

DEVELOPING DIGITAL HUMAN CAPITAL FOR RURAL ECONOMIES: A SYSTEMATIC LITERATURE REVIEW ON EDUCATIONAL TRANSFORMATION AND LABOR MARKET READINESS

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Abstract

This study aims to systematically review the development of digital human capital in rural economies, with particular attention to its relationship with educational transformation and labor market readiness. The study employed a Systematic Literature Review method using the PRISMA approach to ensure a transparent and replicable article selection process. Data were obtained from the Scopus database through advanced searches using keywords related to digital human capital, educational digitalization, digital skills, rural economy, local development, and rural community. After applying inclusion and exclusion criteria, 13 relevant articles were selected and synthesized to answer five research questions. The findings show that digital human capital in rural areas is a multidimensional concept that includes digital literacy, digital financial literacy, digital safety, digital ethics, self-efficacy, social support, and the ability to transform digital access into economic and social benefits. The review also reveals that infrastructure limitations, unequal connectivity, affordability, low digital skills, and weak institutional coordination remain major barriers. However, educational transformation through community training, digital mentoring, coding clubs, lifelong learning, and multi-stakeholder collaboration can strengthen rural communities' readiness to participate in the digital economy. This study contributes by offering an integrated understanding of digital human capital as a foundation for inclusive rural development, educational innovation, and labor market adaptation in the digital era.

Keywords: digital human capital, rural economy, educational transformation, labor market readiness, systematic literature review

INTRODUCTION

The digital economy has fundamentally transformed how people learn, work, and participate in economic development. Central to these changes is digital human capital: the combined skills, knowledge, and adaptability that allow individuals and communities to use digital technologies effectively. This concept, rooted in Human Capital Theory, underscores that education and digital competencies are key drivers of productivity and innovation (Guan & Dong, 2025). In rural areas, building digital human capital is crucial because it helps close the urban–rural gap, supports financial access, and strengthens income resilience. Research shows that digitalization, educational investment, and the growth of human capital all contribute to reducing income disparities between urban and rural communities (Zhang et al., 2025). Further, digital inclusion and empowerment can enhance human capital accumulation and diminish the urban–rural divide,

particularly through improved access to educational and economic resources (Sun et al., 2023; Li et al., 2022).

In recent years, the literature has shown that digitalization of rural economies affects access to information, income growth, entrepreneurship, urban–rural integration, and economic resilience. Lu et al. (2025) explain that the digital economy promotes urban–rural integration by optimizing factor allocation. Zhao et al. (2024) show that digital capital enhances individuals' dynamic capabilities and strengthens rural communities' income resilience. Wang et al. (2025) found that digital skills increase rural household income through more efficient factor allocation. Li and Chen (2025) show that the digital economy creates new non-agricultural employment opportunities in rural areas, though its impact on gender inequality remains to be examined. Zhao et al. (2025) emphasize that digital literacy reduces income inequality among farming households. These findings suggest that digital human capital serves both as a technical capacity and as a tool for economic empowerment, job diversification, and greater rural competitiveness.

Educational transformation is a key pathway for developing digital human capital in rural areas. The digitalization of education has changed curricula, pedagogy, learning resources, and teacher readiness. For example, Valencia-Arias et al. (2025) show that virtual education in rural areas is expanding as demand for flexible education grows. However, it still faces challenges such as infrastructure limitations, teacher preparedness, and unequal access to technology. Similarly, Qi et al. (2025) highlight that teacher readiness, technological support, and institutional factors strongly influence digital transformation in rural education. Additionally, Ihsaniyati et al. (2024) argue that the digital divide in rural areas is shaped by infrastructure, digital literacy, policy capacity, and community willingness to adopt technology. Therefore, educational transformation should prioritize enhancing digital literacy, teacher training, community-based learning, and aligning the curriculum with the digital economy, rather than only providing digital devices or platforms.

Labor market readiness has also become a critical issue in the development of rural digital human capital. Digitalization, automation, and the adoption of new technologies are reshaping occupational structures and increasing the demand for digital skills and transversal competencies. Kravchuk (2025) emphasizes that digital transformation in human capital management is closely linked to social mobility, continuous learning, career advancement, and workforce adaptation to the digital economy. In rural contexts, this means that communities need not only basic technological skills, but also the ability to use technology for employment, entrepreneurship, marketing, financial services, and market access. However, the literature also indicates a persistent gap between educational investment, digital readiness, and labor market needs. This gap is reflected in limited teacher preparedness, low digital skills among some rural communities, and the inadequate alignment between rural education and the skills demanded by the digital economy. Therefore, research on digital human capital needs to integrate three interrelated aspects: educational transformation, rural economic development, and labor market readiness.

Against this background, this Systematic Literature Review aims to identify, synthesize, and map the development of digital human capital in rural economies, particularly in relation to educational transformation and labor market readiness. Specifically, this review seeks to: (1) clarify the concept and dimensions of digital human capital in rural economic contexts; (2) identify the main factors that support and hinder its development; (3) examine the role of educational transformation in strengthening rural communities' digital competencies; (4) explain the

contribution of digital human capital to labor market readiness; and (5) analyze the roles of key stakeholders in building an inclusive rural digital ecosystem.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

This study positions digital human capital as a central concept that links the quality of human resources with the capacity to adapt to the digital economy. Conceptually, human capital is understood as investment in education, training, health, knowledge, and skills that enhance individual productivity and support economic development capacity (Todaro & Smith, 2020). In labor economics, human capital is also defined as the accumulation of productive skills acquired through education, training, work experience, and other learning processes (Borjas, 2020). In a digital context, digital human capital is the accumulation of knowledge, skills, attitudes, and adaptive capacities possessed by individuals and communities to use digital technologies productively, safely, ethically, and in economically valuable ways. This definition is further supported by the concept of digital competence, which views digital ability not merely as a technical skill, but as a multidimensional competence encompassing information skills, communication, participation, problem-solving, social responsibility, and readiness to live in a knowledge-based society (Ilomäki et al., 2016; Falloon, 2020).

In the context of this study, rural economies are understood as systems of economic activities in rural areas that include agriculture, micro and small enterprises, non-agricultural activities, local services, entrepreneurship, and the socio-economic relations of rural communities. Rural economies are not solely dependent on agricultural production, but also on institutional transformation, productivity improvement, job diversification, market access, and the strengthening of local community welfare (Todaro & Smith, 2020). In the digital era, rural economic development is strongly influenced by local communities' and institutions' ability to access and use digital infrastructure and services. Limited connectivity in rural areas can weaken economic activities, social services, access to information, and employment opportunities, making the digital divide a critical issue in rural development (Philip et al., 2017). Therefore, the development of digital human capital in rural economies should be understood as an effort to strengthen rural communities' capacity to transform technological access into learning opportunities, business opportunities, economic participation, and local productivity growth.

The next key variables are educational transformation and labor market readiness. In this study, educational transformation is defined as a systematic change in curricula, pedagogy, learning resources, educational technology, and instructional strategies to ensure that learners and communities acquire knowledge and skills relevant to life and work in the digital era. Bates (2022) emphasizes that education in the digital age requires not only mastery of information technology but also the ability to think critically, learn independently, adapt, and apply knowledge meaningfully. Meanwhile, labor market readiness refers to an individual's preparedness to enter, remain, and develop in the labor market by mastering knowledge, skills, attitudes, personal attributes, and competencies aligned with workplace demands. Studies on employability indicate that work readiness is not only related to obtaining employment but also involves the ability to adapt, develop competencies, and address the gap between graduates' skills and employers' needs (Abelha et al., 2020). This issue has become increasingly relevant as digitalization and automation reshape occupational structures by replacing certain existing tasks while creating new ones

(Acemoglu & Restrepo, 2019), producing different effects on job creation and job destruction depending on workers' skill types (Balsmeier & Woerter, 2019). Thus, this literature framework emphasizes that educational transformation plays a crucial role in developing the digital human capital rural communities need to respond to labor market changes, foster digital entrepreneurship, and support more inclusive local economic development.

RESEARCH METHODS

This study employed a Systematic Literature Review (SLR) using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The PRISMA guidelines provide clear, transparent, and comprehensive reporting standards for conducting systematic reviews. Recent updates indicate that PRISMA is particularly useful for improving clarity, transparency, and replicability in research, especially in network meta-analyses (Page et al., 2021).

The data were obtained from the Scopus database. Scopus was selected for its reputation as one of the largest abstract and citation databases, covering high-quality scientific literature (Q1–Q4) and providing broad global coverage, thereby supporting the validity of the data analyzed in this study (Mongeon & Paul-Hus, 2016). The literature search was conducted in May 2026, with a cut-off date of May 29, using an advanced search technique applied to article titles, abstracts, and keywords (TITLE-ABS-KEY). The search string was designed using Boolean operators (AND, OR) to capture variations of terms related to the development of digital human capital, rural economies, and labor market readiness. To ensure transparency and replicability in the article selection process, this study followed the PRISMA protocol, consisting of four main stages: identification, screening, eligibility, and inclusion, as described below:

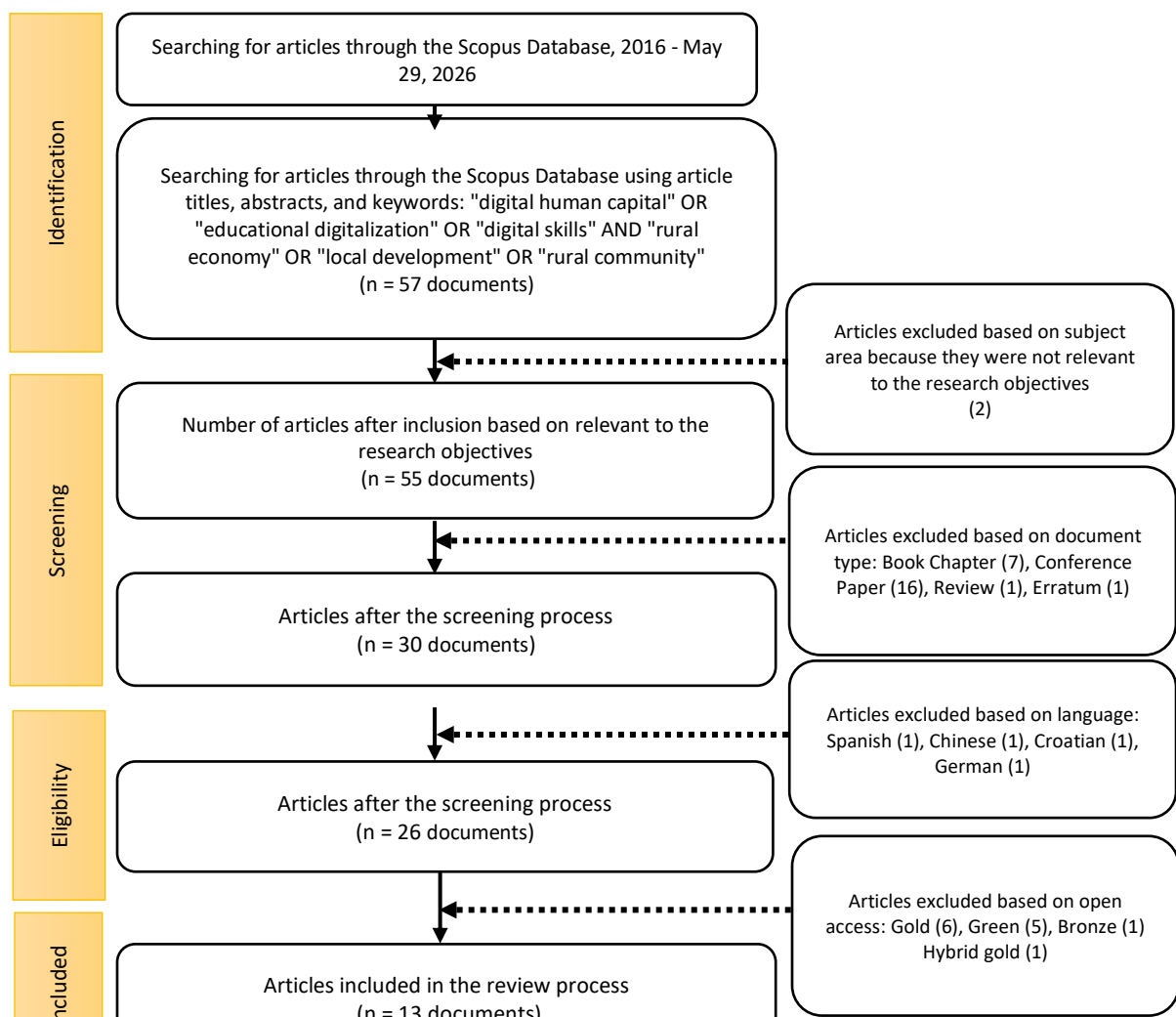


Figure 1. Information Flow of the Systematic Literature Review Using the PRISMA Framework
Research Question

Through this rigorous screening process, including adjustments for access availability (open access eligibility) and full-text relevance, 13 articles met the inclusion criteria and were subsequently selected as the primary data sources for this study. These articles were then systematically analyzed to address the following research questions:

Table 1. Research Question

ID	Research Question	Motivation
RQ1	How is the concept of digital human capital developed in the context of rural economies based on previous literature?	To identify the definition, scope, and main dimensions of digital human capital that are relevant to rural communities and rural economies.
RQ2	What factors support and hinder the development of digital human capital in rural areas?	To identify key factors such as digital infrastructure, digital literacy, affordability of access, social support, policy, and local institutional capacity.
RQ3	How does educational transformation contribute to improving digital literacy, skills, and competencies among rural communities?	To examine the contribution of formal education, non-formal education, community training, libraries, coding clubs, digital mentoring, and technology-based learning in developing digital skills.
RQ4	How does the development of digital human capital contribute to labor market readiness in rural economies?	To explain the relationship between digital literacy, digital work skills, entrepreneurship, access to employment, income growth, and rural community participation in the digital economy.
RQ5	What are the roles of government, educational institutions, communities, and businesses in building an inclusive digital ecosystem for rural economies?	To examine the importance of multi-stakeholder collaboration in developing infrastructure, digital culture, training, place-based policies, and inclusive digital services.

Search Results

To address the research questions described above, the authors conducted a literature search in a widely used scholarly database using specific search keywords. The keywords used were: “digital human capital” OR “educational digitalization” OR “digital skills” AND “rural economy” OR “local development” OR “rural community”. The initial search generated 57 relevant articles from the Scopus database. Inclusion and exclusion criteria were then applied to select the primary studies for review. The articles that met these criteria were subsequently reviewed and analyzed by the authors. The inclusion and exclusion criteria are presented in Table 2.

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	I1	Articles containing the keywords “digital human capital” OR “educational digitalization” OR “digital skills” AND “rural economy” OR “local development” OR “rural community”.
	I2	Articles that are fully accessible.
	I3	Articles written in English.
Exclusion Criteria	E1	Articles that do not contain the keywords “digital human capital” OR “educational digitalization” OR “digital skills” AND “rural economy” OR “local development” OR “rural community”.
	E2	Articles with restricted access.
	E3	Articles written in languages other than English.

After applying the filtering process based on the criteria above and the specified keywords, several journal articles were identified, as shown in Table 3. A total of 13 articles were obtained and selected for review in this study. The results of the filtering process are presented in Table 3.

Table 3. Distribution of Selected Articles by Research Question

ID	Database	Number of Articles
RQ1	<i>Scopus</i>	3
RQ2	<i>Scopus</i>	3
RQ3	<i>Scopus</i>	3
RQ4	<i>Scopus</i>	2
RQ5	<i>Scopus</i>	2

RESULTS AND DISCUSSION

The discussion in this study focuses on the development of digital human capital in the context of rural economies, particularly its relationship with educational transformation and labor market readiness. Based on the article selection process using the PRISMA method, 13 relevant articles were identified as the main sources for synthesis. These articles were analyzed to answer five research questions, namely the concept of digital human capital in rural areas, the factors that support and hinder its development, the role of educational transformation in improving digital literacy and digital skills, its contribution to labor market readiness, and the roles of government, educational institutions, communities, and businesses in building an inclusive digital ecosystem. Thus, the results and discussion section presents a systematic synthesis of the literature to provide a comprehensive understanding of the importance of digital human capital as a foundation for educational transformation and rural economic development in the digital era.

Table 4. Summary of Related Research Publications.

No	Article Title	Researchers	Theory Used	Findings	Main Insight
1.	Rural connectivity inequalities in Finland and Sweden: Evidence, measures, and policy reflections	Sameera Bandaranayake, Amirreza Moradi, Tanja Suomalainen, Harri Saarnisaari, Pasi Karppinen, Payal Gupta, Jaap van de Beek (2026)	A multidimensional digital divide framework and the Cellular Coverage Inequality (CCI) Index as a spatial key performance indicator.	Rural connectivity inequality in Finland and Sweden is not only related to network availability, but also to reliability, service quality, location, seasonal variation, and network performance.	Digital human capital in rural areas requires truly reliable infrastructure. Educational transformation and labor market readiness cannot be supported merely by internet access, but by connection quality that enables stable learning, work, and access to services.
2.	Bridging the digital divide: exploring the challenges and solutions for digital exclusion in rural South Africa	Gardner Mwansa, Matipa Ricky Ngandu & Zolisa Mkwambi (2025)	Van Dijk's Model of the Digital Divide and Sen's Capability Approach.	Evidence from Mkatazo, South Africa, indicates that the dominant factors of digital exclusion are cost, connectivity gaps, and geographical isolation.	Digital literacy will not be effective without a supportive environment. Rural labor market readiness needs to be developed through a comprehensive package that includes infrastructure, affordability, devices, and community-based digital training.
3.	Digital literacy's impact on digital village participation in rural left-behind women through serial mediation of political trust and self-efficacy	Xueyan Bai & Lin Yang (2025)	Socio-Technical Systems (STS) Theory, Stimulus-Organism-Response (SOR) Theory, and the mediating roles of political trust and self-efficacy.	Digital literacy increases the participation of rural left-behind women in digital village development, the digital economy, and digital governance. The effect of digital literacy is mediated by political trust and self-efficacy.	The development of digital human capital is not merely technical training, but also the development of trust, motivation, self-efficacy, and social support so that vulnerable groups can participate in the rural digital economy.
4.	Digital Transformation in Rural Hungary:	Dániel Fróna and Dorina	A rural digitalization framework, digital divide perspective,	Rural digitalization in Hungary increased during	Rural digital human resource development

No	Article Title	Researchers	Theory Used	Findings	Main Insight
	Infrastructure, Skills and Uptake Across Regions	Fróna-Hadas (2025)	place-based policy, and a region-based digital transformation approach.	2010–2024, yet regional differences remain. Internet access increased after 2020, but disparities are still influenced by affordability, digital competence, service quality, local institutional capacity, and regional ability to convert access into productive use.	should be place-based. Rural areas need policies that combine last-mile infrastructure, affordability, training, local institutional support, and the strengthening of digital work skills.
5.	Digital participation with the help of participatively developed information and counselling concepts – A qualitative study with the elderly	Marielle Schirmer, Denny Paulicke, Dietrich Stoevesandt, Patrick Jahn (2025)	No formal theory is explicitly emphasized; the study uses a participatory research approach, digital participation, and information/counselling needs for older adults in rural health services.	Older adults in rural areas feel left behind in the digitalization of health and care services. They lack practical experience, information, and mentoring. The information most needed is delivered personally through face-to-face encounters and trusted figures.	Rural digital transformation must pay attention to older adults. Digital education needs to be designed participatively, based on lived experience, and supported through interpersonal mentoring to avoid creating new forms of exclusion in health and social services.
6.	Exploring the Dynamic Impact of Digital Financial Literacy on Rural Household Income: New Evidence from China	Yue Yu, Wenjing Li, Huarong Li, Shuming Luo and Yan Liu (2025)	Digital financial literacy as digital human capital, social capital mechanisms, and the moderating role of regional financial development.	Digital financial literacy has a significant positive effect on rural household income in China. This effect occurs through increased social capital and is influenced by the level of regional digital financial development.	Labor market and rural economic readiness can be strengthened through digital financial literacy. Digital human capital is not only the ability to use technology, but also the ability to use technology for financial access, income growth, and economic mobility.

No	Article Title	Researchers	Theory Used	Findings	Main Insight
7.	Women's Digital Literacy in Village Information System Use	Mite Setiansah, Nuryanti, Edi Santoso, Kilau Riksaning Ayu (2024)	A four-pillar digital literacy framework: digital skills, digital security, digital ethics, and digital culture; situated in the context of e-governance and Village Information Systems (SID).	Women in Randegan Village, Banyumas, have begun to develop basic digital literacy, especially community leaders. However, awareness of digital security and ethics has not always been translated into practice. Traditional communication is still preferred, and women's participation in SID management remains limited.	The Indonesian case shows that village information systems do not automatically increase participation. Comprehensive digital literacy is needed, including security, ethics, digital culture, and women's involvement in digital village governance.
8.	Perceptions of Digital Economy Opportunities in Diverse Rural Areas in Czechia by Rural Women Leaders	Jana Kouřilová, Martin Pěluha, Aleksander Shemetev and Martina Kubíková (2024)	A digital divide framework, an urban-rural relationship perspective, and a gender perspective in rural development and the digital economy.	Rural women leaders in Czechia view digitalization as beneficial, particularly for accelerating communication. However, they also identify barriers such as weakening social ties, unequal ICT infrastructure, and limited digital skills, especially among older adults.	Rural economic digitalization must balance digital efficiency and social cohesion. IT skills development should be provided for all residents, not only for productive-age or highly educated groups.
9.	Starting from 'scratch': Building young people's digital skills through a coding club collaboration with rural public libraries	Wayne Kelly, Brian McGrath, Ireland Danielle Hubbard (2023)	Digital divide, digital literacy, community-based research (CBR), community capital/social capital, and the CoderDojo/coding club model.	Coding clubs based in public libraries in rural Manitoba, Canada, were able to develop young people's digital skills. The success of the program was influenced by library leadership, skilled volunteers, community partnerships, device access, and peer learning.	Libraries and community institutions can serve as centers for developing rural digital human capital. Young people's digital labor market readiness can be developed through coding clubs, mentoring, peer learning, and local collaboration.
10.	A policy-level perspective to	Sharon Wagg, Boyka	Activity Theory (AT). This theory is used to	Rural digital inclusion	The development of digital human

No	Article Title	Researchers	Theory Used	Findings	Main Insight
	tackle rural digital inclusion	Simeonova (2022)	understand the complexity of delivering rural digital inclusion initiatives through activity elements such as tools, rules, community, division of labor, and contradictions.	initiatives in the United Kingdom involve multiple stakeholders, especially national organizations and intermediary organizations that provide digital skills training and support. However, the process faces barriers such as limited knowledge sharing, poor connectivity quality, limited funding, lack of local resources, assumptions that organizations will automatically collaborate, and assumptions that intermediary organizations have sufficiently skilled and confident staff to provide digital training in rural contexts.	capital in rural areas cannot rely solely on individual training programs. It must be supported by clear policies, inter-institutional coordination, knowledge-sharing mechanisms, sustainable funding, and capacity building for local organizations. This article is important for SLR because it emphasizes that rural digital readiness is strongly influenced by policy governance and the quality of the supporting ecosystem.
11.	The Rural Digital Divide in the Face of the COVID-19 Pandemic in Europe—Recommendations from a Scoping Review	Miguel-Ángel Esteban-Navarro, Miguel-Ángel García-Madurga, Tamara Morte-Nadal and Antonia-Isabel Nogales-Bocio (2020)	A digital divide framework with two main dimensions: access and connectivity, and use and exploitation. The article also employs a PRISMA-based scoping review approach.	The COVID-19 pandemic exposed the digital vulnerability of rural communities in Europe. A review of 28 key documents shows that the rural digital divide is not only a matter of internet networks, but also skills, the use of digital services, public policy, community empowerment, and the ability to use technology for education, health, work, and entrepreneurship. The article formulates short-	In the context of digital human capital, this article emphasizes that rural communities need both digital access and the ability to use technology to survive and grow during crises. Educational transformation should be directed toward applied digital literacy, digital communication skills, and the strengthening of rural entrepreneurship.

No	Article Title	Researchers	Theory Used	Findings	Main Insight
				and medium-term recommendations, including strengthening connectivity, digital literacy, public policy evaluation, and advanced digital skills training.	
12.	Digital transformation challenges: strategies emerging from a multi-stakeholder approach	Federico Brunetti, Dominik T. Matt, Giulio Pedrini, Guido Orzes (2020)	A place-based multi-stakeholder approach, regional innovation system, digital ecosystem, and the triple helix model involving companies, government, and education/research institutions.	Digital transformation in the Tyrol–Veneto region requires a systemic strategy involving multiple stakeholders. Interviews with 60 stakeholders generated three main pillars: culture and skills, infrastructures and technologies, and ecosystems. The article emphasizes that a single intervention is insufficient; digital transformation requires digital culture, digital education, talent, infrastructure, technology, partnerships, long-term vision, and improved quality of life.	Digital labor market readiness is not determined only by individuals, but also by the regional ecosystem. Education, government, and business actors must collaborate to develop digital skills, innovation culture, and partnerships so that rural or semi-rural regions are able to face labor market changes.
13.	Using Internet technologies in rural communities to access services: The views of older people and service providers	Heidi Hodge, Doris Carson, Dean Carson, Lareen Newman, Jaimee Garrett (2017)	A digital divide framework, digital participation, and social network analysis (SNA) to examine digital interactions between rural older adults and service providers.	Older adults in Clare, South Australia, are interested in learning to use the internet to access health, financial, educational, administrative, and social services. However, their digital engagement is influenced by social support,	Rural digital transformation must consider vulnerable groups, particularly older adults. Digital education should be based on mentoring, social networks, and local facilitators. Digital readiness should not be assessed only by

No	Article Title	Researchers	Theory Used	Findings	Main Insight
				third-party facilitators, self-confidence, internet skills, costs, and digital service design. Service providers often hold stereotypes that older adults are unable or unwilling to use online services, while also facing limited digital skills, organizational capacity, and funding.	internet availability, but also by the suitability of digital services for users' needs.

RQ1: How is the concept of digital human capital developed in the context of rural economies based on previous literature?

The literature review indicates that the concept of digital human capital in rural areas has shifted in meaning, from being initially associated merely with infrastructure access to being understood as the capability to use technology productively, safely, critically, and participatively. This shift confirms that digital human capital is a multidimensional asset that integrates technical skills with the social, psychological, ethical, and cultural readiness of local communities. In the context of empowerment, Bai and Yang (2025) emphasize that digital literacy serves as a crucial foundation for rural women's participation in the digital village ecosystem, particularly by strengthening self-efficacy and political trust. The relevance of this dimension is further reinforced by Setiansah et al. (2024) in their study of the Village Information System (SID), which maps digital competence into four main pillars: digital skills, digital safety, digital ethics, and digital culture. These multidimensional characteristics are consistent with the global digital literacy framework proposed by Law et al. (2018), which states that comprehensive digital competence should include the ability to use technology creatively, critically, and safely to support life, learning, and work activities.

Furthermore, digital human capital in the rural sector functions as a strategic economic asset that directly contributes to improving household welfare and income. Yu et al. (2025) found that mastery of digital financial literacy significantly increases rural household income by optimizing modern financial services and strengthening social capital networks. This finding also validates the argument of Lythreatis et al. (2022) that addressing the digital divide no longer depends solely on access to hardware, but rather on communities' capacity to convert digital access into tangible economic value. Therefore, strategies for developing digital human capital in rural areas require a holistic approach; they should not only focus on the provision of physical facilities, but must also be strengthened through formal educational transformation, community-based training, and inclusive mentoring for vulnerable groups. Ultimately, the accumulation of these capabilities serves as a key foundation for bridging educational transformation and ensuring adaptive rural labor-market readiness in the digital economy era..

RQ2: What factors support and hinder the development of digital human capital in rural areas?

Digital human capital in rural areas is primarily held back by limited infrastructure, weak connectivity, and persistent spatial gaps. Bandaranayake et al. (2026) highlight that connectivity shortfalls affect rural areas even in digitally advanced countries, demonstrating that national statistics often obscure local connectivity problems. Therefore, digital access in rural regions must be assessed on the basis of quality, stability, and usability, not merely on presence or absence. As Lythreatis et al. (2022) note, these three dimensions access, use, and outcomes define the digital divide. Structural barriers such as high costs, limited device ownership, low digital literacy, and weak institutional support further compound rural digital exclusion (Mwansa et al., 2025). The International Telecommunication Union (2024) report confirms that deep-rooted differences in geography, income, and education drive the persistent gap in internet use between urban and rural areas, underlining the urgent need to address these barriers as a precondition for rural digital advancement.

Conversely, the acceleration of digital human capital in rural areas is strongly driven by positive perceptions of technological benefits, the strengthening of digital competencies, place-based policies, and the active participation of local actors. For instance, Kouřilová et al. (2024) found that rural women leaders in Czechia perceived digitalization as a strategic opportunity to accelerate communication and support regional development, while also anticipating the risks of weakened social ties and unequal access among older adults. This finding suggests the need for a balanced approach that combines the provision of physical infrastructure with the strengthening of human capacity through inclusive education. In line with this principle, the FAO (2024), through its Digital Villages Initiative, emphasizes the importance of rural digital transformation that empowers farmers, small business actors, and local communities to support regional economic circulation. Thus, the most critical enabling factors are not merely the adoption of advanced technologies, but the synergy among digital education, social support, inclusive policies, and community engagement in converting internet access into tangible economic and social benefits.

RQ3: How does educational transformation contribute to improving digital literacy, skills, and competencies among rural communities?

Educational transformation in rural areas is essential for promoting digital inclusivity, especially for vulnerable groups. Synthesis results show that such transformation embodies lifelong learning by blending formal education, non-formal training, community mentoring, and local needs-based programs. This approach is particularly vital for older rural populations, who often face barriers such as limited experience and technological anxiety. Schirmer et al. (2025) note that as public sector digitalization accelerates, improving digital skills among older adults becomes critical. To address this, digital education should be participatory, practical, and involve trusted local actors. Hodge et al. (2017) support this by highlighting older adults' motivation to use technology for essential services if aided by social and institutional support. By restructuring learning models in this way, educational initiatives can empower rural residents to become independent, confident technology users instead of passive consumers.

Educational transformation also strategically accelerates the development of young people's digital skills in rural areas by leveraging social institutions. Kelly et al. (2023) show that shifting digital education from formal schools to community-based settings, such as public libraries using the CoderDojo model in rural Manitoba, improves both technical and soft skills among youth. This non-formal model fosters programming, problem-solving, creativity, collaboration, and digital

leadership through peer support and volunteers. Detlor et al. (2022) emphasize community-based digital training as especially effective for local needs. On a broader scale, such a transformation builds inclusive, intergenerational digital human capital, aligning with FAO's commitment to rural development. Ultimately, broad digital inclusion is vital for community capacity, expanded access, and readiness for digital economy shifts (Hernandez et al., 2024).

RQ4: How does the development of digital human capital contribute to labor market readiness in rural economies?

The development of digital human capital significantly enhances rural labor market readiness by transforming communities' capacity to access and use technology for productive economic activities. Digital skills have become a crucial prerequisite, as technological penetration has restructured work patterns, production systems, the agricultural sector, and public service governance in rural areas. In this context, Fróna and Fróna-Hadas (2025) emphasize that the success of rural digitalization should not rely solely on the availability of physical infrastructure, but also on improving digital skills and strengthening local institutional capacity to transform internet access into meaningful use. To adapt to this disruption, rural communities need holistic qualifications. Van Laar et al. (2017) argue that 21st-century digital skills must integrate technical abilities with information, communication, collaboration, creativity, critical thinking, and problem-solving skills, all of which are essential for a digital-based labor market.

Digital human capital creates new job opportunities and helps rural businesses diversify. It also increases access to wider markets and boosts remote work. This need has grown since COVID-19. Esteban-Navarro et al. (2020) highlight that advanced digital skills training supports entrepreneurship, social communication, and the economic power of rural communities. However, the economic benefits come only when people actively use these skills. Salemink et al. (2017) note that only then can technology bring real social and economic gains to local communities. Digital human capital also helps protect low-skilled rural workers from being left out of the labor market by automation. The OECD (2019) says digital-age readiness needs both tech skills and strong cognitive and social skills. Therefore, digital human capital links education changes to rural workforce flexibility and competitiveness.

RQ5: What are the roles of government, educational institutions, communities, and businesses in building an inclusive digital ecosystem for rural economies?

The literature review confirms that realizing an inclusive rural digital ecosystem requires a systematic, place-based, multi-stakeholder approach rather than isolated, unilateral interventions. Brunetti et al. (2020) identify three essential pillars in this transformation: culture and skills; infrastructure and technologies; and ecosystems. Within this framework, each actor carries specific but interconnected responsibilities: the government coordinates policy and basic infrastructure; educational institutions facilitate talent development and a culture of lifelong learning; businesses promote the adoption of business innovation and job creation; while local communities function as social spaces that ensure technology use is aligned with people's actual needs. However, through Activity Theory, Wagg and Simeonova (2022) caution that multi-stakeholder synergy often faces structural constraints, such as barriers to knowledge sharing, limited funding, and the misconception that interorganizational collaboration will occur automatically. Therefore, the success of such partnerships requires structured formal coordination, clearly articulated roles, and sustainable funding mechanisms.

At the broader level, the sustainability of digital systems in rural areas largely depends on how technology works with local social structures. As Salemin et al. (2017) note, simply providing information and communication technology (ICT) is not enough unless people use it and benefit from it in their lives. This focus on ecosystem management is also supported by Bonina et al. (2021), who argue that digital platforms work well for development only when they align with local groups, leaders, and ways of life. For sustainable development, the smart village idea is a strategic approach because it leverages ICT in ways that align with the features of rural communities (Zhang & Zhang, 2020). So, building digital skills in rural areas requires broad partnerships, where inclusive policies, expert knowledge, business ideas, and active community support work together to help them become more self-reliant.

CONCLUSION

Based on a synthesis of 13 articles using the PRISMA approach, this study concludes that the development of digital human capital is a fundamental foundation for educational transformation and labor-market readiness in rural economies. Digital human capital encompasses not only technical abilities in using devices and the internet, but also information literacy, digital financial literacy, digital safety, digital ethics, self-efficacy, social support, and the capacity of rural communities to transform technological access into economic and social benefits. The findings indicate that the development of digital human capital in rural areas still faces several barriers, including limited infrastructure, poor connectivity quality, affordability constraints, skills gaps, and weak institutional coordination. However, educational transformation through community-based training, digital mentoring, coding clubs, digital financial literacy, and lifelong learning can strengthen rural communities' capacity to participate in the digital economy, increase income, access public services, and respond to labor market changes. The implication of this study is that rural development policies should not focus solely on the provision of digital infrastructure, but also on strengthening community digital competencies through collaboration among government, educational institutions, local communities, and businesses. Future research is recommended to empirically test models of digital human capital development in rural areas using quantitative, qualitative, or mixed-method approaches, while also expanding the focus to vulnerable groups such as women, older adults, smallholder farmers, rural MSME actors, and young people so that rural digital transformation strategies can be designed in a more inclusive, contextual, and sustainable manner.

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