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Boosting rural digital ecosystems through new combinatorial knowledge dynamics

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The paper explores rural digital ecosystems, focusing on the role of digital technologies in boosting the transition toward sustainable development in rural areas. Drawn on the theoretical perspective of the entrepreneurial and innovation ecosystem, the paper provides a definition of digital rural and agricultural business ecosystem (DRABE), and analyses the role of digital technologies in shaping new knowledge dynamics and influencing innovation ecosystems in rural areas. New combinatorial knowledge dynamics as engine for adopting digital solution within a building process of sustainable rural development is at the basis of an empirical analysis, grounded on the Pollica case study. Results point out a virtuous circle triggered by the adoption of digital solutions within a context of sustainable rural development, boosting new relational configurations and new territorial proximities. The emerging DRABE confirms the dynamic perspective of this rural innovation ecosystem and address policy mixes leading to more sustainable rural development and fostering digital innovation in rural areas.

KEYWORDS
anchoring milieus, digital solutions, geographical and organized proximities, innovation ecosystem, rural area

1 Introduction

In the last decades, agrifood sector and rural areas have been significantly influenced by the emergence of cutting-edge innovations, most notably digitalization. Digitalization is one of the goals of the long-term Vision for the EU's Rural Areas, aimed to developing resilient and sustainable farming sectors within rural contexts (European Commission COM(2021) 345 final, 2021). Moreover, the recent document on the New Vision for Agriculture and Food encourages digitalization as key driver to accelerate a sustainable transition in the agrifood systems and in rural areas (European Commission COM(2025) 75, 2025). Nonetheless, extensive literature underlines that building sustainable processes of smart rural development is challenging, due to the nature of "rural" as a diversified and complex socio-economic system (Organisation for Economic Co-operation and Development, 2018), where barriers and costs associated to the adoption of new technologies may hinder digitalization (Gòmez-Carmona et al., 2023). These barriers may be either technical (Gerli et al., 2025) and social (Jakku et al., 2019; Charatsari et al., 2023), and are exacerbated by the liability of rurality (Clausen, 2020).

The extent to which digital innovation contributes to build up both smart rural areas and sustainable farming sectors is an emerging topic, which is explored through specific theoretical lens of sociotechnical transition (Brunori, 2022b; Geels, 2004) according to which directionality and neutrality issues must be clarified (Fielke et al., 2021; Schnebelin et al., 2021). This paves the way for a critical examination of "digi-grasping" mechanisms in rural areas[1], which necessitates a more context-related approach, focusing on relational assets, proximity issues, and regionally specific modes of knowledge anchoring and governance (Crevoisier, 2016; Foray, 2014; Torre et al., 2021). The issue of knowledge anchoring and the combinatorial knowledge dynamics behind the adoption of digital solutions in rural areas is now widely explored in literature. This paper places these dynamics at its core, aiming to fill an existing research gap.

From a theoretical perspective, relational approaches and ecosystemic perspectives should be prioritized, for their ability of addressing rural socio-spatial disparities in rural areas (Bravaglieri et al., 2025). These approaches consider both material and non-material resources, actors and artifacts that influence rural development dynamics, while also acknowledging the "multiple and contradictory goals which may exist within the ecosystem" (Pigford et al., 2018). Ecosystemic approaches demonstrate greater explanatory, by analyzing a wider set of actors/actants/institutions that contribute shaping innovative trajectories (Brunori, 2022a). Moreover, given the deep territorial embedding of rural development, proximity relations can foster various "combinations": (a) between different forms of geographical and organizational proximity (Gilly and Torre, 2000); (b) between local and mobile knowledge within knowledge-anchoring processes (Jeannerat and Crevoisier, 2016). Against this background, the role of digital technologies can be analyzed from a dual perspective. On the one hand, digital tools are analyzed as a key component of innovation adoption, particularly in transitions toward more sustainable farming systems, as highlighted by twin transition approaches (Brunori, 2022b). On the other hand, digitalization affects knowledge anchoring dynamics, by modifying relational configurations and increasing the velocity and intensity of knowledge recombination. Viewed through the lens of institutional entrepreneurship (Battilana et al., 2009), digital solution acts as context enabler (Baker and Welter, 2020), by fostering new "combinatorial knowledge dynamics" (Crevoisier and Jeannerat, 2009). This second perspective of digitalization in rural areas warrants further attention, as it remains under-explored in recent literature. This paper points out the fundamental importance of territorial knowledge dynamics behind the adoption of digital innovation, which can also address dedicated policy actions to shape and consolidate an innovation ecosystem in rural areas. By investigating the dynamic mechanisms of combinatorial knowledge that bolster the adoption of digital innovations, this study addresses a gap in literature. The aim is to provide a new theoretical framework exploring how digital technologies shape new combinatorial knowledge dynamics and territorial proximities. Two research questions are addressed:

- RQ1–How do digital technologies shape new combinatorial knowledge dynamics and influence innovation ecosystems in rural areas?
- RQ2–How can we contribute to a conceptual framework that fuels innovation policies in rural areas?

To answer these questions, a qualitative case study was conducted in a remote rural context in Southern Italy. The study provides insights into the transition toward a new rural development model, revealing the crucial role of digitalization. The remainder of this paper is organized as follows. The next section outlines the theoretical background and the foundation of our conceptual model. The rural area living lab of Pollica: case, data and methods section is dedicated to the description of the case study, the "Pollica 200" project. Results section presents the discussion, while Discussion section concludes with the study's key findings and implications.

2 Theoretical background: root toward new digital rural ecosystems

Recent changes in rural and agrifood systems are driven by a variety of factors, among which digital innovations may have disruptive effects (Klerkx, 2020). At the same time, digitalization is considered paramount to bolstering the smart development of rural areas (Torre et al., 2021). As a matter of fact, the European Union asserts that rural areas are strategic for complying with the strategic targets of the green transition. Nonetheless, the adoption of digital solutions faces numerous obstacles and involves a complex web of relationships and arrangements among a variety of actors (Spigel, 2017). To address this complexity, the systemic perspective has been superseded by the ecosystemic one, which views innovation as a co-evolutionary process. However, a clear definition of rural ecosystems is still needed. The differences between systemic and ecosystemic approaches to innovation are clearly highlighted by Pigford et al. (2018), who argue that the pluralism characterizing innovation ecosystems leads to the recognition of a wider set of interdependencies and "multidimensional relational linkages." The ecosystemic approach views innovation as a co-evolutionary process combining not only technological, but also social, economic and institutional change (Klerkx et al., 2012). Moreover, actors within an ecosystem share the same objectives and a collective value proposition, and they rely on one another's knowledge and capabilities to achieve those goals (Bravaglieri et al., 2025). In line with this 'ecosystem as structure' approach, *ecosystems are defined by a 'focal value proposition,' which requires the ecosystem as an 'alignment structure of the multilateral set of partners that need to interact in order for the focal value proposition to materialize* (Neudert et al., 2024).

Accordingly, while innovation systems analyse interaction and governance mechanisms among actors involved in value extraction from innovation, the ecosystem perspective emphasizes the co-evolution of innovation and the co-creation of value (Autio, 2017;

1 Digi-grasping was recently conceptualized to denote the journey that is required to understand (grasp) the potential of digitalization to empower people to take part in a digital society (Fielke et al., 2021).

Lioutas et al., 2022). This paves the way for collective and integrated innovation with the aim of better addressing the sustainability transition (Pigford et al., 2018). The definition of innovation ecosystem provided by Granstrand and Holgersson (2020) raises essential issues for analyzing their working mechanisms: an innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors (Granstrand and Holgersson, 2020). Three key elements should be stressed in this definition:

a) The artifacts concept, which includes "*products and services, tangible and intangible resources, technological and non-technological resources, and other types of system inputs and outputs, including innovations*" (for instance, software, hardware, etc.);
b) The relations of competition or cooperation among actors, institutions, artifacts;
c) The evolutionary role of the actors, activities, and artifacts, as for example new technologies can generate new niches to be filled by new or adapted enterprises.

Set against the ecosystems framework, digital business ecosystem may represent a step forward in the analysis of "*socio-economic development catalyzed by ICTs,* (which emphasizes) *the coevolution between the business ecosystem and its partial digital representation: the digital ecosystem*" (Nachira et al., 2007). As suggested by Senyo et al. (2019), a digital business ecosystem (DBE) is articulated in two pillars:

✓ The business ecosystem as an economic community where different actors interact with the purpose of producing valuable goods and services for final customers, who are themselves part of the ecosystem (Moore, 1996).
✓ The digital ecosystem as a virtual environment which involves digital entities, for instance, hardware, software applications, etc. (Senyo et al., 2019).

Consequently, a digital business ecosystem can be defined as a *collaborative environment made up of different entities that co-create value through information and communication technologies (ICTs)* (Senyo et al., 2019). When applied to rural contexts, the concept of digital ecosystem needs to be clarified, due to the specific aspects characterizing rural areas and rural development policies. Drawing on previous definitions, this paper provides an original perspective, and identifies a digital rural and agricultural business ecosystem (DRABE) as a digital business ecosystem whose relational architecture (set of actors and relations involved) is mainly located in rural context. According to this definition, the DRABE maintains a strong territorial embeddedness as its relational architecture is rooted in rural contexts. The development of such an ecosystem warrants further investigation, through an exploration of pre-existing and emerging relationships among actors. By focusing on the relational issues shaping the DRABE, this contribution addresses the dynamic formation of a relational architecture (driven by combinatorial knowledge dynamics) as a catalyst for digital innovation in rural areas. Accordingly, this paper argues that a DRABE is a context-dependent concept, as certain territories are more conducive to innovation than others. Conduciveness relies on the capacity of local and mobile knowledge to foster sustainable innovation (Kebir et al., 2017). This capability is synthesized by the concept of the anchoring milieu, *a set of local players who interact locally and with distant and/or mobile players based on an institutional mix of authorship and ownership to generate ever more advanced (more efficient, exclusive and/or meaningful) knowledge and higher revenues* Crevoisier (2016). Anchoring differs from embeddedness, in that it is conceived as a new knowledge movement toward a new context. Therefore, innovative trajectories boost knowledge creation and adoption as an anchoring process of combinatorial (local and distant) knowledge (Crevoisier and Jeannerat, 2009; Jeannerat and Crevoisier, 2011). When anchoring mechanisms are analyzed in rural areas, specificities (dispersed nature of economic activities, role of natural resources, quality of human and social capital, dedicated technologies adopted by rural businesses) and constraints (depopulation dynamics, lack of infrastructure, low levels of education) make the processes of anchoring in rural areas markedly different. Indeed, the anchoring mechanisms through which new mobile knowledge interacts (or fails to interact) with new territorial contexts can lead to a range of expected and unexpected outcomes (Crevoisier and Jeannerat, 2009). These mechanisms act as mediators synthesizing new mobile knowledge and already existing indigenous local knowledge (Peddi et al., 2023). Despite their significance, these mechanisms remain under-explored in literature. Actually, diverse territorial anchoring capabilities can emerge, resulting in varying cumulative processes of combinatorial knowledge (Crevoisier, 2016), and leading to distinct dynamics of (smart) rural development. Digitalization may act as game changer (Rolandi et al., 2021), by repositioning or transforming prior networks or completely replacing them with new relational configurations. As noted by Autio (2017), the disruption mechanisms activated through digitalization are bolstered by digital affordances, which represents potential opportunities arising from the material properties of digital objects (Ostern and Rosemann, 2021). Digital affordance enables the performance of existing functions or the creation of entirely new ones. For instance, disintermediation mechanisms working along digitalized supply agrifood chain facilitate direct interactions through cutting out intermediate transactions, such as in online trade platforms. Conversely, digital solutions can also engender re-intermediation through internet-based platforms (Autio and Thomas, 2018). Accordingly, new entrepreneurial ecosystems emerge, characterized by a shifting locus of entrepreneurial opportunities and novel entrepreneurial practices (Autio, 2017). In this light, new relational configurations arising from digital innovation may shape new territorial proximities, depending on the specific context.

2.1 New proximities shaped by new combinatorial knowledge dynamics

In their recent book, Baker and Welter (2020) argue against the notion that "*contexts are out there*" and simply impact

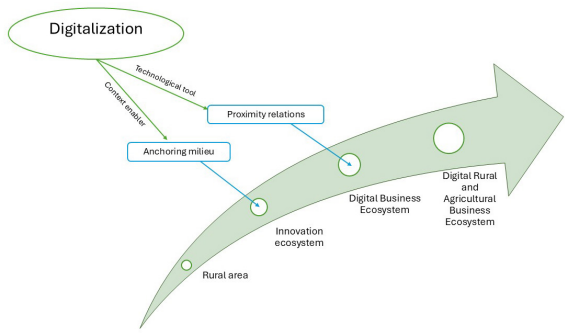

FIGURE 1
Conceptual model of the transition from rural areas to digital rural and agricultural business ecosystem. Source: authors' theorization.

entrepreneurship; instead, they assume that contexts are also constructed and enacted. Drawing on this view, our paper posits that digital solutions act as "*context-enablers*" by reshaping relational architectures and addressing new combinatorial knowledge dynamics. Thus, digitalization plays an "institutional role" (Battilana et al., 2009), affecting and changing institutional contexts and depicting new relational configurations in rural areas. Social capital is central in these processes. Indeed, anchoring mechanisms reshape relational assets and knowledge dynamics, and reconfigure bonding, bridging, and linking ties[2], fostering ambidexterity[3]. More precisely, given the disruptive nature of digital innovation, a reinforcement of both bridging and linking ties is expected. These ties facilitate broader access to formal and mobile knowledge, leveraging experience developed elsewhere and, consequently, opening up new windows of opportunities to diversify business models (Cofré-Bravo et al., 2019). Regarding the local rural context, digital innovations reshape proximity relations (Bernela et al., 2022), and redesign territorial proximity, through the reconfiguration of both geographical and organized (Gilly and Torre, 2000; Torre, 2019; Torre and Gallaud, 2022). If geographical proximity involves physical distances, organized proximity refers to the way actors are relationally close, relying on two main logics (Filippi et al., 2011; Gilly and Torre, 2000; Torre and Gallaud, 2022):

- ✓ Logics of belonging. This refers to actors belonging to the same network, such as a rural localized system.
- ✓ Logics of similarities, meaning that actors share similar norms and values or systems of representation. For instance, the logic of similarity may connect people of the same religious group, or people sharing the same project.

Therefore, as highlighted in Figure 1, an evolutionary process emerges, in which new proximity relations, in turn, affect and transform anchoring processes. This fosters ambidexterity (Cofré-Bravo et al., 2019; Klerkx et al., 2017; Vecchio et al., 2022) and further reshapes the trajectories of smart rural development.

Starting from a rural area, Figure 1 depicts the evolutionary mechanism by which digital tools act as context-enablers, boosting the development of an innovation ecosystem, and, subsequently, the transition toward digital rural and agricultural business ecosystems. How digital solutions act as context-enabler and facilitate new territorial proximities deserves attention and is at the basis of the following empirical analysis, focused on a case study.

3 The rural area living lab of Pollica: case, data and methods

3.1 Introduction to the case

Pollica, located in the Campania region of Italy within the Cilento, Vallo di Diano and Alburni National Park, is a relevant case study for analyzing how digital technologies can influence the dynamics of innovation ecosystems in rural areas. Pollica is recognized as one of the symbolic places of the Mediterranean Diet, declared an Intangible World Heritage Site by UNESCO in 2010. This recognition contributed to strengthening the territorial identity of the municipality and stimulated initiatives focused on sustainability, food culture, ecological transition, and local development. Like many rural areas, it faces several challenges including aging population, low level of education, lack of infrastructures and business opportunities, sustainable management of natural resources, etc. (European Commission, 2008). Demographic trends in Pollica indicate a progressive population decline, from 2,467 residents in 2,001 to 2,102 inhabitants in 2025 (Italian National Institute of Statistics (ISTAT), 2025). The local economy is mainly based on small-scale agriculture, traditional agri-food production, and tourism-related activities. Olive cultivation, traditional Mediterranean agricultural practices, and local food production continue to play an important socio-economic role, while tourism is strongly connected to the environmental and cultural attractiveness of the territory. The analysis focuses on the Pollica 2050 project, a public-private partnership developed between the Municipality of Pollica and Future Food Institute (social entreprise). The project, launched in 2020 and scheduled to run until 2050, aims to support rural regeneration processes through digital transition, innovation, sustainability, and community engagement. More specifically, the initiative seeks to connect local actors with external networks of researchers, entrepreneurs, institutions, and innovators to stimulate knowledge exchange and collaborative development processes. One of the three main pillars of the project is education and training, which is designed to foster new skills and competencies to support the digital and ecological transition. A structured set of digital training laboratories was designed to develop advanced digital and transversal competencies among participants. These laboratories integrate a diversified portfolio of digital technologies, including digital media production tools (such as podcasting, web

2 Following the literature on social capital (e.g., Angeon and Callois, 2006; Woolcock, 1998), bonding ties refer to strong horizontal relations within a community (family, ethnic groups), which may exhibit weaknesses as highlighted by Granovetter (1985). Bridging ties involve more "distant" actors, potentially extraterritorial, connecting individuals across different contexts. Finally, linking ties encompass vertical relations with those in positions of power, such as connections with political or financial institutions.

3 Ambidexterity is defined by Turner et al. (2017) as "*exploiting existing and exploring new networks to access, combine, create, or disconnect capabilities.*"

radio, sound design, and videomaking), software development environments (coding and app design), and digital fabrication technologies (3D modeling and 3D printing). In addition, the programme incorporates smart agriculture technologies, including sensors, drones, robotics, and environmental data monitoring systems, aimed at introducing participants to data-driven and precision-oriented approaches in rural contexts. Within this project, the Paideia Digital Academy and other initiatives were established as a dedicated educational initiative aimed at promoting digital literacy and new forms of learning for younger generations and local communities. The case therefore offers the opportunity to explore how digital transition processes may led the transition from peripheral rural areas to digital rural and agricultural business ecosystem. Within this framework, digital technologies act as enabling tools supporting stakeholder interaction, co-creation practices, and the emergence of new rural proximities between local and external actors. Several project initiatives have promoted digitalisation processes involving farmers, young people, local associations, and community members, with the objective of fostering the development of a digital rural innovation ecosystem.

TABLE 1 Overview of interview participants.

Interviewee	Stakeholder category	Age	Background
INT01	Local administrator	50	Economic
INT02	Farmer	44	Tourism
INT03	Farmer	43	Agricultural entrepreneur
INT04	Residents	33	Tourism
INT05	Residents	29	Artist
INT06	Residents	43	Lower secondary education
INT07	Residents	68	Ex teacher
INT08	Residents	42	Communication
INT09	Future Food institute	45	Entrepreneurial background
INT10	Future Food institute	35	Tourism

Source: authors' theorization, Yin (2013) and Bailey (1994).

3.2 Research design and approach

This study adopts a mixed-methods design to examine how digital technologies shape new combinatorial knowledge dynamics and territorial proximities. By combining quantitative and qualitative data, the study provides a comprehensive understanding of these processes. The research is based on an explanatory case study (Yin, 2013) focused on the Pollica 2050 project, a methodology particularly suitable for addressing "how" and "why" questions related to complex phenomena embedded in a specific territorial context. The qualitative component is based on semi-structured interviews aimed at gaining in-depth insights into the experiences of the stakeholders involved in the Pollica 2050 project. The quantitative data, collected through a structured questionnaire, provides measurable insights into the degree of stakeholder interaction as well as the use and adoption of digital tools, while the qualitative data contextualizes these findings through the experiences and perspectives of the actors involved in the Pollica 2050 project. Internal validity was strengthened through methodological triangulation and the integration of primary and secondary data sources.

3.3 Data collection

For this study, a multi-method data collection strategy was adopted (Bailey, 1994), combining questionnaires, interviews, and secondary sources to gather comprehensive evidence on stakeholder interactions, the use and adoption of digital tools, and rural innovation dynamics within the Pollica 2050 project. Participants were selected through purposive and snowball sampling techniques. Initial access was obtained through the founder of the social enterprise coordinating activities within the Pollica 2050 project. This strategy facilitated the identification and inclusion of stakeholder considered particularly influential or knowledgeable within the Pollica 2050 project. A heterogeneous range of stakeholders participated in the study, including local administrators, farmers, residents, and members of the social enterprise.

3.3.1 Interviews

Primary data collection began in May 2024 through face-to-face interviews. All interviews were anonymised and informed consent was obtained prior to participation. In total, 10 interviews were conducted with strategic stakeholders operating within the project (Table 1).

The interview guide (Appendix A1) was designed to explore:

- The use of digital technologies;
- Stakeholder interactions and collaborative dynamics;
- The role of digital technologies in fostering stakeholder engagement and networking.

The interviews enabled an in-depth understanding of stakeholders' experiences, perceptions, and relational dynamics within the project.

Questionnaire.

In addition to the interviews, the same participants were asked to complete a structured questionnaire in order to complement the qualitative evidence with quantitative insights (Appendix A2) was administered to collect quantitative information. The questionnaire focused on three main dimensions:

- Socio-demographic characteristics;
- Degree of interaction with other stakeholders;
- Use and perception of digital tools.

This sequential design allowed the integration of qualitative insights with quantitative measures. The degree of stakeholder interaction and the use of digital technologies were measured through 5-point Likert scales ranging from 1 ("none") to 5 ("very high"). The questionnaire complemented the qualitative evidence by enabling an assessment of interaction intensity and digital technology adoption among participants.

3.3.2 Secondary sources

To complement and triangulate the primary data, secondary materials published between 2021 and 2024 were also analyzed, including newspaper articles, magazines, institutional documents, project reports, and online materials (Appendix A3).

3.3.3 Validity and reliability

The integration of multiple data sources contributed to strengthening the validity and reliability of the study through methodological triangulation. The combined use of interviews, questionnaires, and secondary materials enabled the cross-verification of findings and supported a more comprehensive interpretation of stakeholder interactions and digital innovation dynamics within the project context.

3.4 Data analysis

The data analysis proceeded through sequential and iterative stages. In a first stage, secondary sources and project documentation were systematically examined to reconstruct the evolution of the Pollica 2050 initiative, identify its principal digital initiatives, and contextualize the broader territorial innovation framework within which the project developed. In particular, this analytical phase supported the distinction between the instrumental use of digital technologies as operational tools and their broader function as enabling socio-technical infrastructures facilitating territorial innovation, stakeholder coordination, and knowledge circulation processes.

Interview transcripts were analyzed through thematic analysis (Braun and Clarke, 2006). An initial open coding phase was conducted to identify recurring themes emerging from the empirical material. Codes were subsequently grouped into broader analytical categories through an iterative constant-comparison process to examine how the adoption of digital technologies influenced stakeholder interactions, collaborative dynamics, and knowledge exchange processes. Coding was conducted manually by the authors and continuously refined through comparison with questionnaire results and secondary materials. Particular attention was devoted to understanding how digital technologies contributed to reshaping relational and territorial proximities among local and external actors. The analysis progressively converged around four analytical dimensions: (i) the role of digital technologies in enabling communication, coordination, and collaboration; (ii) the emergence of local and translocal stakeholder networks; (iii) processes of knowledge anchoring, translation, and co-creation; and (iv) the contribution of digital initiatives to rural regeneration and ecosystem development.

These dimensions were progressively refined through comparison across interviews, questionnaire responses, and documentary evidence. This triangulation process enabled the cross-verification of empirical findings and supported a more comprehensive interpretation of the socio-technical dynamics underpinning the Pollica 2050 initiative.

4 Results

Several key initiatives have been launched to support sustainable development, digital innovation, and active citizen participation. These initiatives identify an integrated model of rural development leveraging either local or external resources and empowered through the effective action of the anchoring milieu shaping a real DRABE. Figure 2 maps the interactions among the various stakeholders involved in the Pollica Digital Rural and Agricultural Innovation Ecosystem, encompassing both local and distant actors. Pollica serves as the central hub of an innovation ecosystem, anchoring localized knowledge and social ties to provide a stable environment for growth. This solid local foundation acts as a bridge, effectively integrating territorial resources with global knowledge sources and distant knowledge. The ties with actors from Europe (Brussels and Germany), linking EU authorities and research centers and enabling the flow of scientific expertise, and policy-oriented knowledge, which enriches the local combinatorial knowledge base. It also connects with actors from the United States (San Francisco and New York), including firms and farms, facilitating the adoption and adaptation of advanced agrifood technologies and practices to the generate new combinatorial knowledge. Finally, Pollica connects with actors from Tokyo (Japan), involving firms and illustrating the ecosystem's ability to establish cross-continental knowledge flows, combining diverse technological and cultural insights with locally practices. These interactions highlight the dual role of Pollica as both a local anchoring milieu and a node in a broader network of global knowledge flows. As indicated in the figure, the project has promoted the development of more distant relationships, thus enriching both bridging and linking social capital, and combining it with existing localized, bonding ties. These relationships have been established in various sectors ranging from agrifood to cultural and rural tourism. Set against this backdrop, the use of digital tools have acted as context-enablers, through redesigning new territorial proximities and engendering the evolution of a rural area toward a digital agricultural and rural ecosystem. The use of communication platforms has enabled the efficient transmission of complex information and the co-creation of content. Videoconferencing platforms have played a crucial role in bringing the Pollica case to global attention through various events and discussions. These online collaboration tools created a multiplier effect, leading to increased engagement. In a first phase, remote access allowed stakeholders to gain an in-depth understanding of the local context through immersive experiences. This experience subsequently led to direct physical interaction, including territorial visits. This transition from digital

FIGURE 2
Overview of stakeholder interactions within Pollica 2050 project. Source: authors' elaboration.

TABLE 2 Overview of some initiatives, purpose and role of digitalization within Pollica 2050 project.

Initiative name	Purpose of the initiative	Role of digitisation
Paideia Digital Academy (PDA)	Digital literacy for youngers to innovate and proactively use technologies to implement ecological transition, and to make digital transitions the engine for sustainable development.	Context enabler
Within PDA: adventure and videomaking	To engage young generations in biodiversity discovery through video-based learning.	Tool
Within PDA: 3D modeling & eco design	To promote circular economy and green economy through eco-design and creative digital practices (3D printing).	Tool
Within PDA: archeo minecraft	To combine experiential learning and digital creativity to foster coding, logic, and interdisciplinary thinking.	Tool
Within PDA: digital storytelling	To foster territorial identity, sustainability awareness, and youth engagement through coding and creative expression.	Tool
Cities 2030	Creating a Data-Driven Platform for collaboration and cultivation of innovative solutions to foster more sustainable City Region Food Systems.	Tool
TestFarms	Connecting European startups with local farmers' networks to fostering innovation.	Tools
Philosophy eco-design lab	Reconciling the drive for innovation, environmental protection, and education with community participation and co-creation.	Tool and context enabler

Source: authors' elaboration.

to physical environments strengthened place-based ties, fostering the development of hybrid (physical-digital) collaborative network. The combination of virtual and physical interactions has stimulated the exchange of knowledge, the dissemination of sustainable development models and the amplification of Pollica's global visibility. In this framework, digital technology is configured not only as a means of communication, but as a catalyst for processes of relational territorialisation and the construction of transnational collaborative ecosystems, helping to redefine the ways in which local heritage is connected and enhanced in a global context.

Following the analysis of secondary sources, we found some initiatives organized within the project and focused on digital literacy involved stakeholders and territories in various parts of the world. To lead the digital revolution different digital tools have been designed for local population and young people (Table 2).

- Paideia Digital Academy is realized within the Paideia Academy, whose purpose is to put forward a multidisciplinary approach to enhance "*a new type of sociality and live the concept of integral ecology, a regenerative approach to face the transition necessary to achieve the Agenda 2030 Goals, in models of lifestyle and*

development of which the Mediterranean Diet is the most concrete example"[4] The Paideia Digital Academy offers an engaging digital training program to young people in the summertime, with the purpose of blending technology with art, music, sports, and nature. The initiatives within Digital Academy (Discovery, Adventure and Videomaking, 3D Modeling and Eco design, ArcheoMinecraft, Digital storytelling) allows people to learn the basics of computer programming, teaching them to "talk" with computers to create video games and apps. Additionally, these initiatives provide a space for the local community to innovate and proactively use technologies to implement ecological transition, and to make digital transitions the engine for sustainable development. Knowledge anchoring in the Paideia Digital Academy is achieved through *learning-by-doing* methodologies, whereby participants acquire digital and computational skills through the design and development of video games, applications, and functional prototypes. This approach enables the immediate translation of theoretical content into practical applications, thereby strengthening processes of internalization, transferability, and stabilization of competences. In parallel, the integration of heterogeneous disciplinary domains—such as technology, visual arts, music, and interaction with the natural environment—fosters processes of cross-fertilization capable of generating deep and meaningful connections across diverse knowledge domains, thus stimulating advanced forms of critical, creative, and systemic thinking. A further element of knowledge anchoring is represented by the strong territorial embeddedness of the educational activities. The projects developed within the Academy are closely connected to the specific needs, resources, and challenges of the local context, allowing learning processes to be anchored in the social, environmental, and cultural dimensions of the territory. By integrating arts, music, sports, and nature, the Academy's programs foster a unique blend of creativity and environmental awareness. Its ultimate mission is to equip the next generation with the mindset and skills necessary to navigate a complex digital landscape, preparing them to lead as informed, active, and socially responsible citizens.

- TEST-Farm, a project aiming to engage local farms, transforming them into test farms for various innovations which involves companies from all over Europe. The purpose of the project is to boost twin transition, joining ecological and digital transition in rural areas. More precisely, the initiatives organized within the Pollica 2050 project exploit digitisation for different purposes, from ecological transition to social and agricultural innovation. Within the TEST-Farm project, knowledge anchoring is enacted through field-based experimentation, co-creation, and technology transfer processes that embed innovation directly within real rural production contexts. Farms operate as living labs, where digital and ecological solutions are tested, adapted, and validated under operational conditions, thus activating an anchoring milieu in which local actors interact with distant knowledge producers to generate advanced and context-specific forms of knowledge (Crevoisier, 2016). Knowledge anchoring is achieved through on-farm experimentation, multi-actor co-design, and the local adaptation of European-level innovations, ensuring the recombination of scientific-technological expertise with situated experiential knowledge.
- Cities 2030, a citizen-centered model where consumer choices, addresses new path of sustainable development. More precisely, the project engages various stakeholders (citizens, researchers, policymakers, etc.) whose purpose is to boost the creation of resilient, sustainable, and innovative urban food systems, based on the Mediterranean diet as example of sustainable farming systems. Within this project, consumers play a key "political" role, which address technological change fostering localized modes of food provisioning. This is realized through a process engendering organized proximity, through alliances and interactive learning among city leaders, entrepreneurs, researchers. Interactive learning models are fostered also through technologically advanced, and exploitable tools are devised to bolster innovation in the food chain. Therefore, local and distant knowledge are combined and anchored in the involved cities to stimulate the creation of the new regional food systems.
- Philosophy Eco-Design Lab, an eco-design lab managed and animated by young makers with the aim to raise community awareness on circular economy and sustainable ways of living. The Lab is designed by young people and for young people, to give new life to plastic waste that otherwise pollutes the sea, reconciling environmental protection and territorial regeneration. Therefore, it is conceived as a project of social innovation and value creation with high environmental impacts in terms of waste recycling and promotion of circular economy. Within the Philosophy Eco-Design Lab, knowledge anchoring is enacted through a laboratory-based, participatory, and community-driven approach, which enables the embedding of knowledge within local social, environmental, and territorial contexts.

As shown in Table 2, digitisation may act as a context enabler, creating the conditions for change and digital literacy it serves as a tool for collecting, analyzing and using data, while in further cases it has a dual role: acting as both a tool and a context enabler and is used to improve communication and knowledge transfer between stakeholders.

5 Discussion

The aim of the paper was to explore how digital technologies influence the dynamics of innovation ecosystems in rural areas, and to contribute to the development of a conceptual framework that can fuel innovation policies in rural areas. The adoption of a structuralist approach (Neudert and Smolka, 2025) to innovation ecosystem in rural areas allowed to better understand the complex value proposition of the Pollica initiative. Against the backdrop of rural ecosystems, we have identified the DRABE as an original concept revealing its efficacy in addressing virtuous paths of digital and social innovation driven by an

4 https://paideiacampus.org/en/.

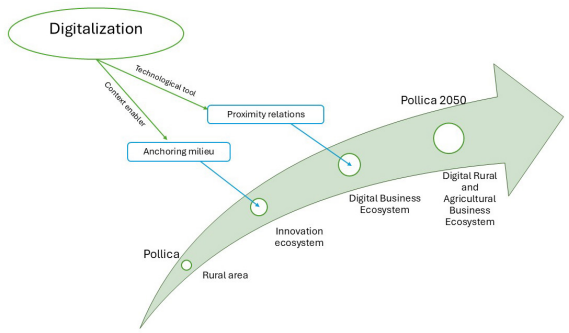

FIGURE 3
Conceptual model of the transition from rural areas to digital rural and agricultural business ecosystem highlighting the position of Pollica in the process. Source: authors' theorization.

anchoring milieu, which is able to synthesize both indigenous and external knowledge sources. The investigated projects clarify the mechanisms of knowledge anchoring and innovation adoption by emphasizing dynamics of cognitive proximity, within the processes of organized proximity, in which an anchoring milieu can reduce the cognitive distance in rural areas (Sternberg, 2022). The process of knowledge anchoring is realized through a strategy which combines community engagement with "external resources" able to boost digital transition. Figure 3 highlights the results of our analysis framed within our theoretical evolutionary model depicting the transition toward digital rural and agricultural business ecosystem. Pollica case study highlights how digitalization fosters new territorial proximity and affects the creation of new combinatorial knowledge, innovation and business dynamics in rural areas. This potential is realized through a sound building process of the two logics informing territorial proximity in the DRABE: the logics of belonging, through the activation of innovation networks connecting local and external actors, and the logics of similarities, synthesized by the sharing of same values of sustainable rural development. Therefore, the digital rural ecosystem allows to performance a wide range of projects strengthening the virtuous circle of sustainable development, then mitigating the "liability of rurality" (Clausen, 2020). Anchoring milieu fostering combinatorial knowledge dynamics is strategic (Crevoisier and Jeannerat, 2009; Manniche, 2012). In the case of Paideia Digital Academy, digital learning is integrated with history, art, music, coding, and environmental activities, enabling the anchoring of theoretical knowledge into practical, socially and ecologically relevant projects. In this way participatory and multidisciplinary training can generate new knowledge pathways and skills applicable to local sustainable development. In the case of TEST-Farm, on the other hand, the initiative transforms farms into living laboratories where digital and ecological innovations are tested, adapted, and validated in real operational contexts. By combining local experiential knowledge with distant scientific and technological expertise, TEST-Farm exemplifies a process of combinatorial knowledge anchoring that strengthens local capacities and drives the ecological and digital transition. Similarly, Cities 2030 illustrates how interactive learning, citizen engagement, and multi-actor networks anchor global scientific and technological knowledge into urban food systems, fostering context-specific solutions and enhancing social and territorial resilience. Finally, the Philosophy Eco-Design Lab demonstrates how community-based, hands-on approaches allow young actors to integrate experiential, creative, and environmental knowledge, generating transformative impacts on circular economy practices and territorial regeneration. The joint action of this variety of projects point out how digital technologies are at the basis of an empowering mechanism of knowledge creation and innovation adoption, shaping a digital rural and agricultural business ecosystem (DRABE). These cases confirm previous studies suggesting that anchoring milieus facilitate the recombination of local and distant knowledge, supporting both innovation diffusion and the creation of socially and ecologically meaningful solutions (Conlé et al., 2023; Jeannerat and Crevoisier, 2022; Vale and Carvalho, 2013). By incorporating digital initiatives, Pollica strengthens its ability to engage its community, co-create solutions, and adapt to the evolving digital landscape, ultimately contributing to the regeneration and resilience of the town and its surrounding ecosystem. Therefore, an anchoring milieu consisting of young people and students, local residents and community members, local businesses, as well as educational, cultural, and municipal actors was able to reconfigure Pollica into a living laboratory that spearheads social, economic, cultural, and digital regeneration processes, while remaining deeply rooted in the education, innovation, digitization, and local community engagement. This expansion has contributed to the activation of the territory, the cultivation of latent relationships, and the establishment of community ties, resulting in heightened awareness of community identity, local animation, and new territorial proximities.

The positive effects of bonding, bridging, and linking ties are well evident in the Pollica project due to the presence of initiatives involving the local community, internal and external stakeholders in the area, and local, national, and European institutions and organizations. Participation in international events has facilitated the promotion and global dissemination of the Pollica's ecological regeneration model. Project participants gain knowledge that they share with others, fostering beneficial between indigenous expertise and new sources of information, bringing about reconfiguring relational architectures and boosting anchoring process based on cooperation (Crevoisier and Rime, 2021). Relations of cooperation among actors, institutions, and artifacts based on digitalization have been characterizing and reconfiguring this rural entrepreneurial ecosystem. Therefore, a "twin transition", combining sustainability and digitalization (Brunori, 2022b), has emerged, seeking to create an entrepreneurial ecosystem that integrates digital innovation with the valorisation of traditional activities and the sustainability of the agricultural processes. To boost the twin transition, various dimensions of social capital operate, well beyond the simple traditionally embedded bonding ties and involving both bridging and linking ties. The composition and the "relevance" of each dimension of social capital has been dramatically affected by recent transformations, which have brought about "ambidexterity" through a balanced relational architecture (Cofré-Bravo et al.,

2019; De Rosa et al., 2024), allowing the territorial ecosystem to "*get ahead*" (Woolcock and Narayan, 2000), by setting up new territorial proximities.

6 Conclusions

This paper contributes to identifying a new configuration of digitally-driven entrepreneurial rural ecosystems. We have named this as digital rural and agricultural business ecosystem (DRABE), on account of the relevance of digital innovation in shaping future trajectories of territorial rural development. With respect to other digital business ecosystems, the DRABE maintains a space-bound trajectory and emerges as an outcome of a cumulative process of combinatorial knowledge boosted by the rural anchoring milieu. The anchoring milieu, identified as a set of actors able to combine local and distant knowledge, by addressing new territorial knowledge dynamics, redesigning the trajectories of rural innovation, through sustaining both spatial and digital affordances. These two issues have been analyzed through the lens of the proximity perspective, by investigating both geographical and organized proximities and setting up new balanced relational architectures. How DRABE interacts with pre-existing business ecosystems and how (and if) shapes them is a crucial aspect to be investigated in future research focused on the analytical perspective of DRABE. The shared definition of DRABE enlightens some critical issues, which are paramount to evaluate processes of ecological transition, the most important of which are neutrality and directionality. As far as directionality is concerned, it is worth underlying that digital innovation addresses different paths of development in rural areas. For instance, the case-study has shown that the adoption of digital solutions has facilitated connections with skills and knowledge from distant places has given a boost to the agroecological transition, as evidenced in other research (Schnebelin et al., 2021). Regarding neutrality, we agree with the idea of non-neutrality characterizing adoption of digital technologies, on account of different social mechanisms at work (Brunori, 2022a). Set against this background, the disruptive characters of technological innovation linked to digital solutions may emerge (Klerkx, 2020). However, the case-study of Pollica emphasizes how twin transition is possible, through engendering both digitalization and ecological transition, mediated by the emergence of new territorial proximities. Therefore, the ecosystemic perspective, which qualify the DRABE, brings about addressing specific policy implications, by encouraging "policy-mix" approaches (di Santo et al., 2024; Del Giudice, 2024). More precisely, the plurality and variety of actors/actants/institutions which typifies the digital rural and agricultural business ecosystem should privilege policies targeted toward building up innovation communities (Pigford et al., 2018), through shaping an anchoring milieu able to territorially attract specific knowledge aimed to boost digital innovations. Moreover, policies should encourage the DRABE's attitude to interact/shape pre-existing entrepreneurial ecosystem with the purpose of addressing and facilitating sustainable innovation. Consequently, a relevant role in this context is played by transformative policies (Jeannerat and Crevoisier, 2022) whose task is to encourage digital innovation as tool to stimulate transition toward more sustainable farming systems, by strengthening their resilience. In coherence with the idea shared in this paper of DRABE as an entrepreneurial ecosystem, this policy should *give prominence to entrepreneurship ecosystems that are not only about developing new production and market opportunities but also about shaping the future social conditions of these opportunities* (Jeannerat and Crevoisier, 2022). These conditions refer to joining the digital affordance and spatial affordance, then allowing the rural ecosystem to perform existing functions more effectively, or perform entirely new functions (Autio and Thomas, 2018). Recent policies documents at EU level point in this direction. The long-term vision for rural areas identifies "connected rural areas" as a pillar for planning future modern rurality: in this context, the recently approved common agricultural policy provides both direct and indirect tools for supporting digital transition, for instance through funding advisory services, cooperation or investment on digitalization. Moreover, the recently published new vision of agriculture and food (European Commission, 2025) highlights the relevance of *Digitalization as a driver to further advance the transition* and address new policy issues as filling skills gaps, and granting access to sound, relevant, and new knowledge across Europe (European Commission, 2017). How rural stakeholders will be able to exploit these opportunities and how the DRABE may encourage them remains to be still explored. To the best of our knowledge, the Pollica case-study is a good starting point.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

GO: Methodology, Writing – original draft, Conceptualization, Investigation, Formal analysis. GB: Validation, Conceptualization, Supervision, Writing – review & editing, Methodology. TD: Writing – review & editing, Validation, Conceptualization, Supervision. MD: Supervision, Conceptualization, Writing – review & editing, Methodology, Validation.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2026.1857819/full#supplementary-material

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