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Revisiting Triple Helix Collaboration for Rural Empowerment through Appropriate Technology Village Cas

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Abstract

Rural development increasingly requires collaborative and context-sensitive approaches to transform local economic potential into sustainable community empowerment. However, limited attention has been given to how triple helix collaboration operates in village-level practices, particularly when linked to appropriate technology. This study examines the enactment of triple helix collaboration in rural community empowerment through appropriate technology in Tetehaka Village, Konawe Regency, Indonesia. A qualitative case study approach was employed, with data collected through in-depth interviews, observation, and documentation involving five purposively selected informants representing key stakeholders. Data were analyzed using an interactive process of reduction, display, and conclusion drawing. The findings indicate that although the core actors of the triple helix are present, their interaction remains fragmented, program-based, and insufficiently institutionalized. Appropriate technology has supported productive activities by improving efficiency and enabling basic digital practices; however, its impact is constrained by limited technological capacity, weak mentoring continuity, and insufficient coordination. The study highlights that sustainable rural empowerment depends not only on technology availability or actor presence but on the quality of collaboration, role alignment, and continuity of institutional support. This study contributes by extending triple helix theory into a rural village context and repositioning appropriate technology as an empowerment-oriented socio-technical instrument. It also proposes a context-sensitive collaboration model emphasizing structured coordination and continuous facilitation.

Keywords: Triple Helix Collaboration; Appropriate Technology; Rural Community Empowerment; Village Innovation; Collaborative Rural Governance

1. Introduction

Rural development is increasingly recognized as a critical pathway toward inclusive and sustainable growth, particularly in developing countries where rural communities still face structural constraints in transforming local economic potential into long-term empowerment (Monda et al., 2023). Despite the presence of natural resources and community-based economic initiatives, many villages struggle to achieve sustainable development due to limited institutional capacity, weak governance structures, and unequal access to technology and markets (Pawitan et al., 2025). Strategies such as strengthening local economic institutions, including village-owned enterprises (BUMDes), have demonstrated potential in mobilizing local resources and fostering entrepreneurship; however, their effectiveness is often constrained by financial limitations, managerial challenges, and weak institutional integration (Ridhowati, 2024). In addition, community empowerment efforts through participatory governance and capacity building have been widely promoted as mechanisms to enhance local agency and resilience, yet these approaches frequently lack coordination and continuity, thereby limiting their long-term impact (Adefila et al., 2024). These challenges suggest that rural development requires more integrative and adaptive approaches that go beyond conventional interventions (Yoganandham, 2024).

In response to these limitations, rural community empowerment increasingly demands collaborative frameworks that integrate governance capacity, knowledge production, and economic actors into a cohesive development system (Yu et al., 2024). The Triple Helix model, which emphasizes interaction among government, academia, and business, offers a robust conceptual foundation for fostering innovation and local development (Kosasih & Sulaiman, 2024). Empirical studies have demonstrated the applicability of this model in various contexts. For instance, in Indonesia, the Triple Helix has been utilized to strengthen innovation ecosystems in villages and MSME sectors, although coordination challenges remain (Rares et al., 2023). Similarly, research in Latin America

highlights the role of university-driven entrepreneurship in local development, while also pointing out institutional fragmentation and financial sustainability issues (Supriadi et al., 2025). In Europe, studies in Portugal and the United Kingdom show that collaborative innovation among universities, industries, and local governments can enhance rural entrepreneurship and competitiveness, particularly when supported by long-term policies and knowledge exchange mechanisms (Leydesdorff, 2020). These findings collectively indicate that while the Triple Helix model has strong potential in stimulating rural innovation, its effectiveness depends heavily on the quality of coordination, institutional alignment, and sustainability of collaboration (Zadegan et al., 2025).

Alongside collaborative governance, the role of appropriate technology (AT) has become increasingly significant in rural transformation. Unlike conventional technological approaches that prioritize sophistication, AT emphasizes contextual relevance, affordability, and usability, making it more suitable for rural environments (Imaduddin & Firdaus, 2025). Empirical evidence suggests that AT can enhance agricultural productivity, reduce labor intensity, and improve community welfare when aligned with local needs (Martins & Hukampal Singh, 2023). However, the implementation of AT often faces significant barriers, including limited infrastructure, low technological literacy, and insufficient institutional support (Nipo et al., 2024). Moreover, the effectiveness of AT is closely linked to the presence of enabling systems such as training, mentoring, and policy support, which are often unevenly distributed across rural areas (Xu et al., 2025). Consequently, while AT holds strong potential as a driver of rural empowerment, its success is contingent upon the integration of technological, institutional, and social dimensions (Nwaichi et al., 2024).

State-of-the-art international research has increasingly emphasized that rural innovation and community empowerment are shaped by multi-actor collaboration, social innovation processes, and locally embedded technological practices. Studies have highlighted the importance of collaborative governance in fostering rural innovation ecosystems, particularly through multi-helix interactions involving public, private, and knowledge institutions (Zadegan et al., 2025). Additionally, research on rural innovation systems demonstrates that innovation in rural areas is often influenced by local networks, external knowledge flows, and institutional support structures, rather than solely by technological inputs (Teixeira et al., 2025). Furthermore, recent studies on digital rural development indicate that while digital technologies can expand access to markets and information, their impact remains limited without strong institutional coordination and community capacity (Fitriana et al., 2025). However, despite these advancements, existing literature has predominantly focused on macro-level policy frameworks, urban-industrial innovation systems, or digital transformation programs, with limited attention to micro-level, village-based collaborative empowerment models that integrate appropriate technology within a triple helix framework (Nowak, 2024).

This gap is particularly important because it highlights the lack of empirical understanding of how triple helix collaboration operates in everyday village development practices, how appropriate technology is socially embedded within community empowerment processes, and why collaboration among actors often fails to become institutionalized and sustainable (Olsen, 2021). While prior studies have acknowledged the importance of multi-actor collaboration, they have not sufficiently explored the interaction dynamics at the village level, where institutional capacity, social relations, and local contexts play a crucial role in shaping development outcomes (MASTIKA et al., 2025). As a result, there remains a need for context-specific studies that examine the interplay between collaboration, technology, and empowerment in rural settings (Karta, 2022).

The case of Tetehaka Village in Konawe Regency provides a relevant empirical context to address this gap. The village exhibits the presence of key actors involved in rural development, including local government, community-based economic groups, and external facilitators, alongside the initial adoption of appropriate technology in productive activities. At the same time, the village also reflects common challenges found in rural areas, such as fragmented collaboration, limited coordination, and insufficient institutional support. These characteristics make Tetehaka Village an appropriate case for examining how triple helix collaboration and appropriate technology interact in shaping rural empowerment processes.

Therefore, this study aims to analyze how triple helix collaboration is enacted in rural community empowerment through the utilization of appropriate technology in Tetehaka Village. Specifically, the study seeks to identify the roles and interactions of key actors, examine the challenges that hinder effective collaboration and technology adoption, and develop an empirically grounded model of collaborative empowerment that is applicable to rural contexts.

This study contributes to the existing literature in three important ways. First, it extends the application of triple helix theory into a rural village context, thereby addressing the gap between macro-level innovation theory and micro-level rural practice. Second, it repositions appropriate technology as an empowerment-oriented socio-technical instrument rather than merely a technical tool. Third, it provides practical insights for policymakers, village governments, and development practitioners by proposing a context-sensitive model of collaboration that can strengthen sustainable rural development pathways.

2. Research Methods

This study employed a qualitative approach with a case study design to examine the dynamics of triple helix collaboration in rural community empowerment through appropriate technology. The case study focused on Tetehaka Village, Konawe Regency, Southeast Sulawesi, Indonesia, which was purposively selected due to its relevance to agriculture-based economic activities and the presence of multiple stakeholders, including local government, community-based economic groups, and external facilitators. This setting provides a suitable context for analyzing collaboration patterns, technology utilization, and empowerment processes in real-life conditions.

The study focused on the suboptimal implementation of triple helix collaboration involving government, knowledge actors, and community-based economic actors, particularly in relation to the use of appropriate technology. The analysis covered collaboration patterns, actor roles, technological practices, implementation challenges, and the formulation of a context-sensitive empowerment model.

Participants were selected using purposive sampling to ensure relevance and depth of information. Five key informants representing the core elements of the triple helix and local stakeholders were involved in the study.

Table 1. Characteristics of Research Participants

Informant Code	Role/Position	Institutional Affiliation	Relevance to Study
I1	Village Head	Local Government	Policy and coordination of village development
I2	BUMDes Manager	Village-Owned Enterprise	Economic management and local business operations
I3	Farmer Group Leader / Entrepreneur	Community	Direct user of appropriate technology
I4	Academic / Village Facilitator	External Institution	Knowledge transfer and technological assistance
I5	Government Representative	District/Agency	Policy support and institutional coordination

Data Collection and Sources 2026

Data were collected through in-depth interviews, observation, and documentation. Semi-structured interviews were conducted to explore participants' perspectives on collaboration practices, technology utilization, and empowerment processes. Observations were used to capture real-life activities, interactions among actors, and the use of appropriate technology, while documentation provided supporting evidence from institutional records, village data, and policy documents.

The study utilized both primary and secondary data sources. Primary data were obtained directly from participants and field observations, while secondary data included village profiles, development reports, and relevant literature. The combination of these sources enabled triangulation and strengthened the contextual validity of the findings.

Data analysis was conducted using an interactive and iterative process, involving data reduction, data display, and conclusion drawing. The analysis focused on identifying patterns, relationships, and key themes related to

collaboration, technology use, and empowerment. To ensure trustworthiness, the study applied source and method triangulation, prolonged engagement in the field, and member checking to validate interpretations. These strategies enhanced the credibility, consistency, and reliability of the findings.

3. Results and Discussions

This study reveals that triple helix collaboration in Tetehaka Village has emerged as a functional yet fragmented mechanism for rural community empowerment through appropriate technology. While interactions among local government, academia, and community-based economic actors are present, the collaboration remains insufficiently institutionalized, resulting in partial implementation and limited sustainability. The findings are organized into four key themes: collaboration patterns, technology utilization, actor roles, and implementation barriers, followed by a synthesized model of effective collaboration.

Triple Helix Collaboration Patterns

The findings indicate that collaboration among government, academic actors, and local economic stakeholders exists but remains predominantly program-driven rather than structurally embedded. The village government acts as a primary initiator and facilitator, establishing connections with external actors to support agricultural development and community capacity building.

However, the collaboration lacks formal integration mechanisms, such as structured coordination frameworks, clearly defined role distribution, and continuous evaluation processes. As a result, collaborative activities are largely episodic and dependent on external interventions rather than sustained institutional partnerships.

From the perspective of the village-owned enterprise (BUMDes), collaboration is primarily operational, focusing on marketing support and economic facilitation. Meanwhile, community members perceive collaboration as external assistance rather than participatory engagement in decision-making or innovation processes. This indicates that collaboration is still positioned at an early developmental stage, characterized by interaction without full synergy.

Utilization of Appropriate Technology

The study finds that appropriate technology has been introduced and partially adopted in both agricultural and economic activities. The technologies employed are generally simple, practical, and aligned with local needs, emphasizing efficiency and productivity rather than technological sophistication.

In agricultural practices, tools such as planting machines and post-harvest processing equipment have significantly reduced manual labor and improved production efficiency. In addition, digital tools have been introduced at the organizational level, particularly in financial recording and product marketing via social media platforms.

Despite these advancements, technology adoption remains uneven. Many community members are still in the early stages of technological adaptation, with limited capacity in operation, maintenance, and further development. The findings suggest that technology effectiveness is strongly dependent on continuous support and contextual adaptation rather than mere availability.

Roles of Actors in Community Empowerment

Each actor within the triple helix framework performs a distinct yet interconnected role. The village government functions as a facilitator and coordinator, mobilizing resources and enabling collaboration. BUMDes acts as an intermediary institution linking production and market access, although its strategic role remains underdeveloped.

Community members and farmer groups serve as direct implementers of technology, demonstrating openness to innovation when it aligns with their practical needs and is supported by adequate guidance. Academic actors and facilitators play a critical role in knowledge transfer, training, and technological adaptation, bridging the gap between technical knowledge and local practices.

Government agencies at higher administrative levels provide policy support and technical assistance. However, their involvement is not yet fully synchronized with local needs, limiting the overall effectiveness of institutional support.

Barriers to Collaboration and Technology Implementation

The findings identify multiple interrelated barriers affecting the effectiveness of collaboration and technology utilization. These barriers are categorized into human, institutional, and systemic dimensions. The most prominent challenge is limited human resource capacity, particularly in technological literacy and operational skills. Although communities show willingness to adopt technology, their ability to sustain and develop its use remains constrained.

Another major barrier is the lack of program continuity. Many initiatives are implemented as short-term interventions without long-term mentoring, resulting in limited impact. In addition, weak coordination among stakeholders reduces the potential for integrated development efforts, as collaboration often occurs in isolation rather than through structured interaction.

Financial constraints and limited maintenance capacity further hinder technology sustainability. Cultural factors also play a role, as some community members exhibit reluctance to shift from traditional practices to new technological approaches.

Synthesis of Key Findings

Table 2. Summary of Key Findings on Triple Helix Collaboration and Technology Utilization

Theme	Key Findings	Implications
Collaboration Pattern	Fragmented, program-based, and non-institutionalized	Requires structured and long-term collaboration framework
Technology Utilization	Practical but limited and uneven adoption	Needs capacity building and continuous support
Actor Roles	Present but not fully integrated	Requires stronger role alignment and coordination
Barriers	HR limitations, weak coordination, lack of sustainability	Indicates systemic rather than technical issues

Proposed Model of Effective Triple Helix Collaboration

Based on the findings, an effective triple helix collaboration model should emphasize structured integration, role clarity, and sustainability. The model positions the community as the central actor, supported by appropriate technology as a functional tool, while collaboration serves as the driving mechanism.

Government actors should function as coordinators and enablers, academia as knowledge providers and innovators, and business/community actors as implementers and value creators. The model also highlights the importance of continuous mentoring, institutional strengthening, and multi-stakeholder coordination platforms.

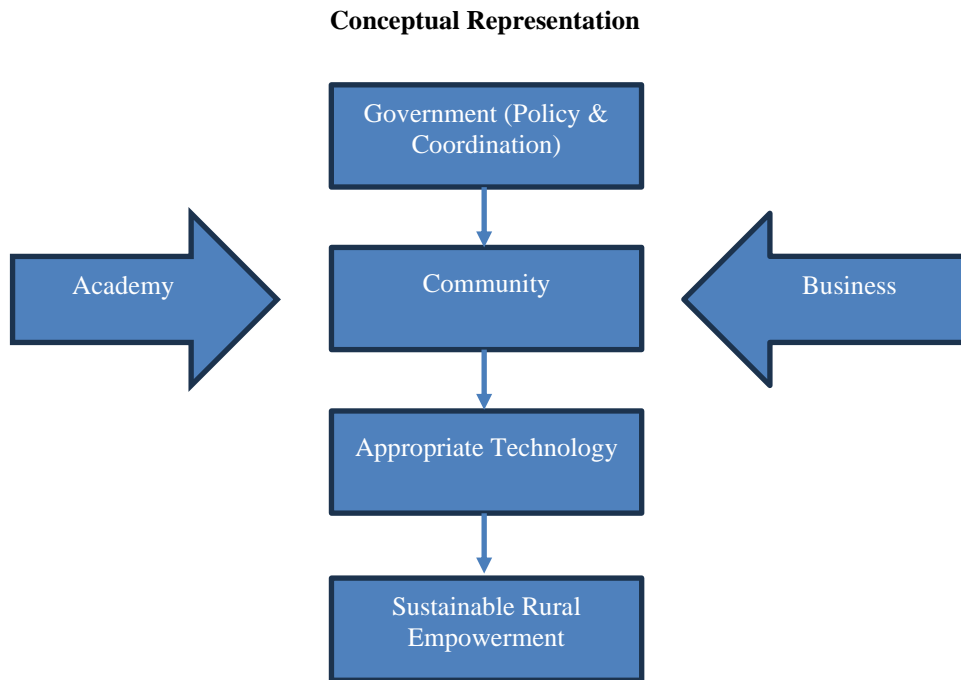


Figure 1. Integrated Triple Helix Collaboration Model for Rural Empowerment

The findings demonstrate that while the foundational elements of triple helix collaboration are present in Tetehaka Village, the system remains underdeveloped due to structural, human, and coordination-related limitations. The primary issue is not the absence of collaboration, but its lack of integration, continuity, and strategic alignment.

The study highlights that sustainable rural empowerment through appropriate technology requires not only technological access but also a well-coordinated collaborative ecosystem that integrates institutional roles, strengthens human capacity, and ensures long-term engagement among stakeholders.

Interpreting the Main Finding: Triple Helix Presence without Full Institutionalization

The present study shows that the core actors of the triple helix government, knowledge actors, and economic actors are already present in Tetehaka Village, yet their interaction has not matured into an institutionalized and durable collaborative arrangement. This distinction is important because triple helix theory does not merely refer to the coexistence of three sectors; rather, it emphasizes recursive interaction, mutual adjustment, and the co-production of innovation across organizational boundaries. In this sense, the findings suggest that the village has moved beyond actor isolation but has not yet reached a stage of embedded collaborative governance. The collaboration observed in Tetehaka is therefore better understood as an emerging configuration of innovation support than as a fully consolidated local innovation system (de Lima Figueiredo et al., 2023).

This interpretation is theoretically significant because it shifts the analytical focus from the mere presence of actors to the **quality of interdependence** among them. The empirical evidence indicates that village government, facilitators, community producers, and local enterprises interact around specific programs, but these interactions remain episodic, largely informal, and weakly institutionalized. Such a pattern is consistent with broader scholarship arguing that innovation in peripheral or less-favored regions often depends not only on actor diversity but also on the strength of coordination, shared agendas, and organizational anchoring. Without these elements, collaboration tends to remain transactional rather than transformative (Tandon & Sarin, 2025).

Triple Helix in Rural Contexts: Why Rural Collaboration Operates Differently

The findings also suggest that triple helix collaboration in rural settings should not be judged using assumptions derived from urban or industrial innovation ecosystems. Rural collaboration often develops under conditions of limited institutional density, constrained technical capacity, and stronger dependence on interpersonal trust and

local leadership. In such settings, innovation is frequently inspired by external knowledge but must be filtered through locally established networks and practical realities. This helps explain why the Tetehaka case exhibits early-stage collaborative interaction without yet achieving strong systemic integration (Bernard et al., 2023).

This rural specificity matters because it implies that the pathway to effective collaboration is not a simple replication of formal triple helix arrangements from metropolitan contexts. Rather, rural innovation tends to rely on bridging actors, localized problem solving, and incremental adaptation. Research on rural social innovation similarly shows that community-driven development depends on coordination among multiple helices, but the vitality of such coordination often comes from grounded local needs rather than from highly formalized institutional architectures. The present findings resonate with that perspective: collaboration in Tetehaka is meaningful because it has emerged around real livelihood needs, but it remains fragile because those needs have not yet been translated into a stable collaborative platform (Suazo-Galdames et al., 2025).

Appropriate Technology as an Empowerment Instrument Rather than a Technical Add-On

A central contribution of the findings lies in showing that appropriate technology in Tetehaka is not valued for sophistication, but for **usability, relevance, and immediate livelihood benefits**. The technologies identified in the study basic agricultural tools, post-harvest equipment, simple digital bookkeeping, and social media-based marketing unction primarily as enabling devices that reduce labor burden, improve operational efficiency, and extend market reach. This pattern is strongly aligned with the conceptual foundation of appropriate technology, which holds that technological effectiveness depends less on technical complexity and more on contextual fit, accessibility, and the capability of users to sustain its operation over time

The discussion therefore needs to move beyond a narrow instrumental view of technology. In the present study, appropriate technology works as a **vehicle of empowerment** only when it is embedded in learning, mentoring, and local institutional support. This is a critical point because technology alone does not transform rural livelihoods; transformation occurs when communities can understand, adapt, and appropriate technology in ways that strengthen agency and local economic control. Earlier work has similarly argued that appropriate technology can serve as a bridge toward sustainable development only when it contributes to empowerment, rather than merely delivering short-term technical solutions (Rahman & Jyoti, 2022). The Tetehaka findings reinforce this argument by showing that technology adoption remains partial when training, maintenance, and organizational follow-up are weak.

Actor Roles and the Problem of Role Misalignment

The study further demonstrates that each actor already occupies a recognizable position in the local empowerment process: the village government acts as facilitator and gatekeeper, BUMDes and producer groups operate as local economic conduits, academic or facilitation actors provide knowledge support, and external government agencies offer policy and program backing. However, the empirical problem is not role absence but **role misalignment**. The roles are present, yet they are not consistently synchronized around a shared developmental architecture. Triple helix scholarship has long emphasized that innovation emerges when institutional spheres partially assume and coordinate one another's functions without losing their distinctive identities. Where that overlap remains weak or uncoordinated, collaborative capacity is reduced (Sun et al., 2024).

In the Tetehaka case, the village government appears active but still operates mainly as a facilitator of access rather than as the architect of a sustained innovation ecosystem. BUMDes plays an intermediary economic role, but its strategic function as an innovation organizer remains underdeveloped. Communities are open to innovation, yet they are still positioned closer to program recipients than to co-designers of rural transformation. Academic and facilitation actors are important knowledge brokers, but their engagement appears periodic rather than continuously embedded. This pattern mirrors the broader literature on innovation intermediation, which argues that intermediary actors are crucial precisely because they connect fragmented interests, align resources, and stabilize collaboration across heterogeneous stakeholders (Rahman & Jyoti, 2022).

Barriers as Systemic Constraints, Not Isolated Technical Problems

One of the most important insights from the findings is that the barriers to empowerment in Tetehaka are systemic rather than merely technical. Limited technological literacy, weak continuity of assistance, insufficient

maintenance support, fragmented coordination, and cautious attitudes toward change are not isolated obstacles; together they form an interdependent set of constraints that dampen the transformative potential of collaboration. This is consistent with research showing that innovation failure in rural areas often stems from weak institutional embedding and insufficient support structures, not simply from a lack of tools or ideas (Chen et al., 2025)

The human capacity dimension is particularly decisive. The findings indicate that community members are not resistant to innovation per se; rather, they require continuous accompaniment to operate, maintain, and eventually internalize technological practices. This matters because rural innovation is cumulative and relational: users learn not just from devices, but from repeated interactions with facilitators, peer groups, and institutional supports. When programs are short-lived, adoption remains shallow. This helps explain why the technology observed in Tetehaka delivers immediate benefits yet has not produced deeper structural change in village economic organization (Gone, 2021; Prasetyo et al., 2022).

The digital component of the findings also deserves careful interpretation. The use of social media and basic digital administration indicates that digital tools can extend local opportunity structures, especially for marketing and communication. However, international evidence suggests that digital rural interventions often produce **positive but modest** outcomes when they are not supported by broader institutional ecosystems, digital literacy, and service diversification. Studies from Bangladesh and China, for instance, show that rural digital platforms can improve access, communication, and local development opportunities, yet their impact remains uneven when infrastructural and capability gaps persist (Bernard et al., 2023; Chen et al., 2025). This comparative insight helps position the Tetehaka findings within a wider rural digitalization debate: digital tools matter, but they do not substitute for collaborative capacity.

Toward an Effective Triple Helix Model for Rural Community Empowerment

Based on the present findings, an effective triple helix model for Tetehaka should be conceived not as a one-time project coalition, but as a **structured, community-centered, and continuously mediated collaboration platform**. In this model, village government should function as the local coordinator that articulates needs, aligns stakeholders, and secures continuity. Academic or facilitation actors should act as translators of knowledge into locally workable solutions. BUMDes and productive community groups should serve as economic drivers that convert innovation into measurable value creation. Most importantly, community members should occupy the center of the model, not as passive beneficiaries but as co-producers of local development. This interpretation extends the classic triple helix logic into a more grounded rural form that foregrounds institutional embeddedness and local usability (de Lima Figueiredo et al., 2023; Tandon & Sarin, 2025).

The proposed model also implies the need for a **coordination interface** whether in the form of regular forums, village innovation meetings, or institutionalized mentoring arrangements that allows actors to move from fragmented intervention to cumulative learning. This point is supported by work on innovation intermediaries, which shows that sustained innovation depends on actors or platforms capable of aligning expectations, brokering knowledge, and balancing diverse interests over time. In a rural context such as Tetehaka, BUMDes, village leadership, or trained facilitators could perform this intermediation role, provided they are supported with authority, skills, and continuity.

Positioning the Findings within Prior Research

The Tetehaka findings are broadly consistent with prior international research showing that rural innovation is rarely the product of a single intervention; rather, it emerges from the interaction of local institutions, knowledge exchange, community initiative, and adaptive support structures. The findings align with (Nordberg et al., 2020), who show that rural development benefits from multi-helix coordination rooted in community needs, and with Schmidt et al. (2022), who demonstrate that rurality shapes how innovation processes unfold, particularly by increasing dependence on external knowledge and existing local networks. At the same time, the present study adds a distinctive empirical contribution by showing how the logic of triple helix collaboration operates in a village setting where appropriate technology is modest in scale but strategically important for livelihood improvement.

The findings also complement research on technology-mediated rural development by suggesting that the success of digital and appropriate technologies should be evaluated not only through outputs, but through their role in strengthening community capability and institutional coordination. In that sense, this study is closer to

empowerment-oriented interpretations of technology than to diffusion-only accounts. It supports the argument that locally adapted technology contributes most when it is integrated with social learning, intermediary support, and participatory institutional arrangements (Sianipar et al., 2013)

Theoretical Contribution

Theoretically, this study contributes to the triple helix literature by showing that in rural contexts the central analytical issue is not whether government, knowledge actors, and economic actors are present, but whether their interaction becomes **embedded, coordinated, and sustained**. The study therefore supports a shift from actor-counting approaches to relational and processual interpretations of triple helix collaboration. In addition, it contributes to the literature on appropriate technology by demonstrating that technological relevance in rural development is inseparable from empowerment dynamics, especially user capability, institutional support, and iterative adaptation. Together, these insights suggest that rural innovation should be conceptualized as a socio-technical process in which collaboration quality and technological appropriateness are mutually constitutive (Carayannis & Eds, 2012; Nordberg et al., 2020; Sianipar et al., 2013)

Practical and Policy Implications

Practically, the findings imply that village empowerment strategies should prioritize long-term collaborative architecture rather than fragmented program delivery. For village governments, this means establishing clearer coordination routines, mapping actor roles, and linking technological support with institutional strengthening. For universities and facilitators, it means designing engagement models that privilege iterative mentoring over one-off training (Nordberg et al., 2020). For BUMDes and local producer groups, it means moving beyond operational roles toward stronger intermediation and market orchestration functions. For district-level agencies, it means aligning sectoral interventions so that rural empowerment is delivered as an integrated ecosystem rather than as separate administrative initiatives. These implications are consistent with the broader international evidence that rural innovation gains durability when collaborative governance and intermediary capacity are deliberately cultivated (Natário et al., 2012)

4. Conclusion

This study offers several theoretical implications for the literature on rural development, triple helix collaboration, and appropriate technology. First, the findings suggest that the application of triple helix theory in rural settings should not be understood merely in terms of the presence of government, academic, and business actors. Instead, greater analytical emphasis should be placed on the quality of interaction, continuity of engagement, and institutional embeddedness among these actors. In the context of Tetehaka Village, the findings demonstrate that actor presence alone does not automatically generate an effective innovation ecosystem. What matters more is whether collaboration is structured, mutually reinforcing, and sustained over time. Second, this study contributes to the literature on appropriate technology by showing that its developmental value lies not only in technical utility, but also in its ability to function as a socio-technical instrument of empowerment. Appropriate technology becomes meaningful when it is relevant to local needs, understandable to users, and supported by institutional arrangements that enable learning, maintenance, and adaptation. This perspective broadens the understanding of technology in rural development from a tool-centered approach to an empowerment-centered approach. Third, this study enriches rural innovation scholarship by demonstrating that community empowerment emerges from the intersection of technology, institutional support, and collaborative governance. Therefore, rural innovation should be conceptualized not as a purely technological or economic process, but as a relational and context-sensitive process shaped by social interaction, local capacity, and coordinated support.

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