REA Italian Review of Agricultural Economics JUST ACCEPTED

Received: 21/05/2026

Received: 06/07/2026

Accepted: 07/07/2026

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interest: The authors declare no conflict of interest in this manuscript.

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Research article

Rural digitalisation and territorial diversity: A configurational analysis of contexts, mechanisms, and outcomes

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Abstract

Rural digitalisation is a place-based process that is expected to support regional development and reduce spatial digital divides, yet its outcomes vary widely depending on local conditions, institutional capacity, and territorial arrangements. This study investigates the ways in which rural digitalisation processes produce differing outcomes by applying the context–mechanism–outcome logic of realist evaluation to 35 empirical cases drawn from a systematic literature review. Through the use of multiple correspondence analysis, six distinct configurations are identified, and it is shown how various mechanisms, such as facilitation of access to services, knowledge dissemination, and digital infrastructure restructuring, interact with contextual conditions to generate divergent outcomes across rural territorial settings. This analysis indicates that digitalisation is not inherently inclusive: in cases where mechanisms are contextually aligned and governance arrangements support local

adaptation, positive outcomes are more likely, whereas digital initiatives that are externally imposed or poorly adapted to local institutional realities tend to reinforce dependency, mistrust, or exclusion. These findings call for more adaptive, context-sensitive governance models that are responsive to place-based conditions, with implications for the design of rural development policies and spatially targeted digital inclusion strategies.

Keywords: rural digitalisation, realist evaluation, territorial governance, digital divide, place-based policy.
JEL codes: O18, O33, Q18.

Highlights:

- Rural digitalisation produces divergent outcomes shaped by territorial and institutional conditions;
- Six configurational archetypes representing context–mechanism–outcome are identified through systematic review and multiple correspondence analysis;
- Infrastructural access alone is insufficient: cultural fit and governance capacity determine digital inclusion;
- Assessments informed by the context–mechanism–outcome approach can strengthen place-based rural development and digital investment strategies.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record.

Please cite this article as:

Medici M., Brunori G., Martino G. (2026). Rural digitalisation and territorial diversity: A configurational analysis of contexts, mechanisms, and outcomes. *Italian Review of Agricultural Economics*, Just Accepted

DOI: 10.36253/rea-17411

1. Introduction

Digitalisation can be defined as the transformation of the socioeconomic environment through the processes of adopting, applying and utilising digital artifacts (Gradillas, Thomas, 2023). Rural digitalisation refers to the integration of digital technologies into the everyday services, economies, and social infrastructures of rural areas. Although this transformation is reshaping public services, communication, and socio-economic participation (Kraus *et al.*, 2021; Schmidt, Tang, 2020), significant gaps remain between policy intentions and the level of technology adoption in rural areas, a situation that is often aggravated by limited connectivity, poor infrastructure, limited technical capacity, and technological options that are not aligned with local cultures (Alant, Bakare, 2021; Aranguri *et al.*, 2025; Cerjak *et al.*, 2025; Michels, Musshoff, 2022; Mu *et al.*, 2024). Beyond infrastructure and skills, the quality of local institutions has been shown to be correlated with the

spatial distribution of digital divides, suggesting an institutional component to the geographic unevenness of digital inclusion (Caragliu, Del Bo, 2025). To address these gaps, a clearer understanding will be required of the factors that enable or hinder rural digitalisation and of how these factors interact to shape adoption processes and outcomes.

Digitalisation activates transformative dynamics, thereby reshaping how people, institutions, and technologies interact (Capello *et al.*, 2025; Ciliberti *et al.*, 2024; Metta *et al.*, 2022), and rural areas are particularly characterised by heterogeneity, a factor that in turn reshapes digitalisation processes (Zhang *et al.*, 2023). Gaining an understanding of these changes requires a territorial perspective in which the diversity of rural areas and digital practices is acknowledged and brought to the forefront (Zhang *et al.*, 2023).

This article therefore examines the ways in which territorial systems shape rural digitalisation processes. This perspective is justified by a twofold motivation. Firstly, it is necessary to take into account the inherent and multiple territorial dimensions of rural development processes (Gkartzios, Lowe, 2019; Van der Ploeg *et al.*, 2017), and especially their capacity to contribute to the definition of the institutional arrangements shaping rural development trajectories (Dervillé, Allaire, 2014; Martino, 2024). As described in the rural development literature, territory in particular is understood as a system of socio-economic relations and interactions in which space and proximity play crucial roles (Murdoch, 2000; Musotti, 1997; Ray, 1997; Tinacci, 2002; Torre, 2014, 2019; Tregear *et al.*, 2007; Urry, 2001). In the following, we use the term "territorial context" as a shorthand for this bundle of place-based conditions shaping digitalisation pathways. Secondly, recent research increasingly recognises that rural digitalisation should be analysed as a systemic process involving multiple actors (Del Giudice *et al.*, 2022; Granstrand, Holgersson, 2020; Metta *et al.*, 2022; Rijswijk *et al.*, 2021).

Although there is an extensive body of literature addressing the territorial dimensions of rural development processes, a comprehensive understanding of how territorial systems may contribute to the diffusion of digitalisation in rural areas has not yet been achieved. This study seeks to contribute to the development of such knowledge by exploring the analytical opportunities arising from the assumption that rural digitalisation processes can be seen as a dynamic configuration of contexts and mechanisms through which multiple stakeholders contribute to the process. The investigation is substantiated through the development of this assumption with reference to evidence derived from a systematic review of recent literature. More specifically, the aim of the study is to address the following research question: How do contextual conditions and digitalisation-enabled mechanisms interact to produce different outcomes in rural digitalisation processes? An important premise of this study is that rural development processes, including digitalisation, are socio-institutional phenomena in which institutional arrangements affect whether outcomes foster inclusion or reinforce exclusion, rather than being purely technological interventions. Accordingly, rural digitalisation can be seen as a configuration of contexts and mechanisms through which multiple stakeholders contribute to the process. Stakeholder relations therefore have a direct influence on digitalisation trajectories, making outcomes highly contingent on context. Consequently, causal associations between digitalisation inputs and observed results cannot be treated as universal or linear, but must be seen as emergent products of situated interactions among actors, rules, and resources (Geels, 2004; Latour, 2005; Ostrom, 2008b; Salemink *et al.*, 2017). In other words, causal associations themselves are rarely universal but are always strongly influenced by the setting and context (Dalkin *et al.*, 2015).

Consistent with this view, we argue that an understanding of rural digitalisation requires a framework that explicitly accounts for the interplay between context, mechanisms, and outcomes, and for the ways in which governance arrangements mediate these relationships. The extension and effectiveness of digitalisation processes depend not only on the design of technological systems but also on how local actors interpret, negotiate, and adapt them within their institutional environments. We therefore adopt the context–mechanism–outcome (CMO) logic of realist evaluation to explain how contextual conditions are associated with digitalisation-enabled mechanisms to generate differentiated outcomes via the framework described in Section 2.

The remainder of this paper is organised as follows: Section 2 presents some conceptual background, including a theoretical model developed based on a pilot literature review of CMO items. In Section 3, we introduce the methodology for the study and provide a detailed description of the systematic literature review that was conducted. In Section 4, the results are presented, while an in-depth discussion of the main findings and the main study implications are given in Section 5. Finally, in Section 6, some concluding remarks for the study are outlined.

2. Conceptual background

2.1. The context–mechanism–outcome framework

To gain an understanding of rural digitalisation, an analytical framework is required that is capable of capturing the dynamic interaction between contextual conditions, digital and human processes, and the effects they generate. In view of this, we adopt the CMO logic (De Brun *et al.*, 2019; De Weger *et al.*, 2020; Pawson, Tilley, 1997), inspired by realistic evaluation, which focuses on understanding "what works, for whom, in what circumstances, and how". At its heart, realistic evaluation is based on the idea that outcomes are generated by mechanisms that are triggered in particular contexts (De Brun *et al.*, 2019; De Weger *et al.*, 2020). This approach emphasises that outcomes result from the interaction of mechanisms and contexts rather than via simple linear causation. Instead of assuming uniform cause and effect relations, causality is viewed as conditional and situated, emerging from the interactions among multiple social, technical, and environmental factors.

This perspective is particularly suited to rural digitalisation, where adoption and impact depend on diverse contextual attributes such as infrastructure, local capacities, cultural norms, and socio-economic conditions, and on the mechanisms these factors enable or constrain (Dolinska, d'Aquino, 2016; Geels, 2004; Metta *et al.*, 2022). In line with Ostrom's insights into institutional diversity and contextual fit (Ostrom, 2008b; Poteete *et al.*, 2010), we assume that what succeeds in one setting may not necessarily work in another, and that no single governance model or causal pathway can explain the variability in digital transformation processes across rural contexts. In both Ostrom's institutional perspective and the CMO logic (De Brun *et al.*, 2019; De Weger *et al.*, 2020), it is emphasised that outcomes depend on configurations of contextual features and interaction processes rather than on universal rules.

Accordingly, in this study, contexts are understood as the settings or conditions under which digitalisation processes unfold; mechanisms as the processes, relationships, or systems that

digitalisation enables or alters; and outcomes as the observable effects resulting from their interactions. Interaction processes are operationalised through four categories of mechanism (AccServ, KnowD, Hum, Rest), each of which captures a distinct type of process through which digitalisation alters or enables interactions among actors and resources (Section 2.1.2). Multiple correspondence analysis (MCA) is then applied to identify which mechanisms co-occur with which contextual conditions and outcomes, constituting the configurational logic of the analysis. The three analytical components are detailed in Sections 2.1.1–2.1.3.

Contexts

Rural digitalisation, as a multifaceted concept, both influences and is influenced by a variety of contextual dimensions, including cultural specificity, socio-economic vulnerability, governance systems, institutional support, and geographic remoteness, and inevitably has ethical, social, political, cultural, and environmental implications (Lioutas *et al.*, 2021). To capture this complexity, a variety of contextual dimensions were identified as explanatory dimensions for the adoption of rural digitalisation, and were categorised into five main groups in line with work by Kraus *et al.* (2021), Lioutas *et al.* (2021), and Schmidt and Tang (2020), as follows:

- *Geographic dimension*: Remoteness and infrastructural accessibility can limit access to services and affect service quality (Park, 2017; Salemink *et al.*, 2017);
- *Socio-economic dimension*: This is characterised by resource scarcity and by vulnerable groups that may face compound barriers such as low income or limited investment capacity, thereby impacting access to services (Fisk *et al.*, 2023; Helsper, 2012; Park, 2017; Van Dijk, 2005);
- *Demographic dimension*: Digital literacy and age are often significant enablers of digital engagement and are correlated with adoption rates (Selwyn, 2004; Van Dijk, 2005);
- *Cultural dimension*: Social norms and traditions influence the perception and adoption of technology (Mihai, Novo-Corti, 2022; Rubino *et al.*, 2020; Venkatesh, Davis, 2000);
- *Institutional dimension*: Digital transformation depends on good governance at both the meso-scale and the micro-scale (Salemink *et al.*, 2017; Ciliberti *et al.*, 2024; Fitzpatrick, 2005).

Taken together, these dimensions capture the multi-layered determinants of digital inclusion identified in previous research on digital divides (Helsper, 2012; Van Dijk, 2005) and rural territorial development (Pike *et al.*, 2007), and provide an integrative lens that links the infrastructural, socio-economic, and institutional factors affecting rural digitalisation. This multidimensional characterisation of context also resonates with Welter's (2011) framework, in which social, institutional, spatial, and industry contexts are identified as primary determinants of how actors navigate and respond to their environment, a perspective that reinforces the need for place-sensitive analytical frameworks in rural digitalisation research.

Mechanisms

In practical terms, a mechanism refers to the response triggered by an intervention among stakeholders and the resulting outcome (Weiss, 1997). Mechanisms can be viewed as the “underlying entities, processes, or structures which operate in particular contexts to generate outcomes of interest” (Astbury and Leeuw, 2010, p. 368). They therefore include both structural changes (enabled or

disrupted systems) and social responses. Four main dimensions of mechanisms can be identified from the literature:

- *Accessibility*. One important set of processes enabled by digitalisation involves the facilitation of access to services such as healthcare, training, education, and natural resource management. In this study, accessibility is understood as the degree to which digitalisation reduces barriers to essential services for rural populations and enhances engagement in the digital ecosystem (Brunori 2022; Gopalan *et al.*, 2022; Lioutas *et al.*, 2021; Mehrabi *et al.*, 2021). For example, telemedicine platforms and online agricultural extension services have been shown to improve accessibility to expertise and information in remote areas where physical services are scarce (Cerjak *et al.*, 2025; Mosa *et al.*, 2012). However, evidence from rural municipalities suggests that improvements in high-speed broadband coverage do not necessarily translate into higher household internet use, indicating that infrastructure expansion alone may be insufficient to trigger uptake mechanisms (Moral-Arce *et al.*, 2025).
- *Knowledge*. Knowledge mechanisms are the processes through which digitalisation supports the creation, dissemination, and application of information relevant to rural actors. This includes both formal knowledge transfer (e.g., digital extension services, online training) and informal learning through peer networks and community platforms (Gradillas, Thomas, 2023; Andersson, Ostrom, 2008). These mechanisms support what Teece *et al.* (1997) refer to as dynamic capabilities, which are actors' abilities to perceive, capture, and reorganise resources in response to changing digital environments.
- *Human connection*. This dimension refers to how people interpret, engage with, or resist digitalisation. Trust, reciprocity, and knowledge sharing act as core mechanisms in collective governance (Dalkin *et al.*, 2015; Pawson, 2006), and interpersonal relationships grounded in trust, empathy, and peer influence are essential in sustaining or inhibiting adoption.
- *Restructuring infrastructures*. Digitalisation restructures real-world systems by means of sensors, actuators and cloud services, and reconfigures both digital and physical infrastructures, with significant implications for rural socio-economic conditions (Gradillas, Thomas, 2023; Melnyk *et al.*, 2019; Rijswijk *et al.*, 2021).

Digital infrastructure can also be conceptualised as the digital commons, the sustainability and inclusiveness of which depend on how stakeholders are empowered and engaged in their governance (Ostrom, 1990, 2010). Infrastructure mechanisms therefore operate not only through material reconfiguration but also through the distribution of agency among the actors involved.

Outcomes

The use and adoption of digitalisation may lead to diverse outcomes that are context- and mechanism-dependent. Outcomes may be positive (e.g., improved access to services), or negative, such as reinforced digital divides between urban and rural areas. In line with the goals of this study, the outcomes are interpreted as observed effects resulting from the interaction between contexts and mechanisms. In this framework, outcomes are empirically observed effects that are classified through the systematic identification of patterns, with detailed interpretations presented in the Results section.

3. Methodology

This study followed a theory-driven, evidence-based methodology aligned with the CMO framework described in Section 2 to explore how digitalisation mechanisms unfold in rural contexts. Based on empirical information, a four-stage analytical approach was adopted.

In the first stage, a systematic literature review was conducted following PRISMA guidelines (Page *et al.*, 2021), with a focus on the empirical contexts of rural digitalisation and stakeholder participation (Fig. 1). In the second stage, eligible articles were coded according to the CMO logic. In the third stage, MCA was applied to identify the associations among CMO categories. Descriptions of stakeholder roles across CMO groups were created based on the studies included in each configuration.

3.1. Search strategy

A document search of the Scopus database was conducted, which covered publications up to December 2024, with no lower date limit, in order to avoid imposing arbitrary temporal constraints on an exploratory corpus. The search query was structured around three key components: (i) rural topics, including rural geography, rural areas, geographic remoteness, accessibility constraints, socio-economic vulnerability, and cultural specificity; (ii) digitalisation, including digital adoption and digital ecosystems; (iii) stakeholder participation, including socio-ecological contexts, socio-technical systems, and actors' influence (concepts that underpin processes such as stakeholder engagement, empowerment, and collaboration). The search was limited to document titles, abstracts, and author keywords. The final search query was structured as follows: TITLE-ABS-KEY(digit* AND rural AND (socio* W/2 (system* OR context*))) AND ORIG-LOAD-DATE < 20241231. These components were chosen to reflect the multidimensional nature of rural digitalisation as outlined in Section 2, and to ensure alignment with the CMO framework.

3.2. Eligibility criteria

All thematic areas (e.g., agriculture, education, medicine, natural resources) and document types (journal articles, conference papers, and book chapters) were retained. The first criterion for inclusion was that studies should involve an empirical context with documented outcomes related to the adoption of (or experimentation with) digitalisation. Accordingly, documents reporting insufficient information on digitalisation, or lacking an empirical context related to its adoption or use, were excluded. In addition, non-English language documents were excluded during the study selection phase, in accordance with Pieper and Puljak (2021).

A total of 35 studies were ultimately included in the review (Figure 1). The search strategy applied to obtain this selective corpus was designed to prioritise empirical depth over bibliometric breadth, as the CMO configurational analysis required empirical studies documenting both contextual conditions and observable outcomes. Temporal trends indicate a recent rise in interest in rural digitalisation with stakeholder involvement in empirical contexts. The near absence of empirical studies published in 2021 is likely to be due to the disruptions caused by the SARS-COV-2 pandemic (Figure 2).

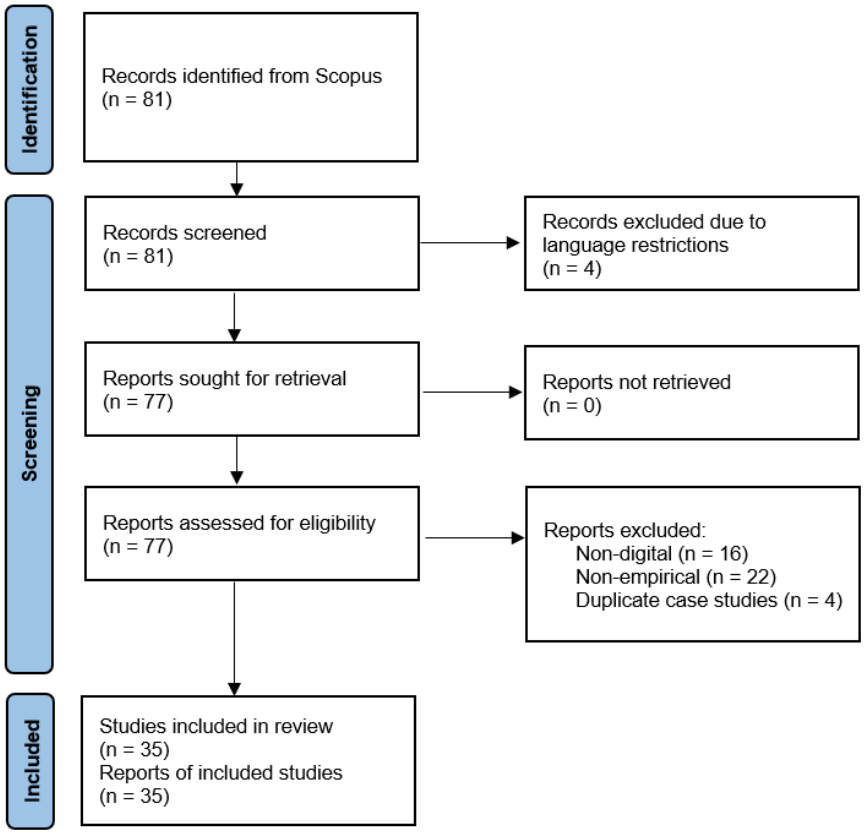

Figure 1. PRISMA 2020 flow diagram illustrating the selection process of the reviewed reports.
Source: Authors' own elaboration based on systematic literature review data.

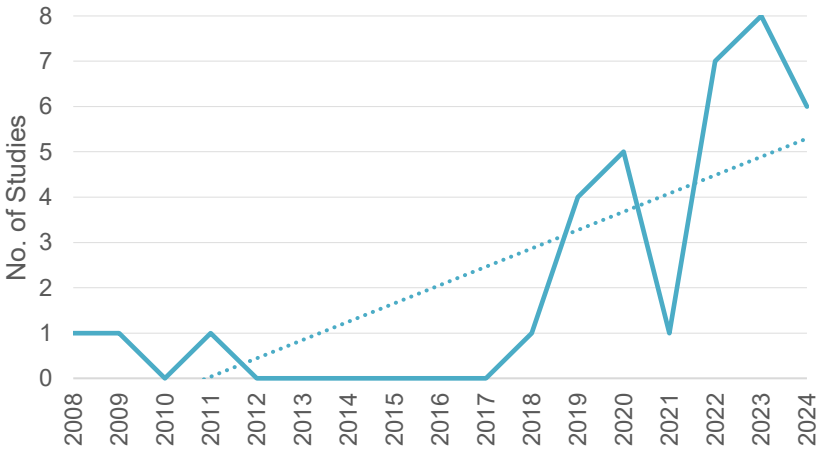

Figure 2. Temporal distribution of studies included in the review.
Source: Authors' own elaboration based on systematic literature review data.

3.3. Coding process

To ensure a thorough analysis of the full text contents, a deductive coding approach was adopted (Elo, Kyngäs, 2008), with reference to the contexts, mechanisms, and outcomes described in Section 2. The aim of this step was to identify the specific interactions between them, although it should be noted that in a number of the reviewed studies, establishing a causal relationship was not the primary objective.

Contexts

To inform the coding framework, we classified a set of context categories representing distinct socio-territorial, institutional, and cultural dimensions (Table 1), drawing on a targeted review of the foundational contributions to each dimension. Each category was selected based on its relevance to digital adoption processes in rural contexts as documented in the literature reviewed below.

In regard to the geographic dimension, the remoteness category (Remot) draws on work by Salemink *et al.* (2017) and Park (2017), who document how geographic isolation and infrastructural deficits compound digital exclusion in rural areas. With respect to the demographic dimension, Selwyn (2004) challenges optimistic narratives depicting older adults as "silver surfers," showing instead that individuals over 60 often display ambivalence toward digital technologies: their limited engagement reflects not incompetence but a lack of "life fit," whereby digital tools provide insufficient added value relative to established routines. This effect underpins the category of digital literacy (DigLit), which captures how age and literacy levels shape digital engagement and adoption rates. In terms of the cultural dimension, Rubino *et al.* (2020) find that cultural profiles significantly influence digitalisation trajectories: high levels of uncertainty avoidance and competitive orientations impede digital advancement, whereas cooperative and gratification-oriented cultures have higher adoption rates. At the individual level, Venkatesh and Davis (2000) offer a refined model, validated across a range of digital contexts, that explains technology adoption through social influence and cognitive instrumental processes and shows how perceived usefulness and intention to use are shaped by peer expectations and normative pressures. Together, these contributions support the category of norms and traditions (Cult). One important aspect is that cultural elements directly affect institutional functioning in rural contexts, particularly in terms of trust, reciprocity, and collective action; these are described by Ostrom (2008a) as enabling conditions for effective governance, reflecting the frequent overlap between the cultural and institutional dimensions. In regard to the institutional dimension, Ciliberti *et al.* (2024) show that digital tools can enhance transparency, governance, and product quality, while also revealing persistent cultural resistance and privacy concerns among producers. As discussed by Andersson and Ostrom (2008), decentralisation can foster responsiveness and local adaptation but may also limit access to specialised knowledge and coordination across levels. Conversely, in heavily centralised systems, it may often be difficult to design rules that effectively address local needs, norms, and knowledge (Salemink *et al.*, 2017; Fitzpatrick, 2005). These contributions ground the categories of organisational capacities and local policies (Inst1 and Inst2), which capture the ways in which governance arrangements and administrative capabilities shape the effectiveness of digital transformation, and represent pivotal contextual conditions influencing whether rural digitalisation reinforces exclusion or fosters inclusion.

These categories were used to code each empirical study on a consistent basis. Coding was applied deductively, with each study assessed against the full set of contextual dimensions. Taken together, these elements shape how digitalisation unfolds across cases, which mechanisms are triggered, and what outcomes are ultimately achieved.

Table 1. Selected contextual dimensions influencing rural digitalisation.

Dimension	Category (code)	Rationale	References
Geographic	Remoteness (Remot)	Remoteness and infrastructural accessibility limit access to services and affect service quality	Park, 2017; Salemink *et al.*, 2017; Welter, 2011
Socio-economic	Social vulnerability (SocVuln)	Vulnerable groups face compound barriers such as low income, which is correlated with service use; resource scarcity limits investment in infrastructure	Fisk *et al.*, 2023; Helsper, 2012; Park, 2017; Van Dijk, 2005; Welter, 2011
Demographic	Digital literacy (DigLit)	Digital literacy is an important enabler of digital engagement; elder people often have lower adoption rates	Selwyn, 2004; Van Dijk, 2005
Cultural	Norms and traditions (Cult)	Social norms and traditions influence technology perception and adoption	Rubino *et al.*, 2020; Venkatesh, Davis, 2000
Institutional	Organisational capacities (Inst1) Local policies (Inst2)	Digital transformation depends on good governance at both the meso-scale and micro-scale	Salemink *et al.*, 2017; Ciliberti *et al.*, 2024; Fitzpatrick, 2005; Ostrom, 2008a; Welter, 2011

Source: Authors' own elaboration based on systematic literature review data.

Mechanisms

In parallel, mechanisms were coded using the categories defined in Section 2.1 (Table 2), to capture how digitalisation is described as enabling, altering, or constraining processes and relationships in the reviewed studies. Drawing on realist evaluation and rural innovation studies, we elaborated five main categories of mechanism based on the dimensions discussed in Section 2 (Table 2). For instance, facilitation of access to services (AccServ) refers to mechanisms that improve or expand access to essential services such as healthcare, education, training, or information platforms. These mechanisms reduce barriers to participation in underserved rural areas (see, e.g., Lioutas *et al.* (2021)). Knowledge creation and dissemination (KnowC/KnowD) represent processes or relationships through which knowledge is developed or spread in the context of digitalisation adoption (Gradillas, Thomas, 2023). Interpersonal relationships (Hum) relate to the expression of human connection through trust, empathy, or resistance in digital engagement (Dalkin *et al.*, 2015). Moreover, following Cofré-Bravo *et al.* (2019), interpersonal relationships in rural digitalisation can be further differentiated according to their social capital structure: bonding ties (within tightly knit groups), bridging ties (across communities), and linking ties (between citizens and institutions). These

specific instances may in turn foster knowledge transfer and trust, among others. Lastly, digitalisation may even involve the reconfiguration of digital or socio-technical systems (e.g., IoT platforms, platform governance), with implications for local roles and power dynamics (see, e.g., Geels (2004) and Ostrom (2010)).

Table 2. Categories for mechanisms identified from the literature and refined during coding.

Dimension	Category (code)	Rationale	References
Accessibility	Facilitation of access to services (AccServ)	Processes improving or expanding access to essential services	Gopalan *et al.*, 2022; Lioutas *et al.*, 2021; Mehrabi *et al.*, 2021
Knowledge	Knowledge creation (KnowC) Knowledge dissemination (KnowD)	Support from digitalisation for collaborative learning, local innovation, and adaptation through new information channels	Gradillas, Thomas, 2023
Human connection	Interpersonal relationship (Hum)	Relationships affecting user acceptance through peer influence or emotional ties	Cofré-Bravo *et al.* 2019; Dalkin *et al.*, 2015; Ostrom, Ahn, 2003; Pawson, 2006
Restructuring infrastructures	Restructuring digital infrastructures (Rest)	Processes involving the reconfiguration of digital or socio-technical systems	Melnyk *et al.*, 2019; Rijswijk *et al.*, 2021; Gradillas, Thomas, 2023

Source: Authors' own elaboration based on data from a systematic literature review.

Outcomes

During the coding phase, we carried out an *ex post* evaluation of the occurrence of both the positive and negative outcomes reported in the analysed studies. Outcome categories were iteratively refined as the studies were assessed. This methodological approach is justified by the fact that outcomes are not universal but context-dependent. As observed by Poteete and colleagues, "what works in one community or resource setting may fail in another, even if the formal rules appear similar" (Poteete *et al.*, 2010, p. 283). Unlike contexts and mechanisms, for which the categories were defined deductively prior to coding based on the existing literature, outcome categories were identified inductively through iterative reading of the reviewed studies. This asymmetry is intentional from a methodological perspective: while the contextual and mechanistic dimensions of rural digitalisation are relatively well-theorised, the range of observed outcomes (particularly negative ones such as dependency and trust erosion) is less systematically documented, meaning that an open coding approach was required in the first instance. The final set of six outcome categories (Table 3 and Section 4.2) thus represents a synthesis of empirically observed effects, anchored in the realist principle that outcomes are context-specific and cannot be fully pre-specified. Their activation, strength, and observable outcomes depend on the specific contextual conditions that enable or constrain them. Stakeholder roles were documented descriptively across the reviewed studies to

contextualise the identified configurations, but were not treated as an independent analytical dimension in the MCA.

3.4. Multiple Correspondence Analysis

Eligible studies were analysed using MCA to uncover associations among the contexts, mechanisms and outcomes retrieved from the literature. As a rule of thumb, CMO categories with frequencies below 5% were excluded from analysis (Le Roux, Rouanet, 2005). MCA is particularly suited to regional and spatial research because it captures multidimensional (and potentially nonlinear) associations among categorical territorial attributes, enabling the identification of recurrent configurations, rather than relying on the assumption of linear effects. MCA also enables the geometric representation of a data matrix in a low-dimensional space, facilitating visual interpretation (Hair, 2011). The analysis was conducted based on a maximum of three dimensions, which together accounted for more than 50% of the total cumulative variance (inertia), a threshold that was considered acceptable for this study and was consistent with previous research (Chang *et al.*, 2018; Duncombe *et al.*, 1985; Sáez *et al.*, 2023). The decision to retain only three dimensions rather than four was supported by both statistical and interpretive criteria: although the fourth dimension accounted for an additional 9.7% of inertia (cumulative total 60.8%), its inclusion did not yield clearly distinguishable configurational patterns in the geometric representation, nor did it substantially alter the positioning of the variables most relevant to the research question. The three-dimensional solution was therefore preferred on grounds of parsimony and interpretability, consistent with exploratory applications of MCA in regional research (Le Roux, Rouanet, 2005).

Identification of the CMO groups (Section 4.2) was done via a two-step interpretive procedure. In the first step, study coordinates in the three-dimensional MCA space were inspected visually by rotating the graphical output along all three axes. Studies positioned in close geometric proximity and sharing interpretable patterns of CMO co-occurrence were provisionally assigned to the same group. In the second step, group membership was validated by cross-checking the binary coding matrix: studies assigned to the same group were verified as sharing at least two CMO categories with above-average frequency within the group. Groups 1 to 3 were identified through the co-occurrence of full CMO triads, while Groups 4 to 6 were defined by dominant partial associations (in particular, a C-M dyad in Group 4, and recurring single outcome categories in Groups 5 and 6), reflecting cases where MCA did not produce a complete triadic configuration.

The analysis was implemented in R using the FactoMineR package (R Core Team, 2023), which was applied to the transposed binary coding matrix (with variables as rows, and studies as columns). This approach is mathematically equivalent to MCA of binary indicator variables, and is consistent with established practice in configurational analysis of coded categorical data (Le Roux, Rouanet, 2005). The chi-square statistic obtained from the correspondence analysis function (χ^2 = 303.3, p = 1.0) reflects the expected non-significance of the independence test for this type of structured binary matrix, and does not affect the interpretive validity of the geometric solution. Before interpreting the six configurations, the quality of representation of each variable in the retained three-dimensional space was assessed using the $\cos^2$ statistic, which expresses the proportion of the variance for a category that is explained by the retained dimensions, and the contribution value (ctr), which indicates the relative weight of each variable in defining each dimension.

4. Results

4.1. Coded categories

The CMO categories identified from the reviewed articles are listed in Table 3. All categories are well represented and were retained for the statistical analysis, with the exception of the mechanism category of knowledge creation (KnowC), which appeared infrequently. This is not surprising, since digitalisation in rural contexts is more commonly associated with knowledge dissemination and communication rather than with the generation of new knowledge *per se*. A total of six outcomes were identified, of which three were positive (improved access to economic resources, to education/healthcare, and strengthened social inclusion) and three were negative (exacerbated inequalities, increased dependency, and trust issues).

Table 3. Distributions of context, mechanism and outcome categories derived from a literature review (n=35).

Type	Category (code)	Frequency (n)	Percentage (%)
Context	Remoteness (Remot)	20	*57.1*
	Social vulnerability (SocVuln)	19	*54.3*
	Digital literacy (DigLit)	25	*71.4*
	Norms and traditions (Cult)	12	*34.3*
	Organisational capacities (Inst1)	16	*45.7*
	Local policies (Inst2)	7	*20.0*
Mechanism	Facilitation of access to services (AccServ)	21	*60.0*
	Knowledge creation (KnowC)	1	*2.9*
	Knowledge dissemination (KnowD)	19	*54.3*
	Interpersonal relationships (Hum)	19	*54.3*
	Restructuring digital infrastructures (Rest)	10	*28.6*
Outcome	Access to economic resources (P_AccEcon)	13	*37.1*
	Access to education/healthcare (P_AccEdH)	13	*37.1*
	Strengthened social inclusion (P_Social)	23	*65.7*
	Exacerbated inequalities (N_Ineq)	15	*42.9*
	Increased dependency (N_Dep)	6	*17.1*
	Trust issues (N_Trust)	18	*51.4*

Source: Authors' own elaboration based on data from a systematic literature review.

4.2. Context, mechanism and outcome interplay

In the MCA, only three components were retained, as described above, since they explained most of the total inertia (51.1%). Specifically, the first, second and third components accounted for 22.6%, 15.9%, and 12.6% of the total inertia, respectively. Figure 3 shows the graphical output in three dimensions generated by MCA. Based on the proximity of the studies, which were evaluated by rotating the 3D graph around the axis, six recurrent types of CMO association (groups) were identified, which can be interpreted as recurrent configurational archetypes across rural territorial settings. To aid in interpretation, the positions of the studies are also displayed as a two-dimensional

graphical output (Figure 4). Groups 1-3 correspond to specific CMO associations, while Groups 4-6 include a dyad and two single outcome categories (Table 4). This partial structure is itself a significant finding from an interpretive standpoint, since it indicates that in some cases, the causal pathway from context through mechanism to outcome is either incomplete or insufficiently documented in the reviewed literature.

The results indicate substantial variation in the representation quality across variables. The mechanism category M-Hum shows the strongest positioning on Dimension 1 ($cos^2 = 0.686$), followed by C-Inst2 on Dimension 2 ($cos^2 = 0.583$) and M-Rest on Dimension 3 ($cos^2 = 0.506$). These variables are well-represented, and their interpretive role in the corresponding configurations can be considered reliable. The contribution values confirm this pattern: M-Hum contributes 16.2% of inertia for Dimension 1, C-Inst2 contributes 34.0% for Dimension 2, and M-Rest contributes 33.5% for Dimension 3, meaning that these can be identified as the primary drivers of the respective configurational axes. By contrast, C-Remot ($cos^2 = 0.014$ on Dim. 1), M-AccServ ($cos^2 = 0.021$ on Dim. 1), and C-DigLit ($cos^2 = 0.000$ on Dim. 2) are less represented. Their positioning in the geometric space is less stable, and their contributions to the corresponding configurations should be interpreted with greater caution. This does not imply that these contextual and mechanistic dimensions are substantively irrelevant, as their empirical frequency in the corpus (Table 3) confirms their importance, but rather that their associative patterns with other CMO categories are more diffuse and less geometrically concentrated in the retained solution.

The six CMO configurations identified here are consistent with the exploratory and theory-building purpose of realist evaluation, which seeks to identify recurrent causal patterns across diverse contexts rather than to confirm statistically universal relationships. This configurational approach is particularly appropriate for research into rural digitalisation, where contextual heterogeneity and small empirical corpora make the generation of hypotheses more valuable than their testing at this stage of knowledge development. The configurations should therefore be read as theoretically grounded archetypes (each internally coherent in its CMO logic) whose generalisability and boundary conditions can be further examined through primary data collection or larger-scale evidence synthesis in future research.

Group 1: Social vulnerability (C) - Knowledge dissemination (M) - Access to education/ healthcare (O). This CMO association emphasises the beneficial aspects of digitalisation in improving access to education and healthcare services for vulnerable rural communities in underserved areas. Various digital tools, such as digital books (Chen, 2024), digital platforms for cooperative learning (Yen *et al.*, 2023), and offline educational contents (Pariyar *et al.*, 2019), have been effectively adopted to support learning and problem-solving. In parallel, more structured digital technologies, including platforms for health screening applications (Bagalkot *et al.*, 2022; Hui *et al.*, 2022; Morelli, 2022; Verdezoto *et al.*, 2020) as well as video, smart phones, and tablets (Wyckhuys *et al.*, 2018) have improved access to healthcare and enhanced communication of health knowledge. The main stakeholders involved in this group are healthcare professionals and educators, who act as institutional intermediaries in adapting and delivering digital content to underserved communities (Morelli, 2022; Verdezoto *et al.*, 2020). This group represents technology as a partial but important solution for improving access to services, and the findings contribute to the broader literature on urban–rural disparities in terms of literacy and services.

Group 2: Norms and traditions (C) - Interpersonal relationships (M) - Strengthened social inclusion and Trust issues (O). This configuration reflects how cultural norms and local traditions shape the adoption of digital communication tools in rural social systems characterised by geographic dispersion and population mobility (Chen, 2022; Cummings, 2020; Fernández-Larragueta *et al.*, 2023; Han, 2025; Rajagopalan, Sarkar, 2008). The mechanism of interpersonal relationships operates through digitally mediated social ties, producing outcomes of strengthened social inclusion alongside trust-related tensions where digital interaction fails to adequately replace established relational and institutional patterns. Following Cofré-Bravo *et al.* (2019), the interpersonal relationships activated in this configuration can be differentiated according to their social capital structure: bonding ties predominate within tightly knit family or community groups (Chen, 2022; Han, 2025), while bridging ties emerge across communities through work and social networks (Cummings, 2020; Fernández-Larragueta *et al.*, 2023).

Group 3: Remoteness and digital literacy (C) - Facilitation of access to services (M) - Strengthened social inclusion and Trust issues (O). This group is defined by two contextual challenges, namely geographic remoteness and low digital literacy, which significantly constrain access to services and digital adoption. Relevant mechanisms involve telehealth (Curioso *et al.*, 2023), mental health platforms (Mukherjee *et al.*, 2022), digital agricultural platforms (Ferrari *et al.*, 2023; Kameswari *et al.*, 2011), educational technologies (Feldman, Czerniewicz, 2023), and social networks (Pei *et al.*, 2022). In these contexts, access facilitation mechanisms support broader service reach and contribute to strengthened social inclusion. However, the expansion of digital connectivity also generates trust-related issues. Stakeholders report perceived inequities in treatment, concerns over data transparency and security (Ferrari *et al.*, 2023), scepticism about digital advisories, and a preference for traditional, face-to-face interactions (Curioso *et al.*, 2023; Kameswari *et al.*, 2011). Concerns about surveillance and control were also noted, particularly in the context of education (Feldman, Czerniewicz, 2023). This group shows how access facilitation mechanisms must be paired with trust-building to achieve equitable outcomes.

Group 4: Organisational capacities (C) - Restructuring digital infrastructures (M). This group represents cases where digital adoption requires strong institutional readiness and governance coordination (Ferrari *et al.*, 2023; Moyano *et al.*, 2023). Institutional readiness, which can be defined as the combination of technical capacity, organisational adaptability, and governance legitimacy required for effective digital transformation (Geels, 2004; Ostrom, 2008b), emerges as the primary determinant of outcomes in this configuration. In this context, the ability to successfully restructure digital infrastructures and implement new services is closely linked to the technical and organisational capacities of the actors involved. Outcomes were found to be varied and closely tied to the technical capacity and collaboration dynamics of the actors. Within this configuration, diverse forms of collaboration or competition may take place, reflecting differing levels of influence. This pattern is aligned with Ostrom's view on institutional diversity as a determinant of governance performance in complex systems (Ostrom, 2010).

Group 5: Increased dependency (O). This group highlights the recurring outcome of increased dependency on external actors. Digitalisation has been found to improve access to resource data in areas such as water management (Argente García *et al.*, 2024), food traceability (Ciliberti *et al.*,

2024), and land management (Krigsholm *et al.*, 2020), thereby helping stakeholders to optimise resource use.However, these benefits are achieved through mechanisms (ranging from facilitated access to services to substantial restructuring of digital and economic infrastructures) that simultaneously generate reliance on external technical support, ultimately compromising local autonomy. However, an important dilemma emerges: although digital platforms have expanded access to governance tools and resource data (He *et al.*, 2025), less empowered groups are increasingly expressing concern about the growing dependence on external technical support required for sustained adoption of digital governance tools. This reliance may ultimately compromise local autonomy and long-term sustainability.

Group 6: Exacerbated inequalities (O). This group highlights how the introduction of digital innovations can exacerbate the digital divide between urban and rural communities. Individuals with limited digital literacy or limited access to infrastructure often lack the capacity to benefit from digital initiatives, while professionals in remote areas struggle with systems that are poorly adapted to their needs (Mettenberger *et al.*, 2024; Rosborg *et al.*, 2019). This configuration reflects technocratic models of digitalisation, where rural stakeholders are positioned as passive recipients rather than active co-creators or decision makers. Ultimately, this reinforces existing disparities and limits the potential for inclusive digital transformation.

Overall, the results confirm that rural digitalisation generates conditional outcomes: in areas where digital mechanisms are contextually aligned and stakeholders are actively engaged, positive outcomes are more likely. Conversely, externally imposed or poorly adapted digital initiatives tend to reinforce mistrust, dependency, or exclusion. From the perspective of the contextual categories, it can also be argued that cultural dimensions (Group 2) and organisational capacity (Group 4) are as essential in terms of the success or failure of digital initiatives as more commonly emphasised factors such as infrastructure and digital literacy (Groups 3 and 6).

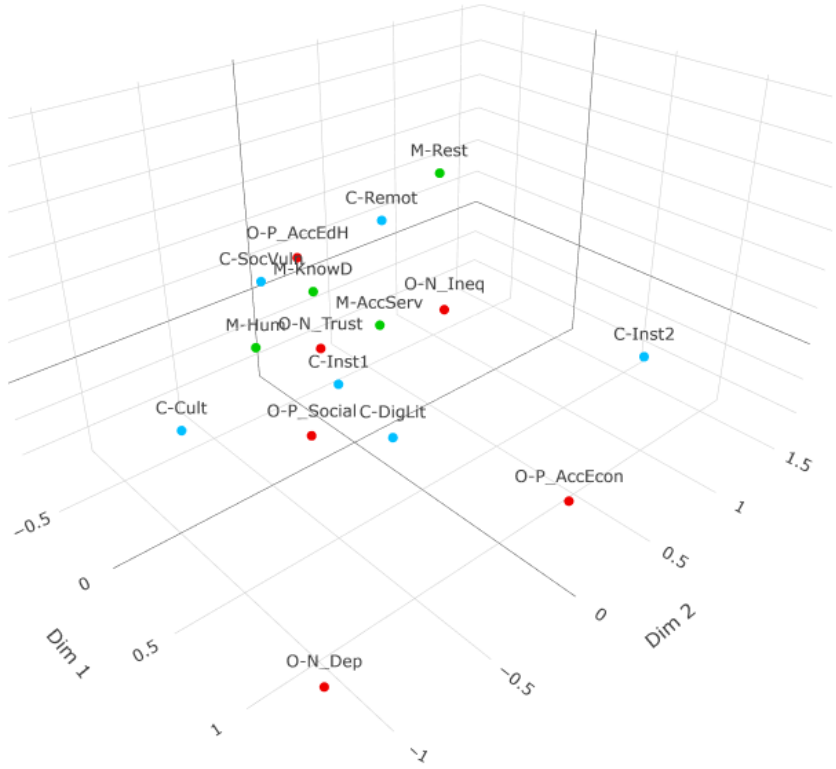

Figure 3. MCA of CMO data: 3D mapping
Source: Authors' own elaboration using FactoMineR (R Core Team, 2023).

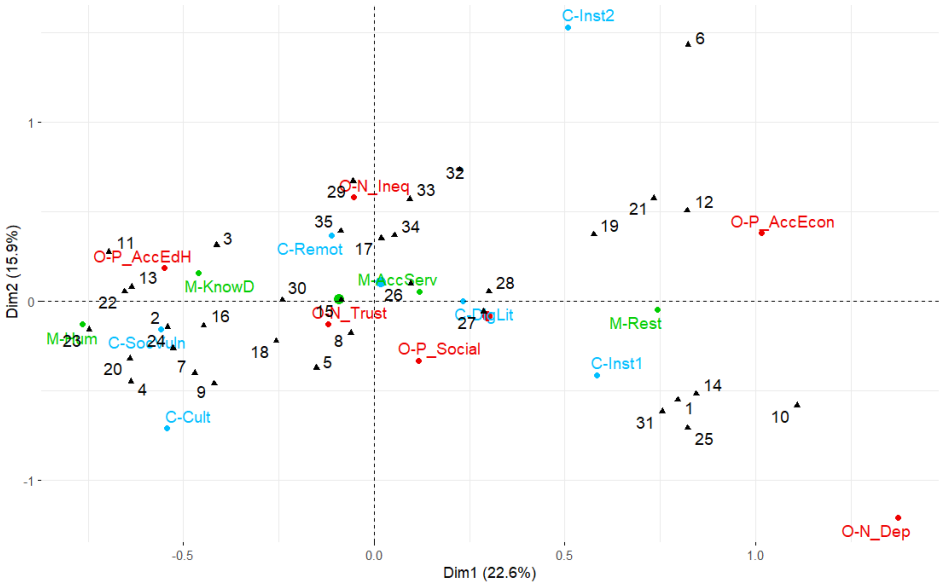

Figure 4. MCA of CMO data: 2D mapping with studies displayed
Source: Authors' own elaboration using FactoMineR (R Core Team, 2023).

Table 4. Associations among the different contexts, mechanisms, outcomes and stakeholder participation (n=35).

Group	Studies	Stakeholders
1: C–M–O (SocVuln–KnowD–P_AccEdH)	Bagalkot *et al.*, 2022; Chen, 2024; Hui *et al.*, 2022; Morelli, 2022; Pariyar *et al.*, 2019; Verdezoto *et al.*, 2020; Wyckhuys *et al.*, 2018; Yen *et al.*, 2023	Remote communities and educators; indigenous women and healthcare workers
2: C–M–O (Cult–Hum–P_Social, N_Trust)	Chen, 2022; Cummings, 2020; Fernández-Larragueta *et al.*, 2023; Han, 2025; Rajagopalan, Sarkar, 2008	Separated families; students and educators
3: C–M–O (Remot, DigLit–AccServ–P_Social, N_Trust)	Curioso *et al.*, 2023; Feldman, Czerniewicz, 2023; Ferrari *et al.*, 2023; Gebremeskel *et al.*, 2022; Kameswari *et al.*, 2011; Pei *et al.*, 2022	Remote communities and healthcare workers; educators and educational institutions; farmers and public utility companies
4: C–M (Inst1–Rest–/)	Ferrari *et al.*, 2023; Moyano *et al.*, 2023	Public utility companies, rural residents, and farmers
5: O (/–/–N_Dep)	Argente García *et al.*, 2024; Ciliberti *et al.*, 2024; He *et al.*, 2025; Krigsholm *et al.*, 2020; Moyano *et al.*, 2023	Farmers, food processors and public utility companies; local administrations and landowners
6: O (/–/–N_Ineq)	Gush, Cambridge, 2024; Mettenberger *et al.*, 2024; Rosborg *et al.*, 2019)	Various actors

Source: Authors' own elaboration based on systematic literature review data

5. Discussion

This study has investigated the relationship between CMO configurations in rural digitalisation processes based on a systematic review of 35 empirical studies. Using a realist evaluation framework and MCA, six distinct CMO groups were identified, which revealed how rural digitalisation can produce varying or even contradictory outcomes depending on local conditions and institutional arrangements.

The primary contribution of the study is methodological: a combination of CMO logic and MCA is applied here for the first time to a systematic corpus of rural digitalisation studies, and represents a replicable procedure for identifying recurrent configurational patterns across heterogeneous territorial contexts. This methodological contribution produced an empirical finding

in the form of six archetypical CMO configurations, which in turn carried a conceptual implication: territorial heterogeneity, rather than infrastructural deficit alone, is the central explanatory variable of divergent digitalisation outcomes in rural areas. The empirical and policy implications discussed below should therefore be interpreted as exploratory extensions of this configurational analysis rather than as independently validated causal claims.

The results suggest that the success of rural digitalisation efforts should be analysed in relation to how mechanisms are activated within specific contexts. Depending on governance capacity, stakeholder trust, or cultural fit, similar mechanisms in similar contexts (such as digital health in remote areas) produced different outcomes. Access facilitation and knowledge dissemination, for example, generated inclusion in some configurations but led to trust issues in others. This finding is aligned with the view that digital adoption must be interpreted as a situated and contingent process (Geels, 2004). In line with Ostrom (2007), natural resource contexts, including digital platforms for land, water, or food management, present inherent governance challenges due to the multi-functional and overlapping institutional logics. Here, digital success was more likely when information was shared at multiple scales and decision making remained legitimate and manageable for the actors involved: our findings illustrate that this principle applies beyond natural resources and is equally relevant to digitalisation efforts in healthcare, education, or infrastructure planning.

This study also shows that digital technologies can strengthen stakeholder involvement and collective governance when they are well-integrated into existing local practices, as described by Ciliberti *et al.* (2024). The results are also consistent with those of Zhang *et al.* (2023), who highlighted the significance of social connections and community experiences in influencing the results of digital adoption. These dynamics were particularly evident in configurations where cultural norms and local institutional arrangements shaped the adoption and governance of digital tools (Groups 2 and 4).

At the same time, this research moves beyond traditional explanations of the digital divide, which have often focused primarily on access to infrastructure (see e.g., Helsper, 2012; Van Dijk, 2005). This interpretation is consistent with empirical evidence from rural municipalities showing that increases in high-speed broadband coverage do not necessarily represent higher household internet use (Moral-Arce *et al.*, 2025). Although access remains important, our findings highlight the role of trust and cultural alignment in determining whether digitalisation is embraced or resisted. These results support the claim that successful innovation in rural contexts depends not only on access to tools, but also on whether those tools can be negotiated among stakeholders and adapted through social processes (Dolinska, d'Aquino, 2016; Medici *et al.*, 2023). Our findings are consistent with those of Salemink *et al.* (2017), whose systematic review supported community-based, context-sensitive policy approaches as the most effective means of reducing structural digital inequalities in rural areas. Similarly, Park (2017) showed that bridging the rural digital divide would require combining infrastructural investment with measures targeting digital literacy and local socioeconomic constraints, a conclusion directly reflected in the co-occurrence of Remot and DigLit as contextual drivers in Group 3. Our results are also aligned with Ingram's (2008) observation that tensions often arise at the boundary between internal community dynamics and the introduction of external knowledge or systems, a pattern clearly reflected in this group, where the expansion of digital connectivity through externally designed platforms generated skepticism, concerns over data transparency, and a preference for traditional face-to-face interactions among actors. In our findings,

this tension was often manifested in stakeholder resistance or selective adoption. In particular, the discrepancies observed in studies in the literature may be explained by variations in stakeholder empowerment (e.g., Group 1 vs. Group 6) or institutional readiness (e.g., Group 4 vs. Group 5).

Our findings are consistent with Andersson and Ostrom's (2008) argument that imperfections in governance can be balanced by complementary actions at multiple levels. However, governance capacity and institutional fit emerge as the primary determinants of the quality of outcomes: configurations characterised by weak institutional readiness or misaligned governance arrangements (Groups 5 and 6) consistently produced negative outcomes regardless of stakeholder involvement, confirming that incremental, context-sensitive implementation is necessary to avoid undermining local capacity (Ciliberti *et al.*, 2024). As argued by Poteete *et al.* (2010), progress in understanding collective action depends on combining diverse methods, and our study supports this claim by combining realist logic with correspondence analysis.

This study is among the first to apply the CMO configurational logic in a systematic way to rural digitalisation through a combination of systematic literature review and MCA. The findings make visible an aspect of the problem that is often underemphasised in rural development research, namely the roles of institutional diversity and territorial context in shaping whether digitalisation produces inclusion or reinforces existing divides. The main strength of this study lies in its theory-informed yet empirically grounded approach, in which realist evaluation logic is combined with configurational analysis. This allows for the identification of recurring patterns across diverse cases while remaining sensitive to context and contextual nuance. However, the study is limited by its reliance on secondary data, meaning that some context-specific details may have been omitted or institutional outcomes not fully acknowledged in the studies reviewed here. Moreover, the analytical focus on five contextual dimensions and five mechanism dimensions, while methodologically necessary, may not capture all relevant variations. A more dynamic and process-based analysis would be beneficial to complement these findings.

This study opens several avenues for further investigation. Future research could examine how CMO configurations evolve over time, and particularly how governance configurations evolve as digital platforms become more diffused in society. In line with Poteete *et al.* (2010), combining different methodological lenses (e.g., realist evaluation, network analysis, longitudinal studies) could provide a more comprehensive picture of how digital systems interact with local governance and social cohesion

5.1. Implications for practice and policy

These findings highlight that digital infrastructure is necessary but not sufficient: technologies must be supported by socially grounded, trust-enhancing processes that are responsive to user needs and cultural peculiarities. The six CMO configurations identified here can serve as a diagnostic framework that rural development practitioners and policymakers can used to predict where risks of exclusion, dependency, or mistrust are most likely to emerge. In particular, for configurations characterised by weak institutional readiness (Group 4) or technocratic digitalisation models (Group 6), there is a need for governance interventions that strengthen local organisational capacities before or alongside the deployment of digital tools. Place-based rural development strategies (including LEADER/CLLD approaches and multi-fund programming under EU rural development frameworks)

could benefit from integrating CMO-informed assessments of local contextual conditions as a prerequisite for digital investment design. For instance, a CMO-informed assessment applied to a LEADER local action group territory could identify in advance whether the prevailing contextual configuration (e.g., high remoteness, low digital literacy, weak institutional capacity) corresponded to Group 3 or Group 5 archetypes, highlighting the need for trust-building measures and capacity development before deploying digital governance tools.

6. Conclusions

Although digital transformation is frequently defined as a catalyst for economic and social change, its effects in a rural context are neither uniform nor inherently inclusive. This study has shown that digitalisation outcomes depend not only on technological access or platform design but on the relational, institutional, and contextual conditions under which digital tools are introduced and used. One important finding was that all configurations did not yield the same effects: where mechanisms were contextually aligned and governance arrangements supported local adaptation (as in Groups 1 and 3), positive outcomes were more likely, whereas configurations characterised by weak institutional readiness or externally imposed digital tools (Groups 5 and 6) consistently produced dependency, mistrust, or exclusion.

This suggests that digital inclusion in rural areas must be understood not only as a technical or infrastructural process, but as an institutionally embedded transformation whose outcomes are contingent on the quality of local governance and the fit between digital tools and territorial conditions. The findings therefore confirm that stakeholder relations directly influence digitalisation trajectories: the same mechanism, activated under different contextual and relational conditions, can generate inclusion or exclusion, trust or dependency. This research also confirms that externally imposed or top-down models, in which users are only partially involved or lack decision-making power, are more likely to generate exclusion, mistrust, or disengagement. This supports the growing consensus that digitalisation efforts need to move beyond deployment to embrace governance models that are adaptive, place-sensitive, and institutionally grounded.

Compared to many previous studies, a wider analytical scope was adopted in this work with the aim of examining multiple governance levels and stakeholder roles rather than focusing on single interventions or actor groups. This yielded a broader understanding of how rural digitalisation emerges not as a linear project, but as a complex and contingent transformation shaped by interlocking systems and relationships. These insights call for a shift in how digital inclusion is conceptualised in policy and practice. Future strategies for rural digitalisation must take into account not only infrastructure and connectivity but also trust, culture, and local governance capacity.

Acknowledgements and Funding

This study was financed by Italian Ministry of University and Research: PRIN 2020 “PUZZLING OUT SMART RURALITIES, SOUND KNOWLEDGE AND RURAL (agricultural/agrifood) ENTREPRENEURIAL ECOSYSTEM – SmARTIES Protocollo 2020SMZPZX_004 – SH1).

Author Contributions

Conceptualization, M.M and G.M.; Methodology, M.M and G.M.; Investigation, M.M, G.B., and G.M.; Data curation, M.M.; Writing - Original Draft, M.M and G.M.; Writing –Review, Editing, M.M, G.B., and G.M.; Funding Acquisition, G.M.; Resources, G.M.; Supervision, G.M., and G.B.

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