2021). Understanding land-use change conflict: A systematic review of case studies. *Journal of Land Use Science*, 16(3), 223–239. <https://doi.org/10.1080/1747423X.2021.1933226>
- De La O Campos, A. P., Edouard, F., & Salvago, M. R. (2023). Effects of land titling on household tenure security and investments: Evidence from Nicaragua. *Land Use Policy*, 126, 106547. <https://doi.org/10.1016/j.landusepol.2023.106547>

- De Schutter, O. (2015). The role of property rights in the debate on large-scale land acquisitions. *International Development Policy*, 6, 53–77. https://doi.org/10.1163/9789004304758_004
- de Soto, H. (2000). *The mystery of capital: Why capitalism triumphs in the West and fails everywhere else*. Basic Books.
- Deere, C. D., Durán, R. L., Mardon, M., & Mesteron, T. (2004). *Female land rights and rural household incomes in Brazil, Paraguay and Peru*. (Working Paper No. 2004-08). <https://hdl.handle.net/10419/105741>
- Deininger, K., Ali, D. A., Holden, S., & Zevenbergen, J. (2008). Rural land certification in Ethiopia: Process, initial impact, and implications for other African countries. *World Development*, 36(10), 1786–1812. <https://doi.org/10.1016/j.worlddev.2007.09.012>
- Deininger, K., Goyal, A., & Nagarajan, H. (2013). Women's inheritance rights and intergenerational transmission of resources in India. *Journal of Human Resources*, 48(1), 114–141. <https://doi.org/10.3368/jhr.48.1.114>
- Deininger, K., Xia, F., & Holden, S. (2019). Gendered incidence and impacts of tenure insecurity on agricultural performance in Malawi's customary tenure system. *Journal of Development Studies*, 55(4), 597–619. <https://doi.org/10.1080/00220388.2018.1425395>
- Deininger, K., Xia, F., Kilic, T., & Moylan, H. (2021). Investment impacts of gendered land rights in customary tenure systems: Substantive and methodological insights from Malawi. *World Development*, 147, 105654. <https://doi.org/10.1016/j.worlddev.2021.105654>
- Dell'Angelo, J., D'Odorico, P., Rulli, M. C., & Marchand, P. (2017). The tragedy of the grabbed commons: Coercion and dispossession in the global land rush. *World Development*, 92, 1–12. <https://doi.org/10.1016/j.worlddev.2016.11.005>
- Dell'Angelo, J., Rulli, M. C., & D'Odorico, P. (2023). Will war in Ukraine escalate the global land rush? *Science*, 379(6634), 752–755. <https://doi.org/10.1126/science.adf9351>
- Dillon, B., & Voena, A. (2018). Widows' land rights and agricultural investment. *Journal of Development Economics*, 135, 449–460. <https://doi.org/10.1016/j.jdevecto.2018.08.006>
- Doss, C. (2006). The effects of intrahousehold property ownership on expenditure patterns in Ghana. *Journal of African Economies*, 15(1), 149–180. <https://doi.org/10.1093/jae/eji025>
- Doss, C., Kim, S. M., Njuki, J., Hillenbrand, E., & Miruka, M. (2014, April). *Women's individual and joint property ownership: Effects on household decision-making*. (IFPRI Discussion Paper No. 01347). <http://dx.doi.org/10.2139/ssrn.2483968>
- Duflo, E., & Udry, C. R. (2004). *Intrahousehold resource allocation in Côte d'Ivoire: Social norms, separate accounts and consumption choices* (Working Paper No. 10498). National Bureau of Economic Research. <https://doi.org/10.3386/w10498>
- Efobi, U. R., Beecroft, I., & Atata, S. N. (2019). Female access and rights to land, and rural non-farm entrepreneurship in four African countries. *African Development Review/Revue Africaine de Développement*, 31(2), 179–189. <https://doi.org/10.1111/1467-8268.12376>
- FAO. (1996). Rome Declaration on World Food Security and World Food Summit Plan of Action.
- FAO. (1999). *Nutrition and development: A global challenge*. <http://www.fao.org/4/u9920t/u9920t07.htm>
- FAO. (2011). *The state of food and agriculture 2010-2011: Women in agriculture: Closing the gender gap for development*.
- Folbre, N. (1996). Engendering economics: New perspectives on women, work, and demographic change. In M. Bruno & B. Pleskovic (Eds.), *Annual World Bank Conference on Development Economics 1995* (pp. 127–153). International Bank for Reconstruction and Development / World Bank.
- Goldstein, M., Hounghbedji, K., Kondylis, F., O'Sullivan, M., & Selod, H. (2018). Formalization without certification? Experimental evidence on property rights and investment. *Journal of Development Economics*, 132, 57–74. <https://doi.org/10.1016/j.jdevecto.2017.12.008>
- Goldstein, M., & Udry, C. (2008). The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6), 981–1022. <https://doi.org/10.1086/595561>
- Grabe, S. (2010). Promoting gender equality: The role of ideology, power, and control in the link between land ownership and violence in Nicaragua. *Analyses of Social Issues and Public Policy*, 10(1), 146–170. <https://doi.org/10.1111/j.1530-2415.2010.01221.x>
- Grabe, S. (2015). Participation: Structural and relational power and Maasai women's political subjectivity in Tanzania. *Feminism & Psychology*, 25(4), 528–548. <https://doi.org/10.1177/0959353515591369>
- Higgins, D., Balint, T., Liversage, H., & Winters, P. (2018). Investigating the impacts of increased rural land tenure security: A systematic review of the evidence. *Journal of Rural Studies*, 61, 34–62. <https://doi.org/10.1016/j.jrurstud.2018.05.001>

- Holden, S. T. and Ghebru, H. (2011, March). *Household welfare effects of lowcost land certification in Ethiopia*. (CLTS Working Papers 3/11). Centre for Land Tenure Studies, Norwegian University of Life Sciences.
- Jackson, C. (2003). Gender analysis of land: Beyond land rights for women? *Journal of Agrarian Change*, 3(4), 453–480. <https://doi.org/10.1111/1471-0366.00062>
- Kamande, M. W., & Bahati, E. M. (2019). Effects of women land rights on agricultural outcomes in Rwanda. *African Journal on Land Policy and Geospatial Sciences*, 2, 60–70. <https://doi.org/10.48346/IMIST.PRSM/AJLP-GSV2I1.15205>
- Kelly, L. D., Deaton, B. J., & Amegashie, J. A. (2019). The nature of property rights in Haiti: Mode of land acquisition, gender, and investment. *Journal of Economic Issues*, 53(3), 726–747. <https://doi.org/10.1080/00213624.2019.1644922>
- Krishna, A. (2004). Understanding, measuring and utilizing social capital: Clarifying concepts and presenting a field application from India. *Agricultural Systems*, 82(3), 291–305. <https://doi.org/10.1016/j.agry.2004.07.003>
- Kudo, Y. (2015). Female migration for marriage: implications from the land reform in Rural Tanzania. *World Development*, 65, 41–61. <https://doi.org/10.1016/j.worlddev.2014.05.029>
- Kumar, S., Patel, R., & Chauhan, S. (2020). Does land possession among working women empower them and improve their child health: A study based on National Family Health Survey-4. *Children and Youth Services Review*, 119, 105697. <https://doi.org/10.1016/j.childyouth.2020.105697>
- Laura, T., Constanza, T., Silke, S., Loui, W., & Brianna, H. (2023). *Feminist climate justice: A framework for action*. UN-Women.
- Lawry, S., Samii, C., Hall, R., Leopold, A., Hornby, D., & Mtero, F. (2017). The impact of land property rights interventions on investment and agricultural productivity in developing countries: A systematic review. *Journal of Development Effectiveness*, 9(1), 61–81. <https://doi.org/10.1080/19439342.2016.1160947>
- Linkow, B. (2019). Inheritance practices, investment incentives and women's control over land in rural Kenya. *Journal of African Economies*, 28(3), 304–322. <https://doi.org/10.1093/jae/ejy025>
- Lovo, S. (2016). Tenure insecurity and investment in soil conservation. Evidence from Malawi. *World Development*, 78, 219–229. <https://doi.org/10.1016/j.worlddev.2015.10.023>
- Luke, N., & Munshi, K. (2011). Women as agents of change: Female income and mobility in India. *Journal of Development Economics*, 94(1), 1–17. <https://doi.org/10.1016/j.jdeveco.2010.01.002>
- Lundberg, S. J., Pollak, R. A., & Wales, T. J. (1997). Do husbands and wives pool their resources? Evidence from the United Kingdom Child Benefit. *Journal of Human Resources*, 32(3), 463–480.
- Masterson, T. (2007). Female land rights, crop specialization, and productivity in Paraguayan agriculture. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.998600>
- McElroy, M. B. (1990). The empirical content of Nash-bargained household behavior. *Journal of Human Resources*, 25(4), 559–583. <https://doi.org/10.2307/145667>
- Meier Zu Selhausen, F. (2016). What determines women's participation in collective action? Evidence from a Western Ugandan coffee cooperative. *Feminist Economics*, 22(1), 130–157. <https://doi.org/10.1080/13545701.2015.1088960>
- Meinzen-Dick, R., DiGregorio, M., & McCarthy, N. (2004). Methods for studying collective action in rural development. *Agricultural Systems*, 82(3), 197–214. <https://doi.org/10.1016/j.agry.2004.07.006>
- Meinzen-Dick, R., Quisumbing, A., Doss, C., & Theis, S. (2019). Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. *Agricultural Systems*, 172, 72–82. <https://doi.org/10.1016/j.agry.2017.10.009>
- Meinzen-Dick, R. S., Brown, L. R., Feldstein, H. S., & Quisumbing, A. R. (1997). Gender, property rights, and natural resources. *World Development*, 25(8), 1303–1315. [https://doi.org/10.1016/S0305-750X\(97\)00027-2](https://doi.org/10.1016/S0305-750X(97)00027-2)
- Melesse, M. B., Dabissa, A., & Bulte, E. (2018). Joint land certification programmes and women's empowerment: Evidence from Ethiopia. *Journal of Development Studies*, 54(10), 1756–1774. <https://doi.org/10.1080/00220388.2017.1327662>
- Mendola, M., & Simtowe, F. (2015). The welfare impact of land redistribution: Evidence from a quasi-experimental initiative in Malawi. *World Development*, 72, 53–69. <https://doi.org/10.1016/j.worlddev.2015.02.010>
- Menon, N., van der Meulen Rodgers, Y., & Kennedy, A. R. (2017). Land reform and welfare in Vietnam: Why gender of the land-rights holder matters. *Journal of International Development*, 29(4), 454–472. <https://doi.org/10.1002/jid.3203>
- Menon, N., Van Der Meulen Rodgers, Y., & Nguyen, H. (2014). Women's land rights and children's human capital in Vietnam. *World Development*, 54, 18–31. <https://doi.org/10.1016/j.worlddev.2013.07.005>

- Montcho, M., Padonou, E. A., Montcho, M., Mutua, M. N., & Bayen, P. (2023). Impact of land tenure on livelihoods of women livestock-keepers in Burkina Faso. *Land Use Policy*, 133, 106848. <https://doi.org/10.1016/j.landusepol.2023.106848>
- Muchomba, F. M. (2017). Women's land tenure security and household human capital: Evidence from Ethiopia's land certification. *World Development*, 98, 310–324. <https://doi.org/10.1016/j.worlddev.2017.04.034>
- Muchomba, F. M., Wang, J. S.-H., & Agosta, L. M. (2014). Women's land ownership and risk of HIV infection in Kenya. *Social Science & Medicine*, 114, 97–102. <https://doi.org/10.1016/j.socscimed.2014.05.055>
- Murken, L., & Gornott, C. (2022). The importance of different land tenure systems for farmers' response to climate change: A systematic review. *Climate Risk Management*, 35, 100419. <https://doi.org/10.1016/j.crm.2022.100419>
- Murshid, N. (2017). An assessment of the association between asset ownership and intimate partner violence in Pakistan. *Public Health*, 150, 1–8. <https://doi.org/10.1016/j.puhe.2017.05.004>
- Mustafa, S. (2022). The importance of Ukraine and the Russian Federation for global agricultural markets and the risks associated with the current conflict. FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/4fce6098-a3ba-4742-b8f4-685454a5d409/content#page=56.10>
- Newman, C., Tarp, F., & Van Den Broeck, K. (2015). Property rights and productivity: The case of joint land titling in Vietnam. *Land Economics*, 91(1), 91–105. <https://doi.org/10.3368/le.91.1.91>
- Nguyen, M., & Le, K. (2023). The impacts of women's land ownership: Evidence from Vietnam. *Review of Development Economics*, 27(1), 158–177. <https://doi.org/10.1111/rode.12941>
- Ogundari, K. (2022). A meta-analysis of the impact of agricultural extension services. *China Agricultural Economic Review*, 14(2), 221–241. <https://doi.org/10.1108/CAER-07-2021-0130>
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
- Otsuka, K., & Place, F. M. (2001). *Land tenure and natural resource management: A comparative study of agrarian communities in Asia and Africa*. John Hopkins University Press.
- Owoo, N. S., & Boakye-Yiadom, L. (2015). The gender dimension of the effects of land tenure security on agricultural productivity: Some evidence from two districts in Kenya. *Journal of International Development*, 27(7), 917–928. <https://doi.org/10.1002/jid.3028>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372(71). <https://doi.org/10.1136/bmj.n71>
- Panda, P., & Agarwal, B. (2005). Marital violence, human development and women's property status in India. *World Development*, 33(5), 823–850. <https://doi.org/10.1016/j.worlddev.2005.01.009>
- Pandolfelli, L., Meinzen-Dick, R., & Dohrn, S. (2008). Gender and collective action: Motivations, effectiveness and impact. *Journal of International Development*, 20(1), 1–11. <https://doi.org/10.1002/jid.1424>
- Persha, L., Greif, A., & Huntington, H. (2017, March). *Assessing the impact of second-level land certification in Ethiopia* [Paper presented at the World Bank Conference on Land and Poverty, Washington, DC, United States]
- Peterman, A. (2011). Women's property rights and gendered policies: Implications for women's long-term welfare in rural Tanzania. *Journal of Development Studies*, 47(1), 1–30. <https://doi.org/10.1080/00220381003600366>
- Peterman, A., Pereira, A., Bleck, J., Palermo, T. M., & Yount, K. M. (2017). Women's individual asset ownership and experience of intimate partner violence: Evidence from 28 international surveys. *American Journal of Public Health*, 107(5), 747–755. <https://doi.org/10.2105/AJPH.2017.303694>
- Pickering, C., & Byrne, J. (2014). The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. *Higher Education Research & Development*, 33(3), 534–548. <https://doi.org/10.1080/07294360.2013.841651>
- Polavarapu, A. (2020). Without land, without justice: How women's lack of land rights impedes access to justice. In D. Lawson, A. Dubin, & L. Mwambene (Eds.), *Gender, poverty and access to justice: Policy implementation in Sub-Saharan Africa* (pp. 133–145). Routledge.
- Prindex. (n.d.). Five infographics on land and property rights in the Middle East and North Africa. <https://www.prindex.net/reports/fiveinfographics-land-and-property-rights-middle-east-and-north-africa/>
- Quisumbing, A. R., Estudillo, J. P., & Otsuka, K. (2003). *Land and schooling: Transferring wealth across generations*. IFPRI
- Quisumbing, A. R., & Maluccio, J. A. (2003). Resources at marriage and intrahousehold allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa. *Oxford Bulletin of Economics and Statistics*,

- 65(3), 283–327. <https://doi.org/10.1111/1468-0084.t01-1-00052>
- Ratner, B. D., Meinzen-Dick, R., May, C., & Haglund, E. (2013). Resource conflict, collective action, and resilience: An analytical framework. *International Journal of the Commons*, 7(1), 183–208. <https://doi.org/10.18352/ijc.276>
- Rehman, A., Ping, Q., & Razzaq, A. (2019). Pathways and associations between women's land ownership and child food and nutrition security in Pakistan. *International Journal of Environmental Research and Public Health*, 16(18), 3360. <https://doi.org/10.3390/ijerph16183360>
- Rosenblum, D. (2015). Unintended consequences of women's inheritance rights on female mortality in India. *Economic Development and Cultural Change*, 63(2), 223–248. <https://doi.org/10.1086/679059>
- Roy, S. (2015). Empowering women? Inheritance rights, female education and dowry payments in India. *Journal of Development Economics*, 114, 233–251. <https://doi.org/10.1016/j.jdeveco.2014.12.010>
- Santos, F., Fletschner, D., Savath, V., & Peterman, A. (2014). Can government-allocated land contribute to food security? Intrahousehold analysis of West Bengal's microplot allocation program. *World Development*, 64, 860–872. <https://doi.org/10.1016/j.worlddev.2014.07.017>
- Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, 68(3), 249–262. <https://doi.org/10.2307/3146375>
- Schling, M., & Pazos, N. (2024). Effective land ownership, female empowerment, and food security: Evidence from Peru. *World Development*, 181, 106680. <https://doi.org/10.1016/j.worlddev.2024.106680>
- Sen, A. (1999). *Development as freedom*. Anchor Books.
- Shi, X., Huangfu, B., Jin, S., & Gao, X. (2024). Property rights, labor reallocation, and gender inequality in rural China. *Journal of Economic and Behavior Organization*, 220, 325–342. <https://doi.org/10.1016/j.jebo.2024.02.020>
- Shwachman Kaminaga, A., & Sheldon, H. (2022). Help or harm? The impact of property titling on women's acceptance of intimate partner violence. *Journal of International Development*, 34(6), 1197–1212. <https://doi.org/10.1002/jid.3624>
- Stevens, C., Panfil, Y., Linkow, B., Hagopian, A., Mellon, C., Kulkarni, N., Bouvier, I., Brooks, S., Lowery, S., & Green, J. (2020). *Land and development: A research agenda for land and resource governance at USAID*. USAID
- Teklewold, H. (2023). Understanding gender differences on the choices of a portfolio of climate-smart agricultural practices in Sub-Saharan Africa. *World Development Perspectives*, 29, 100486. <https://doi.org/10.1016/j.wdp.2023.100486>
- Thomas, D. (1990). Intra-household resource allocation: An inferential approach. *Journal of Human Resources*, 25(4), 635–664. <https://doi.org/10.2307/145670>
- Udry, C. (1996). Gender, agricultural production, and the theory of the household. *Journal of Political Economy*, 104(5), 1010–1046. <https://doi.org/10.1086/262050>
- Ward, C. L., & Harlow, S. (2021). R.E.S.P.e.c.T and intimate partner violence: A cross-sectional study using DHS data in Kenya. *BMJ Open*, 11(9), e046069. <https://doi.org/10.1136/bmjopen-2020-046069>
- Ward-Batts, J. (2008). Out of the wallet and into the purse. *Journal of Human Resources*, 43(2), 325–351. <https://doi.org/10.3368/jhr.43.2.325>
- Wiig, H., Bråten, R. H., & Fuentes, D. O. (2011). *Land ownership and women's empowerment – Combining survey and experiments in Peruvian rural households*. (Background paper for World Development Report 2012). World Bank.
- Yokying, P., & Lambrecht, I. (2020). Landownership and the gender gap in agriculture: Insights from Northern Ghana. *Land Use Policy*, 99, 105012. <https://doi.org/10.1016/j.landusepol.2020.105012>



Citation: Escobar Jaramillo, D., Coderoni, S. & Sckokai, P. (2026). The concept of circular economy in agriculture. A review of the literature and a possible way forward. *Bio-based and Applied Economics* 15(3): 77-94. doi: 10.36253/bae-17477

Received: March 21, 2025

Accepted: August 1, 2026

Published: October 2, 2026

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor in Chief: Fabio Bartolini

ORCID

DEJ: 0000-0003-1547-1449

SC: 0000-0001-8751-7376

PS: 0000-0001-8278-9663

The concept of circular economy in agriculture. A review of the literature and a possible way forward

DIANA ESCOBAR JARAMILLO^{1*}, SILVIA CODERONI², PAOLO SCKOKAI³

¹ Department of Agricultural and Food Economics, Università Cattolica del Sacro Cuore, 29122, Piacenza, Italy

² Department of Biosciences and Agro-Food and Environmental Technologies, Università degli Studi di Teramo, 64100, Teramo, Italy

³ Department of Agricultural and Food Economics, Università Cattolica del Sacro Cuore, 29122, Piacenza, Italy

*Corresponding author. E-mail: diana.escobar@unicatt.it

Abstract. The EU prioritises the circular economy to foster sustainability, optimise resources, and minimise waste. Despite its potential, lacking a clear definition for circular economy in agriculture limits its benefits and cumulative knowledge. This study systemically identifies a consensus concept of circular economy in agriculture and its relationship with circular bioeconomy. We conducted a two-stage review and coding analysis of academic and grey literature, 22 documents define circular economy in agriculture and 12 define circular bioeconomy. Results indicate that circular economy in agriculture closes production loops, reduces, manages, and repurposes waste, primarily through the R's principles - reduce, reuse, recycle. Its aims include environmental, economic, health and food security benefits. Circular economy in agriculture is overarching and synergistic to circular bioeconomy, since cascading mechanisms improve sustainable resource management. As circular economy evolves, this study offers a foundation for future research integrating expert validation and qualitative assessments with implementation and monitoring strategies.

Keywords: circular economy, circular bioeconomy, sustainability, concept, coding.

1. INTRODUCTION

Population growth and the produce-use-dispose model have driven actual estimates in which we use more than the available amount of raw materials on Earth (United Nations Development Programme, 2023). This situation makes circularity indispensable for sustainable development. The European Union (EU), through the European Green Deal and the Circular Economy Action Plan, promotes a sustainable development through the circular economy, defined as an economic system that optimises the use of materials, maintains the value of resources, and minimises the generation of waste (European Commission, 2015). The agricultural sector is strategic for transition-

ing to the circular economy, given its high use of natural resources, specifically water and nutrients (European Commission, 2022). Furthermore, if circular economy in agriculture promotes sustainability, it will maintain the economic, social, and environmental bases so that food security and nutrition for future generations are not compromised (FAO, 2018).

Despite its widespread presence in the policy debate, the definition of a circular economy remains ambiguous, with scholars and practitioners adapting the idea of circularity according to their contexts and expertise. Much of the literature on circular economy has focused on practical and technical levels, leaving aside the evaluation of its values, structure, and potential (Korhonen, Nuur, et al., 2018). Furthermore, different definitions have been applied from diverse perspectives, either a post-political stand (Borrello et al., 2020) or different backgrounds and geographic regions, making the circular economy an “umbrella concept” (Homrich et al., 2018). The vagueness of the concept of circular economy poses the risk of obstructing its benefits (Arru et al., 2022; Borrello et al., 2020) and a collapse of the model due to impeded cumulative knowledge (Kirchherr et al., 2017).

A clear theoretical framework recognised by researchers, policymakers and practitioners is essential for realising the potential of circularity in agriculture, as it would connect technological advances in a comprehensive knowledge base and provide the foundation for effective supporting policies (Rinaldi & Biaggi, 2025). Modern research and technologies in the areas of waste recovery, wastewater treatment, biochar application, and clean energy (Amoah-Antwi et al., 2020; Barros et al., 2020; Hidalgo et al., 2019; Maaß & Grundmann, 2018) are expanding opportunities to enhance resource efficiency and value creation. Yet, the integration of circularity into agricultural production remains fragmented, largely due to a lack of consensus on definitions (Tamasiga et al., 2022; Velasco-Muñoz et al., 2021). Current conceptualisations in the agrifood sector tend to be narrow in scope, focusing either on compiling circular practices (De Boer & van Ittersum, 2018) or on specific components such as livestock systems (Van Zanten et al., 2019), rather than offering a comprehensive and operational framework.

Usually, sustainability tends to be an effect associated with a circular economy. Businesses and policymakers view the circular economy as an approach to pursuing sustainable development (Ghibelline et al., 2016; Ministero della Transizione Ecologica, 2022; Murray et al., 2017). However, being more circular does not always translate into being more sustainable. The relationship between circularity and sustainability often

has trade-offs, such as the environmental impact of the energy required to recycle materials (Barcelos et al., 2021; Geissdoerfer et al., 2017). Also, improvements in the different pillars of sustainability may happen separately, such as specifying benefits in environmental sustainability (Koppelmäki et al., 2021; Van Zanten et al., 2019). The achievements of a circular economy may vary depending on the interest of the government to reach specific sustainable development goals, sometimes resulting in trade-offs with other objectives (Livingstone et al., 2022).

The circular bioeconomy is a term often used in the agricultural sector to talk about the circular economy due to the biological nature of the main resources used in this field. However, there is still debate about the connection between circular economy and bioeconomy, which influences the definition used for circular bioeconomy (Leipold & Petit-Boix, 2018)¹. Furthermore, bioeconomy has been thought to be circular inherently due to the material circularity of nature (Konstantinis et al., 2018). Hence, circular economy in agriculture has often been used interchangeably with circular bioeconomy (Velasco-Muñoz et al., 2021), but the relationship between these concepts has not been properly assessed.

Previous research has looked for a consensus definition of a circular economy (Kirchherr et al., 2017), but they do not focus on the characteristics of the agricultural sector (i.e., being based on managing biological resources), that must be instead considered to give precise guidelines (Ellen MacArthur Foundation, 2019c). Most studies still focus on circularity in the agri-food industry and distribution phases rather than the production phase (Martínez-Moreno et al., 2024; Velasco-Muñoz et al., 2021), although this last one is the biggest contributor to the European agrifood circularity index (Arru et al., 2022). Further research is thus needed to compare understandings of circularity in agricultural production and to systemically address the connection between circularity and sustainability.

In this research we aim to fill this gap by proposing a new, comprehensive definition of circular economy applied to agriculture. This definition is built answering the questions: i) what principles define the concept of a circular economy presently applied to agriculture by scholars and practitioners? ii) what is the relationship between circularity and the economic, social and environmental sustainability of farms? Then, given the

¹ The circular economy and the bioeconomy may be in fact connected in five possible ways: i) separate but reinforcing, ii) completely integrated, iii) partially antagonistic, iv) bioeconomy a precondition to circular economy, v) circular economy a tool in transitioning to the bioeconomy (Leipold & Petit-Boix, 2018).

close relationship between the concepts of circular economy in agriculture and of circular bioeconomy, we also address a complementary research question: iii) what is the connection between the identified definition of circular economy applied to agriculture and the concept of circular bioeconomy?

The approach we adopted for this review article is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement 2020 (Page et al., 2021), followed by a coding analysis. The novelty of this work with respect to the existing literature is, first, the focus on agriculture when explaining the concept of circular economy, and second, the use of the literature review combined with a coding framework to get a structured consensus definition and its connection with sustainability.

2. METHOD AND DATA

The method used in this research consists of collecting documents, coding their information, and analysing the classified information to construct a unified concept. The circular economy may be considered a social construct since its definition has depended on the users' perspective of circularity practices. Dahl-

srud (2008) recognise that though it is not possible to develop an unbiased definition of social constructions, studying similarities and differences of the available definitions through a coding framework allows identifying a consensus idea. To find a consensus concept, Singh & Aggarwal (2022) used an open coding process to unpack and repack qualitative data.

The PRISMA statement 2020 was used to identify, select and review documents to recognise a consensus concept of circular economy in agriculture. The PRISMA approach allows users to construct a transparent, accurate, and complete systematic literature review (Page et al., 2021).

The literature review was divided into two stages: the first stage was the collection of definitions of circular economy applied to the agricultural sector and the second was on the collection of definitions of circular bioeconomy to allow for comparison among the two (for a detailed description of the steps followed, please refer to Supplementary Materials).

Figure 1 presents the flow diagram with information about the selection of documents for the literature review, following the PRISMA approach. We found 109 records during database search. After removing duplicates, we screened 72 records, from which we reviewed 17 full-text documents, and finally included 9 docu-

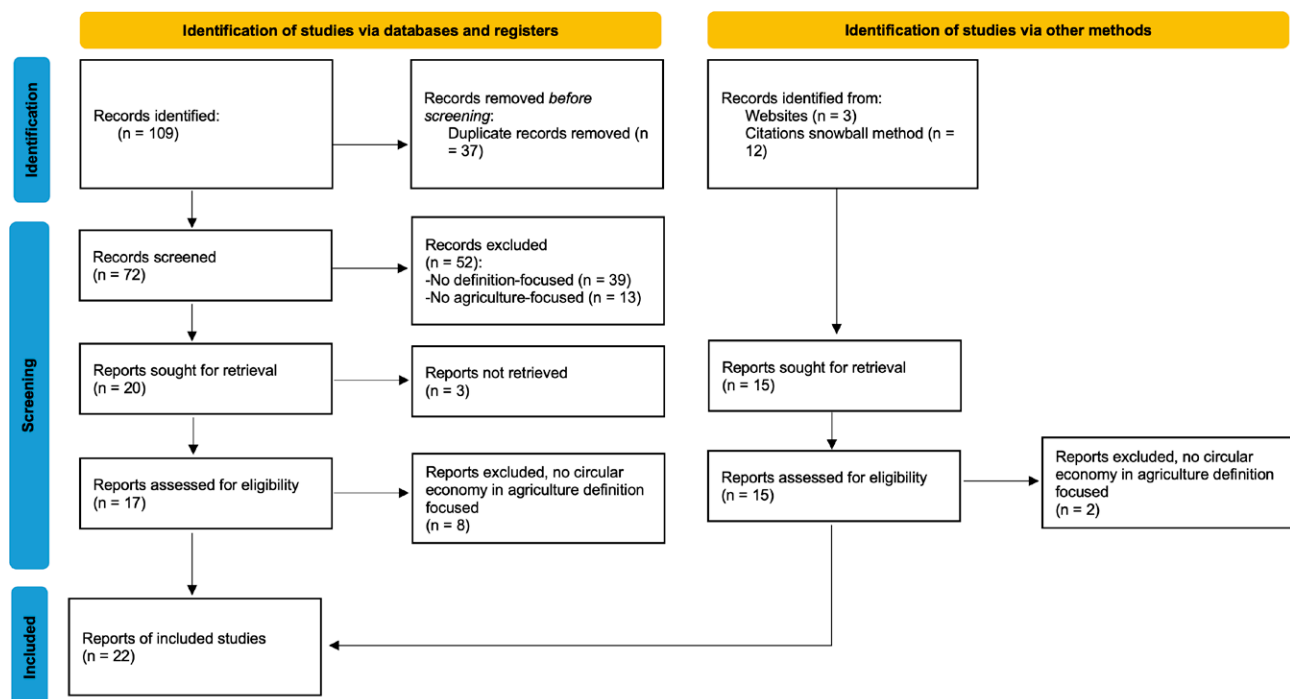


Figure 1. PRISMA 2020 flow diagram of the systematic review of definitions of circular economy applied to agriculture. Source: our elaboration based on the format of Page MJ, et al. *BMJ* 2021;372: n71. Doi: 10.1136/bmj.n71. This work is licensed under CC BY 4.0.

ments. Later, we searched references of the initially included studies, using the snowball method. We also added relevant documents from the Ellen MacArthur webpage. 13 extra documents that fulfilled inclusion criteria were found in these searches. The final number of documents analysed, including academic and grey literature, was 22 (see Table S1).

Figure S1 presents the flow diagram with information about the selection of documents for the second stage literature review, following the PRISMA approach. We found 57 records during database search. After removing duplicates, we screened 55 records, from which we reviewed 18 full-text documents, and finally included 12 documents (see Table S3).

Building on the literature defining circular economy applied to agriculture and the literature defining circular bioeconomy, we performed a conceptual comparison of the two perspectives. This analysis examines how each concept frames circularity, with particular attention to their respective principles and economic, social, and environmental aims.

3. RESULTS

The following text presents the coding framework used to analyse the information collected through the literature review, which leads to the replies to the research questions. Section 3.1 replies to the first research question by identifying the principles that

define the circular economy in agriculture; section 3.2 replies to the second research question on the relationship between circular economy and sustainability aims, and finishes by presenting the new comprehensive definition of circular economy in agriculture which englobes principles and aims; while section 3.3 defines circular bioeconomy and its relationship with the definition of circular economy in agriculture.

The coding framework for circular economy applied to agriculture, generated after analysing the collected literature, is presented in Figure 2. This figure is a graphic representation of how the concept of circular economy in agriculture has been structured: the connection between the ideas is represented by straight lines connecting the nodes, a “child” is a subordinate idea depicted at a lower level, and “sibling” ideas are the ones represented at the same horizontal level. Figure 2 identifies five core principles: cascading, efficiency, regeneration, systemic approach, and the R’s principles.

The aims of the circular economy applied to agriculture are categorised as economic, social, environmental, and those explicitly referring to sustainability. This classification of the aims enables recognising the difference between circularity associated explicitly with sustainability and its three pillars and circularity associated with aims only in economic, social, or environmental aspects. With this categorisation of the aims we intend to identify if the common critique of circularity’s relationship with sustainability applies also to the agricultural sector, meaning that when circular economy is said to be

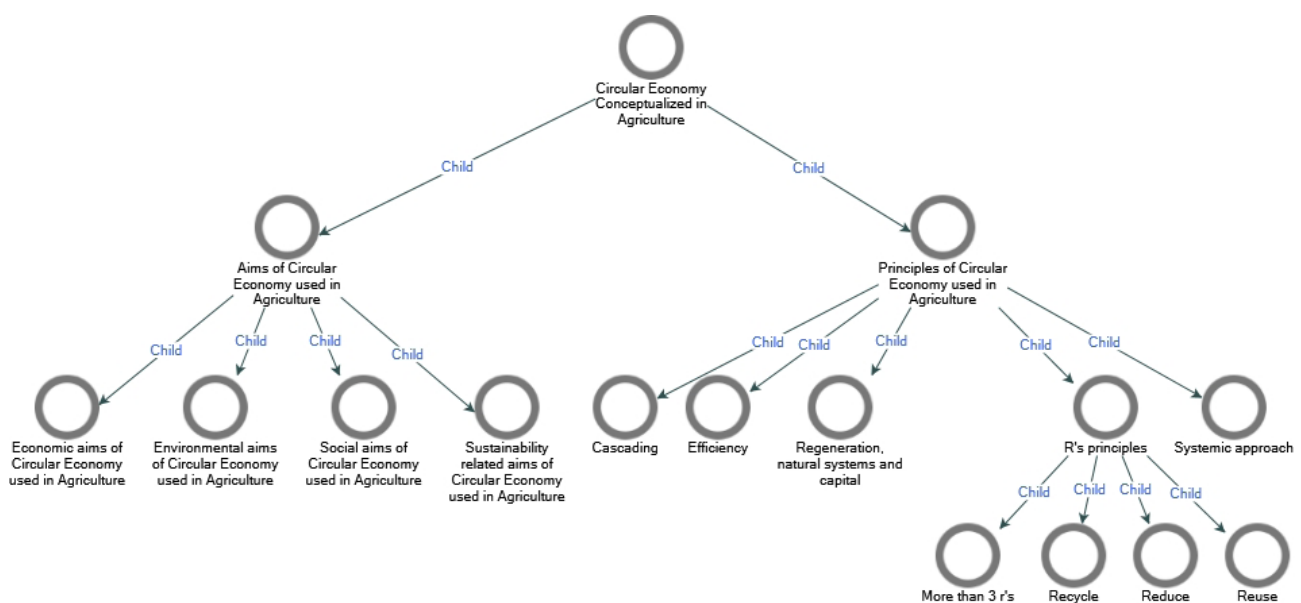


Figure 2. Coding framework map of the concept of circular economy applied to agriculture. Source: our elaboration.

sustainable, it refers to economic and environmental sustainability only, leaving behind social sustainability (Schöggel et al., 2020). Furthermore, we contribute to the broader discussion about the components of sustainability, which suggests that the unjustified use of the three-pillar model may blind us from a better understanding of the complex synergies and trade-offs between the three pillars of sustainability (Purvis et al., 2019).

3.1. Circular economy principles in agriculture

Looking at the words mentioned in the literature (see Figure S2), the principles of circular economy in agriculture refer to “Waste” and “Products”, discussing closing the loop production patterns, reducing waste, effectively managing waste, and using waste as a resource.

The most used principles are the R's - reduce, reuse, and recycle (see Figure S3). Within the R's principles, “recycle” is the leading topic, followed by “reuse”, while “reduce” is mentioned in less than 50% of the documents analysed. Recycling refers to closing the loop for waste, such as using agricultural and livestock residues to generate agricultural inputs. Yuille et al. (2022) refer to recycling as a way to design out waste and obtain resources to replenish the system's self-supporting capacity, while the Ellen MacArthur Foundation (2019b) and Ruiz et al. (2009) add that waste passes from being a cost to a potential source of value. Furthermore, Fassio & Tecco (2019) and Pimbert (2012) go back to the foundation of the circular economy, mentioning that the principle of recycling originates from the proposal of mimicking the dynamics of natural ecosystems adopted by industrial ecology².

Reusing includes the conservation of water, secondary raw materials, and food. Food redistribution is recognised as a more valuable use of resources than recycling (Ruiz et al., 2019). Recycling is only recommended when reusing is impossible, as when food surplus becomes food waste. Food waste is generated when edible food surplus becomes inedible due to the lack of preparation or preservation (Jurgilevich et al., 2016). Food redistribution improves the environmental performance of the whole agri-food value chain. Unclaimed food implies unnecessary greenhouse gas emissions during production, processing, transportation, storing, distribution and retail (Papargyropoulou et al., 2014).

Reducing in agriculture means minimising the use of natural resources, chemical fertilisers, food waste, and pollution. The reduction is motivated by the finitude of resources (Jurgilevich et al., 2016; Paño Yañez, 2021) and to separate income from material inputs (Pimbert, 2012). Jun & Xiang (2011) define reducing as the diminished use of scant and non-renewable resources, keeping fixed production and consumption targets. Conversely, Barañano et al. (2021) consider the principle of reduction as a general decrease in the number of resources used and the quantity extracted, the number and amount of products discarded. The circular economy is also expected to reduce pollution (Therond et al., 2017), by using local inputs in opposition to a globalised food system based on commodity trade.

Cascading, which means using resources sequentially and consecutively at their highest value (Ellen MacArthur Foundation, 2019c), is considered by only 60% of the documents assessed. Cascading is commonly referred to as “optimising” the management of the stock of resources (Fassio & Tecco, 2019; Paño Yañez, 2021). Barañano et al. (2021) explain that cascading is applied when biomass is converted into products, the waste from this process is used as input for a lower-level production, this step is repeated until the waste can no longer be transformed into products, and finally, the waste is burned to provide energy. The highest-value use of resources is based on prioritizing plant biomass for human food production. In this hierarchy, edible biomass should first be used to produce food for humans, by-products should be reused or recycled, and inedible biomass should be used as animal feed. Livestock can then convert this biomass into additional food, manure, and ecosystem services (Van Zanten et al., 2019; Velasco-Muñoz et al., 2021). However, the opportunities for valorising residues and by-products are determined by the purity of the waste and the effectiveness of the collection system (Ellen MacArthur Foundation, 2019b).

3.2. The relationship between circular economy in agriculture and sustainability

Circular economy applied to agriculture targets sustainability mainly through environmental and economic aims, and least frequently, though still considered by 70% of the documents analysed, social aims (see Figure S4).

The environmental aims of the circular economy are the most extensively described. Figure S5 section a in the Supplementary Materials presents the keywords used in their description, which refer to the environmental aims of using fewer inputs, generating less waste, and improving soil.

² Industrial ecology proposed increasing efficiency whilst decreasing the use of non-renewable resources in agriculture (Pagotto & Halog, 2016; Trokanas et al., 2014).

Table 1. Environmental aims of the circular economy applied to agriculture.

Circular economy strategy	Environmental aims	Reference
Regenerate nature	Climate change solution	Velasco-Muñoz et al., 2021; Ellen MacArthur Foundation, 2019b; Freeman et al., 2022; Yuille et al., 2022
Resource efficiency, pollution reduction, and enhancing soil, agrobiodiversity and ecosystems	Climate change solution	De Rosa et al., 2021; Ellen MacArthur Foundation, 2019b; Pimbert, 2012; Therond et al., 2017; Velasco-Muñoz et al., 2021
Reduce stress on natural ecosystems	Improve environmental conditions of marginal lands while preserving landscapes	EIP-AGRI, 2015; Freeman et al., 2022; Paño Yañez, 2021
Soil improvements	Resilience to wind, floods, and droughts	Ellen MacArthur Foundation, 2019b; SYSTEMIQ & Ellen MacArthur Foundation, 2017
Composting residues	Improve soil	Bos & Broeze, 2020; Ellen MacArthur Foundation, 2019b; Yuille et al., 2022
Local resource use	Minimize pollution	Barcelos et al., 2021; Jurgilevich et al., 2016; Therond et al., 2017
Water demand reduction and wastewater reuse	Alleviate pressure on hydrological resources	Velasco-Muñoz et al., 2021
Carbon sequestration capacity enhancement	Reduce carbon emissions and improve resilience to environmental challenges	SYSTEMIQ & Ellen MacArthur Foundation, 2017
Waste used to produce energy	Reduce resource depletion and pollution from waste disposal	Barcelos et al., 2021; EIP-AGRI, 2015

Source: our elaboration.

Table 1 shows the specific environmental aims of the circular economy with the reference documents mentioning them, which are the basis of the subsequent information. According to these documents, the circular economy in agriculture aims at restoring nature's balance, thereby shifting the agricultural sector from a contributor to climate change to a solution. This framework operates by maximizing resource efficiency, reducing pollution, and fostering the regeneration of soil, agrobiodiversity, and ecosystems. By alleviating the strain on natural ecosystems, the circular economy model simultaneously improves food production and rejuvenates marginal lands, preserving the integrity of landscapes. Crucially, the return of nutrients to the soil enhances food production, promotes carbon sequestration and mitigates pollution. Effective waste management practices, including composting, further amplify these results by conserving water resources. Such soil enhancements strengthen resilience against adverse weather conditions like wind, floods, and droughts. Additionally, soil improvement and waste management decrease the reliance on chemical fertilizers, thus diminishing resource extraction and lowering energy consumption and transportation-related pollution. Using local resources further minimises the environmental footprint of transportation activities. Moreover, strategies focusing on water demand reduction and wastewater reuse alleviate the

strain on hydrological resources. Using waste for energy generation serves to both mitigate resource depletion and combat improper waste disposal practices.

The aim of economic sustainability under the framework of circular economy is expected from the efficient use and reuse of materials, as well as logistic and resilience improvements (see Figure S5 section b in the Supplementary Materials).

Table 2 shows the economic aims of the circular economy with the reference documents that mention them, which are the basis of the subsequent information. According to these documents, the circular economy is expected to bring sustainable economic growth while reducing resource consumption. This is achieved by efficient resource use and recycling. Reducing excess nitrogen (N) and phosphorus (P) and reusing resources like water in fertirrigation improves productivity. Furthermore, the circular economy reduces dependence on costly and risky external sources like agrochemicals, transgenic technologies, and fossil fuels. Adopting circular practices also enhances resilience by promoting adaptation to climate change. Circularity is a way to achieve long-term higher yields and performance thanks to environmental protection. Additionally, it encourages the renewal of infrastructure and the creation of networks for better resource management, fostering innovation and multiple revenue streams, such as generating income from biomass energy.

Table 2. Economic aims of the circular economy applied to agriculture.

Circular economy strategy	Economic aims	Reference
Efficient resource use and recycling	Economic growth	Burgo-Bencomo et al., 2019; De Rosa et al., 2021; EIP-AGRI, 2015; Ellen MacArthur Foundation, 2019a; Fassio & Tecco, 2019; Jun & Xiang, 2011; Ruiz et al., 2019; Velasco-Muñoz et al., 2021
Minimise resource use	Economic growth	Hens et al., 2018; Velasco-Muñoz et al., 2021
Valorisation of organic waste	Business opportunities	Ellen MacArthur Foundation, 2019b
Control excess N and P	Productivity improvements	Yuille et al., 2022
Regenerate nature	Benefit profitability	SYSTEMIQ & Ellen MacArthur Foundation, 2017
Reduced dependence on external agrochemical inputs, transgenic technologies, and fossil energy	Reduced costs and risks	EIP-AGRI, 2015; Pimbert, 2012; SYSTEMIQ & Ellen MacArthur Foundation, 2017; Yuille et al., 2022
Local transport of inputs	Reduced costs	Barcelos et al., 2021
Environmental protection	Improved resilience, better incomes, higher yields	Ellen MacArthur Foundation, 2019a, 2019b; Freeman et al., 2022; SYSTEMIQ & Ellen MacArthur Foundation, 2017; Burgo-Bencomo et al., 2019; Ellen MacArthur Foundation, 2019a; Jun & Xiang, 2011; Kristensen et al., 2016; Velasco-Muñoz et al., 2021
Renewal of infrastructure and the formation of networks	Improved resource use	Barcelos et al., 2021; Fassio & Tecco, 2019
Innovative entrepreneurship	Multiple revenue streams	Ruiz et al., 2019; Velasco-Muñoz et al., 2021; EIP-AGRI, 2015; Ellen MacArthur Foundation, 2019a; Therond et al., 2017

Source: our elaboration.

Social sustainability is aimed by circularity in agriculture through two main aspects: human health protection and food security. Additionally, some mention improved human capital and technology (See Figure S5 section c). Table 3 shows the social aims of the circular economy with the reference documents mentioning them, which are the basis of the subsequent information. The circular economy lessens the negative impacts of production that damage human health, including extraction of raw materials, waste production, hazardous substances emission, and pollution of soil, water and air. Besides, human health may benefit from the consumption of food with a higher-quality nutrient profile. Circular Economy practices are expected to increase soil organic matter and improve soil health, which can enhance nutrient availability and favour micronutrient uptake by plants, potentially leading to crops with a richer nutrient profile. Food security might also improve by reducing food waste and enhancing the production and resilience of agriculture. Furthermore, energy and water security would improve through reduced pollution and the use of renewable resources. The circular econo-

my might also reduce poverty because it allows farmers to have multiple revenue streams. The participation and importance of women in business may also increase, as circular economy provides an opportunity for the creation of new businesses in which women may contribute and lead. Social development may be improved by promoting farmers' knowledge and technology application to create biobased products. Moreover, circular economy in agriculture is expected to allow farmers to improve their quality of life by investing in health and education with the money they save through simplified logistics and self-sufficient production.

Based on the results of Section 3.1 and 3.2, we propose a comprehensive concept of circular economy applied in agriculture, which departs from the basics and reaches the objectives that emerge from the available documents:

Circular economy in agriculture is a comprehensive framework that integrates the principles of reusing resources and recycling waste through cascading processes that maximize resource value, it strives to reduce

Table 3. Social aims of the circular economy applied to agriculture.

Circular economy strategy	Social aims	Reference
Reduced extraction of raw materials from nature, waste production, greenhouse gases and hazardous substances emission	Human health protection	Burgo-Bencomo et al., 2019; Ellen MacArthur Foundation, 2019a, 2019b; Kristensen et al., 2016; Yuille et al., 2022
Production of food with a higher-quality nutrient profile	Human health benefit	Ellen MacArthur Foundation, 2022; SYSTEMIQ & Ellen MacArthur Foundation, 2017
Reduction of food waste, enhanced production and resilience of food production systems	Food security improvement	Burgo-Bencomo et al., 2019; Fassio & Tecco, 2019; Jurgilevich et al., 2016; Kristensen et al., 2016; Yuille et al., 2022; Ellen MacArthur Foundation, 2019a, 2019b
Reduced pollution and production of energy from renewable sources	Energy and water security	Pimbert, 2012
Opportunity generator of multiple revenue streams	Poverty reduction	Pimbert, 2012; EIP-AGRI, 2015; Ellen MacArthur Foundation, 2019a
Innovation to create biobased products	Social development	Burgo-Bencomo et al., 2019; Fassio & Tecco, 2019
Participation and importance of women in business	Social development	Fassio & Tecco, 2019
Farmers' knowledge and technologies reinforcement	Social development	Fassio & Tecco, 2019
Costs reduction by simplified logistics	Health and education investments	Barcelos et al., 2021

Source: our elaboration.

materials used whenever possible, with the ultimate goal of regenerating nature. This approach aims for numerous benefits for environment conservation, improving the condition of soil, water and air, and tackling climate change; thus, enhancing human wellbeing by improving health and nutrition, and consequently bringing opportunities for sustainable economic growth.

3.3. Circular bioeconomy concept and its relationship with circular economy in agriculture

In this section we present the results of the search for the definition of circular bioeconomy which drives the identification of the relationship with the concept of circular economy in agriculture.

The definition of circular bioeconomy is not unique; it is influenced by the definition of bioeconomy from which the literature departs. Nevertheless, most documents agree that the circular bioeconomy relies on using bioresources while applying some circular economy principles, from which cascading is central (Jarre et al., 2020). A common statement is that circular bioeconomy constitutes the way towards zero waste (Barañano et al., 2021; Hodson de Jaramillo, 2018a). However, the paper by Giampietro (2019) marks a straight difference from the other publications. It states that the circular economy represents the target outcome of decoupling

resource use from natural resources, while the bioeconomy describes the biophysical processes needed to achieve this result. Konstantinis et al. (2018) combine both approaches, considering that circular bioeconomy means using non-fossil resources for complete economic exploitation while preserving environmental sustainability. Liobikienė & Miceikienė (2023) extend this analysis, indicating that the final aim of circular bioeconomy is improving sustainability. Yet, in a couple of cases, the circular bioeconomy is tightly associated with technological advances and biorefineries are part of its definition (Ptak et al., 2022).

A few recent documents compile previous publications to propose a synergistic definition, gradually driving towards the definition of circular economy in agriculture. Tan & Lamers (2021) and Tolić (2022) compare a series of definitions of the circular bioeconomy, they cite Giampietro (2019), Ptak et al. (2022), Robert et al. (2020), and others highlighting efficient use of biobased renewable resources. Tan & Lamers (2021) propose that circular bioeconomy is a synergy of circularity and bioeconomy, focused on carbon management. Tolić (2022) expands this concept to include reduced resource consumption, recovery, waste recycling, and as last resource safe disposal. Other documents are on the way to this compilation, including in the concept of circular bioeconomy some aspects of circular economy in agriculture

that are not commonly used. Pyka et al. (2022) define circular bioeconomy as using biomass effectively and efficiently through cascading, recycling, reusing, and reducing waste. However, the reduction mentioned in this study referred to waste only, rather than inputs consumed. Ptak et al. (2022) align more closely with the circular economy aims, addressing pollution and costs of resources transport. According to Therond et al. (2017), the circular bioeconomy is an improvement of bioeconomy in territorial socio-economic dynamics, aligning with the systemic approach of circularity in agriculture.

Sustainability and climate change are frequently mentioned in the description of circular bioeconomy, while the strategies to achieve improvements in the three pillars of sustainability are not identified. According to Ptak et al. (2022) sustainability and resource efficiency are part of the definition of a circular bioeconomy, similarly Pyka et al. (2022) define circular bioeconomy as an extension of bioeconomy to achieve goals in sustainability and climate change. On the contrary, Tan & Lamers (2021) argue that circular bioeconomy does not mean sustainability. This argument is supported by studies in which the circular bioeconomy aims for sustainability when complying with conditions like cascading for optimum valorisation of biomass (Barañano et al., 2021) or a systemic approach including different sectors and nations (Hodson de Jaramillo, 2018a).

Economic and environmental aims are the most commonly mentioned within circular bioeconomy, based on the conservation of biomass and reduced extraction and dependence on natural resources (Tan & Lamers, 2021). Addressing climate change is an expected result mentioned in the 2020s (Barañano et al., 2021; Ptak et al., 2022; Pyka et al., 2022; Tolić, 2022). Aims for human well-being are not frequently mentioned, except for Tolić (2022) who underlines that the safe disposal of unavoidable waste should benefit human health. The circular bioeconomy, like the circular economy applied to agriculture, is expected to bring sustainability benefits and tackle climate change, but the concept of circular economy applied to agriculture presents a clearer description of the strategies to achieve these aims.

4. DISCUSSION

4.1. Discussion on circular economy principles in agriculture

According to the most used terms to define circular economy in agriculture, managing waste to close loops is the idea behind this framework. Research about agricultural waste has experienced exponential growth during

the last 20 years. Duque-Acevedo et al. (2020) explain that government and academic authors have influenced the direction of the studies to focus on maize and wheat waste management due to the relevance of their production in the places of research. Furthermore, the consistent application of measurement tools for agricultural waste may facilitate monitoring and understanding the implications of waste reduction. In the EU, up to the year 2018, there was no clear definition or common measurement method for waste. Wastes and byproducts have been considered only marginally in literature, they are not adequately conceptualised in economic terms, and the circularity of flows is not usually highlighted (Viaggi, 2022).

According to most of the documents analysed, circular economy is based on the principles of recycling, reusing, regenerating natural systems, and cascading the use of resources. Nevertheless, in agreement with Velasco-Muñoz et al. (2021), the application of circular economy in agriculture generates an overlapping of principles through specific techniques, like combining livestock raising and crop production activities. Several circular economy principles, namely, reducing, reusing, and recycling, applied through these techniques, still need to be recognised by literature, which has tended to simplify these interactions and define them as recycling only. In this direction, recent research proposes the adaptation of circularity indicators to biological and agricultural goods by integrating the assessment of waste generation with the evaluation of product performance, measured through yield efficiency and the bioavailability period of agricultural inputs (Escribà-Gelonch et al., 2023).

The principle of reducing is the least mentioned within the three R's, maybe due to the thought that reducing resources used would constitute a barrier to economic growth. There has been a hesitant inclusion of this principle in previous research; Velasco-Muñoz et al. (2021) indicate that the goal of circular economy in agriculture is not to minimise (reduce) the use of resources, but to keep cycles (either recycling or reusing) which would benefit economic and environmental aspects; nevertheless, the same authors mention that the principle of reducing should become integral to the circular economy due to its efficiency benefits. Indeed, practitioners' expectations from the circular economy and policies that promise economic growth without highlighting the limits of natural resources tend to mould the development of the circular economy. This is a critique recognised in previous research (Giampietro, 2019; Kirchherr et al., 2017; Korhonen, Honkasalo, et al., 2018), and, Temesgen et al. (2021) explain that relying on recycling ignores ecological economists' concern regarding the actual eco-

conomic model's dependence on increased consumption and production, instead of a sustainable scale of production targeting human wellbeing.

Unfortunately, the scarce inclusion of the principle of reduction is also evidenced in the definition of circular economy in agriculture. The effect of "reducing" on economic, environmental, and social wellbeing must be considered by policymakers, who support actions that may not bring substantial economic benefits to the industry but could benefit people's welfare. The livestock sector illustrates this tension, as reducing production inputs and pollution levels can improve environmental outcomes. A reduction in livestock production may be facilitated by redistribution strategies, accounting for local animal-feed resources, land availability for manure distribution, and potential manure exports to neighbouring areas which rely on synthetic fertilizers (Madelrieux et al., 2023). Yet, literature emphasizes the need for more information about biomass flows to effectively implement such strategies (Dourmad et al., 2019).

The principle of regeneration of natural systems has been increasingly used and is basic for achieving most sustainability aims. Contrary to the results of Velasco-Muñoz et al. (2021), who indicated that most documents discussing circular economy in agriculture analyse technical efficiency, the definition of circular economy in agriculture talks about the best management of resources to regenerate nature. This is positive, as, at least from a theoretical point of view, circular economy in agriculture is driving towards sustainability, considering the negative long-term effects of a narrow focus on efficiency. Focusing on the regeneration of natural systems may be essential to achieving the expected benefits from the circular economy in countries that have already advanced in circularity strategies. For instance, Italy has improved its efficiency in resource use during the last 20 years, it reached a significantly low rate of landfill disposal of waste among the EU countries and invested in one of the most advanced systems of organic waste management (Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2017). Yet, the circular economy is considered a pathway to face Italy's scarcity of raw materials. Complementarity between the applicability of circular economy principles and theoretical research may facilitate their effective implementation.

The increased use of the term regeneration has led to a deeper evaluation of its application. In this respect, Morseletto (2020) highlights the difficulties in measurement, which impact the application of this principle. Quantifying environmental and economic damages from production is challenging due to complex interactions and unknown regeneration time, while assessing soil

regeneration's value and costs is also difficult. Nevertheless, the importance of this principle has not diminished and is considered a metaphorical framework, meaning the "*ability of nature to revive itself, recover from disturbances, and rebuild its functions*" (Morseletto, 2020: 769), that in agriculture is translated into fertility promotion, nutrient cycling, and ecological services (Arfini et al., 2025; Vollaro et al., 2017).

4.2. *The relationship between circular economy in agriculture and sustainability*

The environmental aims are cited in most literature defining circular economy applied in agriculture, and their description is the most detailed. The definition of circular economy in agriculture has benefited from a clearer identification of its expected achievements compared to the circular economy general definition, which has been criticised for poorly reflecting the position of natural capital and ecosystem services (D'Amato & Korhonen, 2021). Likewise, a common agreement in literature is that circularity in agriculture should be part of the solution to climate change (Abitabile et al., 2024), although proper quantification still needs to be developed. Cantzler et al. (2020) identified low greenhouse gas saving potential in agriculture in comparison to other industries; however, other studies quantified the impacts of energy and waste management and efficiency, while regenerative agriculture and recycling nutrients, although promising, have not been evaluated (Deloitte, 2016; Ellen MacArthur Foundation, 2019b). While the theory has advanced in identifying the possible environmental results of circular economy in agriculture, ex-post assessments after the complete concept has been applied still need development and generalisation (Escobar et al., 2025).

The economic aims are the second most mentioned. Economic growth is expected from circularity in agriculture, which would address the problem of population growth and limited resources by minimising resource use. The aim of economic growth has also called more attention in the general definition of circular economy; the first research of Kirchherr et al. (2017) identified no meaningful mention of economic growth, while in 2023 around 15% of the definitions included it (Kirchherr et al., 2023). On the other hand, circularity in agriculture also aims to improve economic resilience due to the protection of the environment, which in turn brings social benefits in food security and protects human health. Indeed, about 70% of the documents that mention sustainability as the objective of circular economy applied to agriculture also include social aims. The inclusion of

social aims is an improvement in comparison to documents revising the general definition of circular economy (El Wali et al., 2021; Kirchherr et al., 2017, 2023; Murray et al., 2017).

Summarising the relationship between circular economy in agriculture and sustainability, we conclude that the circular economy supports an embedded systems approach to sustainability, aligning with other concepts in the EU political agenda, like the EU Bioeconomy strategy (Viaggi, 2019). Hence, it requires passing from the three-pillar structure of sustainability to an embedded system approach, which has sustainability of the biosphere as a base, enclosing society, and sequentially, economy (Fritzsche et al., 2020). On the other hand, even though sustainability aims from the circular economy are extensive, equating these aims with quantifiable relationships is not straightforward. Shadow prices could play a crucial role in reflecting the impacts of circularity on sustainability, going beyond economic gains to environmental and social effects that are scarcely measured. Water pollution is an example where calculating shadow prices could reflect the advantages of circularity. Koundouri et al. (2014) highlight that reliable pricing data for natural resources is scarce, and by estimating the shadow price of groundwater, policymakers could design pumping taxes that encourage farmers to reduce groundwater pollution and aquifer depletion.

Shadow prices are rarely applied in agricultural policy decisions, contributing to the failure to achieve environmental objectives (Huhtala & Marklund, 2008; Mamardashvili et al., 2016). Mamardashvili et al. (2016) explain that the high costs of pollution abatement in Swiss farms pose significant political challenges to implementing effective nitrogen surplus taxes. Furthermore, Huhtala & Marklund (2008) found that farms act within the manure application limits, therefore, shadow prices are very high. High shadow prices suggest that innovative circular economy practices may be necessary to face persisting environmental issues, particularly for intensive animal breeding where manure management remains challenging.

While shadow pricing of environmental impacts has been explored to a wider extent, its application to social aspects remains limited. Ait Sidhoum (2018) made an initial attempt to quantify social outputs from agricultural production technologies in the EU. The results suggest that social outputs - like consumer health, food security, local economic stability, rural community cohesion, and employment retention - have positive shadow prices, aligning with farmers' private interests; however, subsidies may be necessary in efficient farms that tend to prioritise private gains over social and public goods.

The definition of circular economy applied to agriculture proposed at the end of section 3.2 is driven by a wider consensus in principles and aims in comparison to the general definitions used for the circular economy. Previous research found a lack of agreement in the literature about the concept of circular economy (Kirchherr et al., 2017), with interpretations depending on the interests of its users (Korhonen, Nuur, et al., 2018). Aiming to simplify the diversity in definitions, the principles were classified into the 3R's and sustainable design strategies - i.e. eco-design, nature-inspired design, and cradle-to-cradle (Prieto-Sandoval et al., 2018). However, in contrast to the opinion of Kirchherr et al. (2023) who fear that industry-specific studies will constitute a barrier to the broader applicability of the circular economy, we see that the focus on the agricultural sector facilitates agreement in understanding the framework while targeting its application to industry-specific resources.

Our results also suggest that the consensual definition of circular economy applied in agriculture coincides with the latest general definition of circular economy, in using recycling and reusing as principles, and sustainability as the main aim (Kirchherr et al., 2023). Furthermore, our research identified that in agriculture, the social pillar of sustainability is commonly cited, in comparison to the general definition of circular economy. The increased use of the principle of regeneration was also noted in the general definition of circular economy applied in agriculture (Kirchherr et al., 2023).

4.3. Circular bioeconomy concept and its relationship with circular economy in agriculture

We conclude that circular economy in agriculture may be considered overarching and synergistic to circular bioeconomy. This means they are not interchangeable terms, despite the common undifferentiated use. This confusion may be driven by the roots of the concepts: circular economy was mostly focused on urban contexts, while bioeconomy was defined for rural areas (D'Amato et al., 2017). Nevertheless, circularity in agriculture includes processes that involve non-biological cycles, such as the prioritization of local inputs and the efficient use of synthetic materials (Velasco-Muñoz et al., 2021). Circular economy applied in agriculture should have a synergistic effect on bioeconomy by promoting the efficient use of resources, hence making biomass availability and use sustainable. While cascading is not mentioned by more than 60% of the definitions of circular economy applied in agriculture, the term is essential in circular bioeconomy definitions. This is due to the belief

that cascading is the most effective way to close the loop when managing biomass.

The cascading use of biomass is considered a way to claim circularity and sustainability according to policies, as it protects natural capital and the provision of ecosystem services. Policies promoting the circular economy recognise that cascading can maximise sustainability by first using residues to enrich soils, leaving energy production as a lower value option (Ministero della Transizione Ecologica, 2022). Policymakers also mention the role of cascading in promoting efficient resource use (European Commission, 2015).

Indeed, the synergy between circular economy applied to agriculture and circular bioeconomy is necessary to achieve the sustainability expectations of both terms. They are complements, as was suggested by D'Amato et al. (2017). Both models target sustainability improvements and tackling climate change. However, circular bioeconomy tends to focus on economic and environmental aims, while societal outputs are overlooked due to the technical focus of the framework (D'Amato & Korhonen, 2021), confirming the weakness of a technology-based approach versus a socio-ecological one (Priefer et al., 2017). Finally, both target economic growth. Nevertheless, sustainable economic growth is still a contested benefit from these frameworks, as the literature explains that their aims may be contradictory, resulting in weak sustainability (D'Amato et al., 2017; Murray et al., 2017; Tomaselli et al., 2017). Complete assessments of the economic, social, and environmental results from the application of these concepts may bring a clearer idea of their limitations.

Policy documents about circular economy and circular bioeconomy collect information from scholars and practitioners about the principles, strategies, and sustainability aims of these approaches, but raw conceptualizations of these terms, which focus only on technical aspects, may mislead from the expected benefits. Alternatively, technical limitations should be mentioned more clearly in policies to make their expectations more credible. As recognized by Kirchherr et al. (2023), when defining circular economy academics, policymakers, and the private sector each can obtain benefits from learning from the other.

5. CONCLUSIONS

In this paper we intended to construct a consensus concept of circular economy applied in agriculture. We found that the vast majority of literature, including academics and practitioners, define this concept as a

model founded on waste management through the 3Rs, which expects to achieve sustainability in its three pillars through the regeneration of nature. The concept of circular economy applied in agriculture can benefit from the circular bioeconomy approach that prioritizes the cascading of biomass to achieve high efficiency when striving towards zero waste. Furthermore, generalized guidelines on the meaning and application of circular economy are needed to avoid deviations from the sustainability objectives towards merely technical or economic interests. Future economic, social, and environmental wellbeing may depend on the application of circular economy practices, therefore, continuous advancement in solving the main barriers to this framework is fundamental, together with adequate tools to follow up on the progress toward circular economy aims. Nonetheless, we must remember that circular economy is not the panacea to achieve all possible sustainability solutions, but a beneficial framework, when properly applied according to the needs and capacities of each location.

Our study identified needed directions of future research, which mainly relate to the measurement of the application and benefits of circular economy. A constant question concerns whether the broad strategies and aims of the circular economy can be achieved. In this context and considering the increasing promotion of the circular economy in EU regulation, we discussed the relationship between the definition of circular economy in agriculture, policies, and measurement tools needed to assess policy objectives. Existing research has centred on assessing specific aspects guided by policies and new technologies, such as energy production from biomass, leaving aside fundamentals of circularity like an exhaustive measurement of waste. Furthermore, evaluating the environmental and social damages of production and the counteracting power of circular economy remains a challenge for which frames of evaluation, like shadow prices, need to be extended.

A limitation of this study is the use of only one database for the literature review. We chose the Scopus database from Elsevier because it is an internationally recognized source that includes a vast number of scholarly articles, but more information to enrich this study could be obtained from other popular databases. Furthermore, having a single researcher carry out the coding process carries potential interpretative bias. Although we applied a structured coding protocol within NVivo and engaged in continuous peer discussions to mitigate this risk, future studies could enhance reliability through inter-coder agreement measures. Moreover, we did not include external experts during the construction of the coding framework. Expert opinions may further improve

the understanding of the common aspects expected from the concept of circular economy. Finally, we recognize that the definition of circular economy in agriculture is a changing concept, which will be affected by new technologies, practices, and expectations, but we hope that this research serves as a starting point for more synergies in the theory and practice of this concept.

REFERENCES

- Abitabile, C., Arzeni, A., Cisilino, F., & Orlando, M. (2024). Building sustainable futures: The bio-based fertilizer case-study. *Bio-Based and Applied Economics*, 14(1), 3–17. <https://doi.org/10.36253/bae-15786>
- Ait Sidhoum, A. (2018). Valuing social sustainability in agriculture: An approach based on social outputs' shadow prices. *Journal of Cleaner Production*, 203, 273–286. <https://doi.org/10.1016/j.jclepro.2018.08.212>
- Amoah-Antwi, C., Kwiatkowska-Malina, J., Thornton, S. F., Fenton, O., Malina, G., & Szara, E. (2020). Restoration of soil quality using biochar and brown coal waste: A review. *Science of The Total Environment*, 722, 137852. <https://doi.org/10.1016/j.scitotenv.2020.137852>
- Arfini, F., Bartolini, F., Carbone, A., Castellotti, T., Coderoni, S., Cortignani, R., D'Annolfo, R., Dara Gucione, G., Donati, M., Galli, F., Henke, R., Mazzocchi, G., Monteleone, A., Raggi, M., Pesce, A., Pupo D'Andrea, M. R., Rocchi, B., Romano, D., Sardone, R., ... Zumpano, C. (2025). Where is the Italian agriculture heading? A discussion in light of the prospects for the future CAP. *Bio-Based and Applied Economics*, 14(2), 5–14. <https://doi.org/10.36253/bae-18042>
- Arru, B., Furesi, R., Pulina, P., Sau, P., & Madau, F. A. (2022). The Circular Economy in the Agri-food system: A Performance Measurement of European Countries. *Economia Agro-Alimentare/Food Economy - Open Access*, 24(2). <https://doi.org/10.3280/eca-g2022oa13245>
- Barañano, L., Garbisu, N., Alkorta, I., Araujo, A., & Garbisu, C. (2021). Contextualization of the Bioeconomy Concept through Its Links with Related Concepts and the Challenges Facing Humanity. *Sustainability*, 13(14). <https://doi.org/10.3390/su13147746>
- Barcelos, S. M. B. D., Salvador, R., Barros, M. V., de Francisco, A. C., & Guedes, G. (2021). Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons. *Journal of Environmental Management*, 296, 113373. <https://doi.org/10.1016/j.jenvman.2021.113373>
- Barros, M. V., Salvador, R., de Francisco, A. C., & Piekarski, C. M. (2020). Mapping of research lines on circular economy practices in agriculture: From waste to energy. *Renewable and Sustainable Energy Reviews*, 131, 109958. <https://doi.org/10.1016/j.rser.2020.109958>
- Blomsma, F., & Brennan, G. (2017). The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *Journal of Industrial Ecology*, 21(3), 603–614. <https://doi.org/10.1111/jiec.12603>
- Borrello, M., Pascucci, S., & Cembalo, L. (2020). Three Propositions to Unify Circular Economy Research: A Review. *Sustainability*, 12(10). <https://doi.org/10.3390/su12104069>
- Bos, H. L., & Broeze, J. (2020). Circular bio-based production systems in the context of current biomass and fossil demand. *Biofuels, Bioproducts and Biorefining*, 14(2), 187–197. <https://doi.org/10.1002/bbb.2080>
- Bourque, L. (2004). Coding frame. *The Sage Encyclopedia of Social Science Research Methods*. Thousand Oaks, CA: Sage.
- Burgo-Bencomo, O. B., Gaitán Suazo, V., Yanez Sarmiento, J., Zambrano Morales, Á. A., Castellanos Pallerols, G., & Estrada Hernández, J. A. (2019, April 22). *La Economía circular una alternativa sostenible para el desarrollo de la agricultura*. Espacios. 40 (13). <https://www.revistaespacios.com/a19v40n13/a19v40n13p02.pdf>
- Cantzler, J., Creutzig, F., Ayargarnchanakul, E., Javaid, A., Wong, L., & Haas, W. (2020). Saving resources and the climate? A systematic review of the circular economy and its mitigation potential. *Environmental Research Letters*, 15(12), 123001. <https://doi.org/10.1088/1748-9326/abbeb7>
- Dahlsrud, A. (2008). How corporate social responsibility is defined: An analysis of 37 definitions. *Corporate Social Responsibility and Environmental Management*, 15(1), 1–13. <https://doi.org/10.1002/csr.132>
- D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B. D., & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, 168, 716–734. <https://doi.org/10.1016/j.jclepro.2017.09.053>
- D'Amato, D., & Korhonen, J. (2021). Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework. *Ecological*

- Economics*, 188, 107143. <https://doi.org/10.1016/j.econ.2021.107143>
- Davis, G. G., & Hall, J. (2006). *Circular Economy Legislation: The international experience*. Paper for the environment and natural resources protection Committee of the National People's congress. https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjLwbvbw4LRAhUaIFAKHdXJA1wQFggjMAA&url=http%3A%2F%2Fsiteresources.worldbank.org%2FINTEAPREGTOPEENVIRON%2FResources%2FCircularEconomy_Legal_IntExperience_ExecSummary_EN.doc&usg=AFQ.
- De Boer, I. J., & van Ittersum, M. K. (2018). *Circularity in agricultural production*. Wageningen University & Research.
- De Rosa, M., Di Pasquale, J., & Adinolfi, F. (2021). The Root towards More Circularized Animal Production Systems: From Animal to Territorial Metabolism. *Animals*, 11(6). <https://doi.org/10.3390/ani11061540>
- Deloitte. (2016). *Deloitte Sustainability Circular economy potential for climate change mitigation*. <https://www2.deloitte.com/content/dam/Deloitte/fi/Documents/risk/Deloitte%20-%20Circular%20economy%20and%20Global%20Warming.pdf>
- Dourmad, J.-Y., Guilbaud, T., Tichit, M., & Bonaudo, T. (2019). Les productions animales dans la bioéconomie. *INRAE Productions Animales*, 32(2), 205–220. <https://doi.org/10.20870/productions-animales.2019.32.2.2485>
- Duque-Acevedo, M., Belmonte-Ureña, L. J., Cortés-García, F. J., & Camacho-Ferre, F. (2020). Agricultural waste: Review of the evolution, approaches and perspectives on alternative uses. *Global Ecology and Conservation*, 22, e00902. <https://doi.org/10.1016/j.gecco.2020.e00902>
- EIP-AGRI. (2015). *EIP-AGRI Workshop 'Opportunities for Agriculture and Forestry in the Circular Economy'*. https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_ws_circular_economy_final_report_2015_en.pdf
- El Wali, M., Golroudbary, S. R., & Kraslawski, A. (2021). Circular economy for phosphorus supply chain and its impact on social sustainable development goals. *Science of The Total Environment*, 777, 146060. <https://doi.org/10.1016/j.scitotenv.2021.146060>
- Ellen MacArthur Foundation. (2013). Towards the circular economy. *Journal of Industrial Ecology*, 2(1), 23–44.
- Ellen MacArthur Foundation. (2019a). *Cities and circular economy for food*. <https://www.ellenmacarthurfoundation.org/publications>
- Ellen MacArthur Foundation. (2019b). *Completing the picture: How the circular economy tackles climate change*. <https://www.ellenmacarthurfoundation.org/completing-the-picture>
- Ellen MacArthur Foundation. (2019c). *The biological cycle of the butterfly diagram*. <https://ellenmacarthurfoundation.org/articles/the-biological-cycle-of-the-butterfly-diagram>
- Ellen MacArthur Foundation. (2022). *A circular economy for food will help people and nature thrive*. <https://www.ellenmacarthurfoundation.org/topics/food/overview#:~:text=With%20the%20circular%20economy%2C%20we,become%20inputs%20for%20new%20products>.
- Ellen MacArthur Foundation. (2025). *Ellen MacArthur Foundation—What we do*. <https://www.ellenmacarthurfoundation.org/about-us/what-we-do>
- Escobar, D., Sckokai, P., & Coderoni, S. (2025). *The Impact of Italian Farms' Circularity on their Economic Performances*. 14th AIEAA Conference.
- Escribà-Gelonch, M., Butler, G. D., Goswami, A., Tran, N. N., & Hessel, V. (2023). Definition of agronomic circular economy metrics and use for assessment for a nanofertilizer case study. *Plant Physiology and Biochemistry*, 196, 917–924. <https://doi.org/10.1016/j.plaphy.2023.02.042>
- European Commission. (2008). *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives*. (Directive 2008/98/EC). <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN>.
- European Commission. (2015). *Closing the loop—An EU action plan for the Circular Economy*. COM(2015) 614 Final. Brussels
- European Commission. (2022). *Circular economy action plan*. https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en
- European Environment Agency. (2016). *Circular economy in Europe. Developing the knowledge base*. <https://www.eea.europa.eu/en/analysis/publications/circular-economy-in-europe>
- FAO. (2018). *Food Systems | Food and Agriculture Organization of the United Nations*. <https://www.fao.org/food-systems/en/>
- Fassio, F., & Tecco, N. (2019). Circular Economy for Food: A Systemic Interpretation of 40 Case Histories in the Food System in Their Relationships with SDGs. *Systems*, 7(3). <https://doi.org/10.3390/systems7030043>
- Freeman, K. K., Valencia, V., Baraldo, J., Schulte, R. P. O., & van Zanten, H. H. E. (2022). On-farm circular

- technologies for enhanced sustainability: The case of Uruguay. *Journal of Cleaner Production*, 372, 133470. <https://doi.org/10.1016/j.jclepro.2022.133470>
- Fritsche, U., Brunori, G., Chiaramonti, D., Galanakis, C., Hellweg, S., Matthews, R., & Panoutsou, C. (2020). *Future transitions for the Bioeconomy towards Sustainable Development and a Climate-Neutral Economy—Knowledge Synthesis Final Report*. Publications Office of the European Union. JRC121212. doi:10.2760/667966
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Towards Post Fossil Carbon Societies: Regenerative and Preventative Eco-Industrial Development*, 114, 11–32. <https://doi.org/10.1016/j.jclepro.2015.09.007>
- Giampietro, M. (2019). On the Circular Bioeconomy and Decoupling: Implications for Sustainable Growth. *Ecological Economics*, 162, 143–156. <https://doi.org/10.1016/j.ecolecon.2019.05.001>
- Hens, L., Block, C., Cabello-Eras, J. J., Sagastume-Gutierrez, A., Garcia-Lorenzo, D., Chamorro, C., Herrera Mendoza, K., Haeseldonckx, D., & Vandecasteele, C. (2018). On the evolution of “Cleaner Production” as a concept and a practice. *Journal of Cleaner Production*, 172, 3323–3333. <https://doi.org/10.1016/j.jclepro.2017.11.082>
- Hidalgo, D., Martín-Marroquín, J. M., & Corona, F. (2019). A multi-waste management concept as a basis towards a circular economy model. *Renewable and Sustainable Energy Reviews*, 111, 481–489. <https://doi.org/10.1016/j.rser.2019.05.048>
- Hodson de Jaramillo, E. (2018a). Bioeconomía: El futuro sostenible. *Revista de La Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 42(164), 188–201. <https://doi.org/10.18257/raccefyn.650>
- Hodson de Jaramillo, E. (2018b). Bioeconomy: A sustainable future. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 42, 188–201.
- Homrich, A. S., Galvão, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, 175, 525–543. <https://doi.org/10.1016/j.jclepro.2017.11.064>
- Huhtala, A., & Marklund, P.-O. (2008). Stringency of environmental targets in animal agriculture: Shedding light on policy with shadow prices. *European Review of Agricultural Economics*, 35(2), 193–217. <https://doi.org/10.1093/erae/jbn025>
- Jarre, M., Petit-Boix, A., Priefer, C., Meyer, R., & Leipold, S. (2020). Transforming the bio-based sector towards a circular economy—What can we learn from wood cascading? *Forest-Based Circular Bioeconomy: Matching Sustainability Challenges and New Business Opportunities*, 110, 101872. <https://doi.org/10.1016/j.forpol.2019.01.017>
- Jun, H., & Xiang, H. (2011). Development of Circular Economy Is A Fundamental Way to Achieve Agriculture Sustainable Development in China. *2010 International Conference on Energy, Environment and Development - ICEED2010*, 5, 1530–1534. <https://doi.org/10.1016/j.egypro.2011.03.262>
- Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., & Schösler, H. (2016). Transition towards Circular Economy in the Food System. *Sustainability*, 8(1). <https://doi.org/10.3390/su8010069>
- Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- Kirchherr, J., Yang, N.-H. N., Schulze-Spüntrup, F., Heerink, M. J., & Hartley, K. (2023). Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions. *Resources, Conservation and Recycling*, 194, 107001. <https://doi.org/10.1016/j.resconrec.2023.107001>
- Konstantinis, A., Rozakis, S., Efpraxia-Aithra, M., & Kesheng, S. (2018). *A Definition of Bioeconomy through the Bibliometric Networks of the Scientific Literature*. <https://agbioforum.org/wp-content/uploads/2021/02/AgBioForum-21-2-64.pdf>
- Koppelmäki, K., Helenius, J., & Schulte, R. P. O. (2021). Nested circularity in food systems: A Nordic case study on connecting biomass, nutrient and energy flows from field scale to continent. *Resources, Conservation and Recycling*, 164, 105218. <https://doi.org/10.1016/j.resconrec.2020.105218>
- Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. *Ecological Economics*, 143, 37–46. <https://doi.org/10.1016/j.ecolecon.2017.06.041>
- Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544–552. <https://doi.org/10.1016/j.jclepro.2017.12.111>

- Koundouri, P., Dávila, O. G., Anastasiou, Y., Antypas, A., Mavrogiorgis, T., Mousoulides, A., Mousoulidou, M., & Vasiliou, K. (2014). An Econometric Analysis of Agricultural Production, Focusing on the Shadow Price of Groundwater: Policies Towards Socio-Economic Sustainability. In P. Koundouri & N. A. Papan-dreou (Eds), *Water Resources Management Sustaining Socio-Economic Welfare: The Implementation of the European Water Framework Directive in Asopos River Basin in Greece* (pp. 87–100). Springer Netherlands. https://doi.org/10.1007/978-94-007-7636-4_5
- Kristensen, D. K., Kjeldsen, C., & Thorsøe, M. H. (2016). Enabling Sustainable Agro-Food Futures: Exploring Fault Lines and Synergies Between the Integrated Territorial Paradigm, Rural Eco-Economy and Circular Economy. *Journal of Agricultural and Environmental Ethics*, 29(5), 749–765. <https://doi.org/10.1007/s10806-016-9632-9>
- Leipold, S., & Petit-Boix, A. (2018). The circular economy and the bio-based sector—Perspectives of European and German stakeholders. *Journal of Cleaner Production*, 201, 1125–1137. <https://doi.org/10.1016/j.jclepro.2018.08.019>
- Liobikienė, G., & Miceikienė, A. (2023). Contribution of the European Bioeconomy Strategy to the Green Deal Policy: Challenges and Opportunities in Implementing These Policies. *Sustainability*, 15(9). <https://doi.org/10.3390/su15097139>
- Livingstone, L., Börkey, P., Dellink, R., & Laubinger, F. (2022). *Synergies and trade-offs in the transition to a resource-efficient and circular economy*. <https://www.oecd-ilibrary.org/content/paper/e8bb5c6e-en>
- Maaß, O., & Grundmann, P. (2018). Governing Transactions and Interdependences between Linked Value Chains in a Circular Economy: The Case of Waste-water Reuse in Braunschweig (Germany). *Sustainability*, 10(4). <https://doi.org/10.3390/su10041125>
- Madelrieux, S. S., Courtonne, J.-Y., Grillot, M., & Harchaoui, S. (2023). Bioéconomie et économie circulaire: Lecture critique et place de l'élevage. *INRAE Productions Animales*, 36(1), 7430. <https://doi.org/10.20870/productions-animales.2023.36.1.7430>
- Mamardashvili, P., Emvalomatis, G., & Jan, P. (2016). Environmental Performance and Shadow Value of Polluting on Swiss Dairy Farms. *Journal of Agricultural and Resource Economics*, 41(2), 225–246. JSTOR.
- Martínez-Moreno, M. M., Buitrago, E. M., Yñiguez, R., & Puig-Cabrera, M. (2024). Circular economy and agriculture: Mapping circular practices, drivers, and barriers for traditional table-olive groves. *Sustainable Production and Consumption*, 46, 430–441. <https://doi.org/10.1016/j.spc.2024.02.036>
- Ministero della Transizione Ecologica. (2022, June 21). *Strategia Nazionale Per L'Economia Circolare*. https://www.mase.gov.it/sites/default/files/archivio/allegati/PNRR/SEC_21.06.22.pdf
- Ministero dell'Ambiente e della Tutela del Territorio e del Mare. (2017). *Towards a model of circular economy for Italy, Overview and Strategic Framework*. https://circulareconomy.europa.eu/platform/sites/default/files/strategy_-_towards_a_model_eng_completo.pdf
- Morseletto, P. (2020). Restorative and regenerative: Exploring the concepts in the circular economy. *Journal of Industrial Ecology*, 24(4), 763–773. <https://doi.org/10.1111/jiec.12987>
- Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics*, 140(3), 369–380. <https://doi.org/10.1007/s10551-015-2693-2>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery*, 88, 105906.
- Pagotto, M., & Halog, A. (2016). Towards a Circular Economy in Australian Agri-food Industry: An Application of Input-Output Oriented Approaches for Analyzing Resource Efficiency and Competitiveness Potential. *Journal of Industrial Ecology*, 20(5), 1176–1186. <https://doi.org/10.1111/jiec.12373>
- Paño Yañez, P. (2021). Viabilidad de la economía circular en países no industrializados y su ajuste a una propuesta de economías transformadoras. Un acercamiento al escenario latinoamericano. *CIRIEC-España, Revista de Economía Pública, Social y Cooperativa*, 289. <https://doi.org/10.7203/CIRIEC-E.101.15979>
- Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N., & Ujang, Z. bin. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production*, 76, 106–115. <https://doi.org/10.1016/j.jclepro.2014.04.020>
- Pimbert, M. (2012). *Fair and sustainable food systems: From vicious cycles to virtuous circles*. International Institute for Environment and Development. JSTOR. <http://www.jstor.org/stable/resrep01493>

- Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). *Circular Economy: Measuring Innovation in the Product Chain*. <https://www.pbl.nl/uploads/default/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf>
- Priefer, C., Jörissen, J., & Frör, O. (2017). Pathways to shape the bioeconomy. *Resources*, 6(1). Scopus. <https://doi.org/10.3390/resources6010010>
- Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, 179, 605–615. <https://doi.org/10.1016/j.jclepro.2017.12.224>
- Ptak, M., Skowrońska, A., Piñkowska, H., & Krzywonos, M. (2022). Sugar Beet Pulp in the Context of Developing the Concept of Circular Bioeconomy. *Energies*, 15(1). <https://doi.org/10.3390/en15010175>
- Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science*, 14(3), 681–695. <https://doi.org/10.1007/s11625-018-0627-5>
- Pyka, A., Cardellini, G., van Meijl, H., & Verkerk, P. J. (2022). Modelling the bioeconomy: Emerging approaches to address policy needs. *Journal of Cleaner Production*, 330, 129801. <https://doi.org/10.1016/j.jclepro.2021.129801>
- Reh, L. (2013). Process engineering in circular economy. *Measurement Technology for Particulate System*, 11(2), 119–133. <https://doi.org/10.1016/j.partic.2012.11.001>
- Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Sustainable Resource Management and the Circular Economy*, 135, 246–264. <https://doi.org/10.1016/j.resconrec.2017.08.027>
- Rinaldi, G. M., & Viaggi, D. (2025). Towards the knowledge and innovation system for the bioeconomy? *Bio-Based and Applied Economics*, 14(2), 15–30. <https://doi.org/10.36253/bae-17326>
- Robert, N., Giuntoli, J., Araujo, R., Avraamides, M., Balzi, E., Barredo, J. I., Baruth, B., Becker, W., Borzacchiello, M. T., Bulgheroni, C., Camia, A., Fiore, G., Follador, M., Gurria, P., la Notte, A., Lusser, M., Marelli, L., M'Barek, R., Parisi, C., ... Mubareka, S. (2020). Development of a bioeconomy monitoring framework for the European Union: An integrative and collaborative approach. *New Biotechnology*, 59, 10–19. <https://doi.org/10.1016/j.nbt.2020.06.001>
- Ruiz, E., Canales, R., & García, V. (2019). *La medición de la economía circular. Marcos, indicadores e impacto en la gestión empresarial*. https://foretica.org/wp-content/uploads/informe_medida_economia_circular_foretica.pdf
- Schöggel, J.-P., Stumpf, L., & Baumgartner, R. J. (2020). The narrative of sustainability and circular economy—A longitudinal review of two decades of research. *Resources, Conservation and Recycling*, 163, 105073. <https://doi.org/10.1016/j.resconrec.2020.105073>
- Schut, E., Crielaard, M., & Mesman, M. (2016). Circular economy in the Dutch construction sector: A perspective for the market and government. *Beleidsverkenning Circulaire Economie in de Bouw*. <http://hdl.handle.net/10029/595297>
- Sihvonen, S., & Ritola, T. (2015). Conceptualizing ReX for Aggregating End-of-life Strategies in Product Development. *The 22nd CIRP Conference on Life Cycle Engineering*, 29, 639–644. <https://doi.org/10.1016/j.procir.2015.01.026>
- Singh, S., & Aggarwal, Y. (2022). In search of a consensus definition of innovation: A qualitative synthesis of 208 definitions using grounded theory approach. *Innovation: The European Journal of Social Science Research*, 35(2), 177–195. <https://doi.org/10.1080/13511610.2021.1925526>
- SYSTEMIQ, & Ellen MacArthur Foundation. (2017). *Achieving 'growth within'*. <https://www.ellenmacarthurfoundation.org/achieving-growth-within>
- Tamasiga, P., Miri, T., Onyeaka, H., & Hart, A. (2022). Food Waste and Circular Economy: Challenges and Opportunities. *Sustainability*, 14(16). <https://doi.org/10.3390/su14169896>
- Tan, E. C. D., & Lamers, P. (2021). Circular Bioeconomy Concepts—A Perspective. *Frontiers in Sustainability*, 2. <https://doi.org/10.3389/frsus.2021.701509>
- Temesgen, A., Storsletten, V., & Jakobsen, O. (2021). Circular Economy – Reducing Symptoms or Radical Change? *Philosophy of Management*, 20(1), 37–56. <https://doi.org/10.1007/s40926-019-00112-1>
- Therond, O., Duru, M., Roger-Estrade, J., & Richard, G. (2017). A new analytical framework of farming system and agriculture model diversities. A review. *Agronomy for Sustainable Development*, 37. <https://doi.org/10.1007/s13593-017-0429-7>
- Tolić, I. (2022). Concepts of bioeconomy. In *Economics, Ecology, and Policy for the Bioeconomy* (1st Edition, p. 22). Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9781003223733-2/concepts-bioeconomy-iva-tolic%C4%87>
- Tomaselli, M., Hajjar, R., Ramón-Hidalgo, A., & Vásquez-Fernández, A. (2017). The problematic old roots of the new green economy narrative: How far can it

- take us in re-imagining sustainability in forestry? *International Forestry Review*, 19(1), 139–151.
- Trokanas, N., Cecelja, F., & Raafat, T. (2014). Semantic input/output matching for waste processing in industrial symbiosis. *Selected Papers from ESCAPE-23 (European Symposium on Computer Aided Process Engineering - 23)*, 9-12 June 2013, Lappeenranta, Finland, 66, 259–268. <https://doi.org/10.1016/j.compchemeng.2014.02.010>
- United Nations Development Programme. (2023). *What is circular economy and why does it matter?* <https://climatepromise.undp.org/news-and-stories/what-is-circular-economy-and-how-it-helps-fight-climate-change>
- Van Zanten, H. H. E., Van Ittersum, M. K., & De Boer, I. J. M. (2019). The role of farm animals in a circular food system. *Global Food Security*, 21, 18–22. <https://doi.org/10.1016/j.gfs.2019.06.003>
- Velasco-Muñoz, J. F., Mendoza, J. M. F., Aznar-Sánchez, J. A., & Gallego-Schmid, A. (2021). Circular economy implementation in the agricultural sector: Definition, strategies and indicators. *Resources, Conservation and Recycling*, 170, 105618. <https://doi.org/10.1016/j.resconrec.2021.105618>
- 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. <https://doi.org/10.13128/bae-7674>
- Viaggi, D. (2022). Agricultural waste management and valorisation in the context of the circular bioeconomy: Exploring the potential of biomass value webs. *Current Opinion in Environmental Science & Health*, 27, 100356. <https://doi.org/10.1016/j.coesh.2022.100356>
- Vollaro, M., Galioto, F., & Viaggi, D. (2017). The circular economy and agriculture: New opportunities for re-using Phosphorus as fertilizer. *Bio-Based and Applied Economics*, 5(3), 267–285. <https://doi.org/10.13128/BAE-18527>
- Yuille, A., Rothwell, S., Blake, L., Forber, K. J., Marshall, R., Rhodes, R., Waterton, C., & Withers, P. J. A. (2022). UK Government Policy and the Transition to a Circular Nutrient Economy. *Sustainability*, 14(6). <https://doi.org/10.3390/su14063310>
- Zhijun, F., & Nailing, Y. (2007). Putting a circular economy into practice in China. *Sustainability Science*, 2(1), 95–101. <https://doi.org/10.1007/s11625-006-0018-1>
- Zhu, L., Zhou, J., Cui, Z., & Liu, L. (2010). A method for controlling enterprises access to an eco-industrial park. *Science of The Total Environment*, 408(20), 4817–4825. <https://doi.org/10.1016/j.scitotenv.2010.06.035>
- Zhu, Q., Geng, Y., & Lai, K. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management*, 91(6), 1324–1331. <https://doi.org/10.1016/j.jenvman.2010.02.013>

Bio-based and Applied Economics Focus and Scope

The journal *Bio-based and Applied Economics* (BAE) provides a forum for presentation and discussion of applied research in the field of bio-based sectors and related policies, informing evidence-based decision-making and policy-making. It intends to provide a scholarly source of theoretical and applied studies while remaining widely accessible for non-researchers.

BAE seeks applied contributions on the economics of bio-based industries, such as agriculture, forestry, fishery and food, dealing with any related disciplines, such as resource and environmental economics, consumer studies, regional economics, innovation and development economics. Beside well-established fields of research related to these sectors, BAE aims in particular to explore cross-sectoral, recent and emerging themes characterizing the integrated management of biological resources, bio-based industries and sustainable development of rural areas. A special attention is also paid to the linkages between local and international dimensions. BAE's objectives are:

- to stimulate cross-fertilization between the above mentioned research fields;
- to synthesize and integrate lessons learned from current strands of literature in economics;
- to provide a forum for well-established scholars as well as promising young researchers;
- to increase the knowledge about assessment, design and evaluation of public policies;
- to promote the debate on issues relating to the economics profession and its consultancy activities;
- to discuss future research pathways on the above issues.

BAE publishes high quality research and review papers, after a timely and rigorous double blind peer review process. BAE also publishes book reviews.

BAE

Bio-based and Applied Economics

Policy Articles

- 3 Oriana Gava, Francesco Galioto, Francesco Vanni, Gerald Schwarz, Andrea Povellato, *Priority policy areas to support agroecology transitions in rural Europe: insights from an actor-centred approach*

Full Research Articles

- 13 Alberto Giannecchini, Lisa Baldi, Michele Donati, Filippo Arfini, *How milk quotas and the CAP affect GI Systems: The case of Parmigiano Reggiano PDO*
- 29 Chiara Grazini, Giulio Guarini, Alberto Sturla, *The role of Biodistricts in enhancing farms' labour productivity: a Post-Keynesian analysis*
- 43 Riccardo Borgia, Giulia Tiboldo, Elena Castellari, *Investigating the relationship between family environments and children's adoption of obesity-related behaviours in Italy*

Review Articles

- 55 Valeria Strusi, Sara Balestri, *Land, women and development: A systematic review of causal evidence*
- 77 Diana Escobar Jaramillo, Silvia Coderoni, Paolo Sckokai, *The concept of circular economy in agriculture. A review of the literature and a possible way forward*

