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Socio-Technical Transformation of Rural Agriculture: Community-Based Coffee Agroforestry Innovation in Girimekar Village

Transformasi Sosio-Teknis Pertanian Pedesaan: Inovasi Agroforestri Kopi Berbasis Komunitas di Desa Girimekar

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ABSTRACT

This study examines socio-technical transition and community-based innovation in Girimekar Village, focusing on how local actors respond to ecological pressures, institutional change, and economic opportunities. Using a qualitative case study, the research analyzes the transition from conventional vegetable farming to coffee-based agroforestry. Data were collected through in-depth interviews with farmers, village officials, Perhutani representatives, youth groups, and facilitators, plus participatory observation and analysis of village documents. The analysis combines the multi-level perspective, which explores interactions between niche, regime, and landscape levels, with actor-network theory, which captures relational dynamics between human and non-human actors. The findings show that the transition is not simply a change in crops but a broader socio-technical reconfiguration shaped by collective learning, hybrid knowledge systems, improved land-access arrangements, and strengthened actor networks. Coffee functions as a niche innovation that stabilizes through local experimentation, ecological suitability, and expanding markets, while PHBM schemes and village programs facilitate integration into everyday production. This study contributes to socio-technical transition literature by demonstrating how rural innovation in Indonesia emerges through negotiated community-based processes. Unlike work emphasizing technological adoption, it highlights the relational and territorial dimensions through which local knowledge, collaborative governance, and agroforestry collectively shape sustainable rural transformation.

INFO ARTIKEL

Kata kunci:

teori jaringan aktor, inovasi berbasis komunitas, perspektif multilevel, inovasi pedesaan, sosio-teknis

ABSTRAK

Penelitian ini mengkaji transisi sosio-teknis dan inovasi berbasis komunitas di Desa Girimekar, dengan fokus pada bagaimana aktor lokal merespons tekanan ekologis, perubahan kelembagaan, dan peluang ekonomi. Melalui studi kasus kualitatif, penelitian menganalisis peralihan dari pertanian sayuran konvensional menuju agroforestri berbasis kopi. Data dikumpulkan melalui wawancara mendalam dengan

petani, aparat desa, perwakilan Perhutani, kelompok pemuda, dan fasilitator, serta observasi partisipatif dan analisis dokumen desa. Analisis mengombinasikan Multi-Level Perspective untuk menelusuri interaksi antara level niche, regime, dan landscape dengan Actor-Network Theory untuk menangkap dinamika relasional antara aktor manusia dan nonmanusia. Hasil penelitian menunjukkan bahwa transisi bukan sekadar perubahan komoditas, melainkan rekonfigurasi sosio-teknis yang lebih luas yang dibentuk oleh pembelajaran kolektif, sistem pengetahuan hibrida, perbaikan pengaturan akses lahan, dan penguatan jaringan aktor. Kopi berfungsi sebagai inovasi niche yang stabil melalui eksperimen lokal, kesesuaian ekologis, dan berkembangnya peluang pasar; sementara skema PHBM dan program desa memfasilitasi integrasi praktik baru ke dalam sistem produksi sehari-hari. Penelitian ini berkontribusi pada literatur transisi sosio-teknis dengan menunjukkan bahwa inovasi pedesaan di Indonesia muncul melalui proses negosiasi berbasis komunitas. Berbeda dari studi yang menekankan adopsi teknologi, penelitian ini menyoroti dimensi relasional dan teritorial di mana pengetahuan lokal, tata kelola kolaboratif, dan agroforestri secara bersama-sama membentuk transformasi pedesaan yang berkelanjutan.

Introduction

Most changes in rural areas emerge from the dynamic interaction between multiple pressures and opportunities that occur simultaneously. In this context, Girimekar Village reflects how social, ecological, and institutional dimensions interact in shaping local innovation processes. For decades, the village economy has relied heavily on vegetable farming; however, this system has gradually weakened due to dependency on chemical inputs, environmental degradation, market volatility, and increasing ecological pressures. Such conditions align with the concept of socio-technical regime destabilization, where previously stable systems become increasingly vulnerable and unable to provide certainty for actors (Geels, 2019). Recent studies also emphasize that agricultural systems under environmental stress tend to undergo transition when existing practices no longer ensure sustainability or economic viability (El Bilali, 2019; Köhler et al., 2019).

The pressure on the existing regime is further intensified by changes in environmental governance, sustainability discourses, and global market demand for environmentally friendly products. These landscape-level pressures create opportunities for alternative practices to emerge. In this regard, rural areas should not be seen as passive recipients of external change but as active spaces where local actors reinterpret and respond to pressures creatively (Steiner & Teasdale, 2019). As also highlighted in this study, Girimekar demonstrates how local stakeholders transform ecological and economic challenges into innovation opportunities, particularly through the transition toward coffee-based agroforestry.

The emergence of coffee cultivation in Girimekar is not solely driven by ecological degradation but also by the interaction of knowledge systems, social networks, and innovation actors. The increasing involvement of youth, the rise of coffee communities, and access to post-harvest knowledge have created a new socio-economic environment. Within the Multi-Level Perspective (MLP), such developments can be understood as niche innovations and protected spaces where actors experiment, learn, and develop alternative practices (Geels, 2020; Köhler et al., 2019). Successful niche development depends on learning processes, network building, and alignment with broader system changes, enabling innovations to gradually challenge and penetrate the dominant regime.

In Girimekar, innovation should not be understood merely as technological change but as a relational and social process involving diverse actors. Actor-network theory (ANT) provides a useful lens to explain this dynamic, emphasizing that innovation emerges from interactions between human and non-human actors within networks (Birke & Knierim, 2020; Castella et al., 2022). The transition from vegetable farming to coffee production thus represents not only a shift in commodities but also a reconfiguration of social relations, risk management strategies, local identities, and market linkages. This

perspective is consistent with recent literature that highlights the importance of socio-material relations in shaping rural innovation pathways (Polzin et al., 2016).

Furthermore, innovation in rural contexts is strongly rooted in social capital and local knowledge. Community-based innovation often emerges from the ability of local actors to mobilize existing knowledge, cultural practices, and collective action (Neumeier, 2017; Steiner & Teasdale, 2019). In Girimekar, traditional knowledge related to land management, seasonal patterns, and collective work systems combines with modern practices such as post-harvest processing and quality standardization. This results in what can be described as hybrid innovation, integrating traditional practices with modern market-oriented approaches. Such hybridization has been widely recognized as a key feature of sustainable rural innovation systems (Ollivier et al., 2018).

Institutional arrangements also play a critical role in enabling innovation processes. The PHBM (Joint Community Forest Management) scheme provides a collaborative governance framework that reduces land tenure uncertainty and enhances farmers' access to forest resources. Secure land access is widely acknowledged as a crucial factor in promoting agricultural innovation and long-term investment (Schling et al., 2026). Moreover, the presence of farmer groups, technical facilitators, and market networks strengthens the local innovation system by facilitating knowledge exchange and coordination among actors. This aligns with the concept of rural innovation systems, which emphasize multi-actor collaboration, institutional support, and interactive learning processes (Cascone et al., 2024).

Overall, Girimekar Village presents an important case of how community-based innovation emerges under conditions of pressure and uncertainty. The ongoing socio-technical transition illustrates that rural communities possess significant adaptive capacity when supported by opportunities for experimentation, learning, and collaboration. Understanding this process is essential not only for explaining transformations in local agrarian systems but also for informing more inclusive and context-sensitive rural development strategies. As shown in this research, innovation in Girimekar is not a linear process but a negotiated and evolving configuration shaped by ecological adaptation, institutional change, and collective action.

Socio-technical and Community-based Innovation

The literature highlights that the specific characteristics of rural areas play a significant role in shaping the emergence of social innovation. Rural contexts characterized by limited access to services, strong dependence on local resources, and cohesive social structures often present both constraints and opportunities for innovation. Rather than merely acting as barriers, these structural limitations can function as enabling conditions that encourage local actors to develop context-specific and community-based solutions. Recent studies emphasize that social innovation in rural areas is frequently driven by necessity, where local challenges function as catalysts for creative adaptation and collective problem-solving (Musinguzi et al., 2024; Steiner et al., 2023; Steiner & Teasdale, 2019). In this sense, what are often perceived as structural disadvantages can be transformed into productive capacities that foster resilience and innovation.

The pathways through which social innovation emerges are highly contextual and shaped by local conditions. Despite facing similar structural challenges, rural areas exhibit diverse innovation trajectories due to variations in resource availability, institutional arrangements, social capital, and actor capacity. This indicates that social innovation cannot be understood as a standardized or replicable model but rather as a place-based process influenced by the interaction between local needs, knowledge systems, and socio-institutional dynamics (Ollivier et al., 2018; Schling et al., 2026). As also reflected in this study, innovation in rural contexts emerges through negotiated processes involving multiple actors and adaptive responses to changing socio-ecological conditions.

Within a long-term development perspective, social innovation holds transformative potential, particularly when it can scale and influence governance structures. Transformation occurs not only at the level of local practices but also through its ability to reshape institutional arrangements and policy

frameworks. The concept of bottom-linked governance is particularly relevant, as it explains how grassroots initiatives can connect with higher-level institutions through participatory and collaborative processes. This form of governance enables the integration of local knowledge with formal institutional structures, contributing to more inclusive and sustainable development outcomes (Castro-Arce & Vanclay, 2020; Pel et al., 2020). Furthermore, participatory decision-making and power-sharing mechanisms are critical in fostering adaptive and responsive innovation processes, as they create space for collective learning and trust-building among actors.

However, the success of social innovation is often influenced by factors that lie beyond direct external control. Local socio-cultural dynamics, power relations, and institutional contexts shape the extent to which innovation can develop and be sustained. External interventions alone are insufficient to drive innovation if they do not align with local capacities and needs. Instead, policies should focus on creating enabling environments such as institutional flexibility, access to resources, and opportunities for experimentation that allow local actors to co-create solutions (Bosworth et al., 2016; Neumeier, 2017). This perspective reinforces the idea that social innovation is inherently endogenous and cannot be imposed through top-down approaches.

From a theoretical standpoint, social innovation can be understood as a process resulting from the interaction between agency, institutional structures, and broader socio-economic systems. Innovation emerges through the exchange of knowledge, mobilization of resources, and processes of social and institutional legitimation. Recent scholarship argues for an integrated analytical framework that combines agent-centered and structural perspectives to better capture the complexity of innovation processes in rural areas (Pel et al., 2020). Such an approach allows for a more nuanced understanding of how local actors navigate structural constraints while simultaneously shaping new development pathways.

In the context of socio-technical systems, innovation is not limited to technological change but involves the co-evolution of social practices, institutions, and technologies. Socio-technical arrangements produce what can be understood as dynamic and relational configurations, where knowledge, practices, and material elements continuously interact and evolve. These configurations shape how value is created, interpreted, and sustained within a network of actors. Contemporary studies highlight that innovation processes are embedded within these networks, where meaning and value are constructed through ongoing interactions between human and non-human elements (Polzin et al., 2016).

The actor-network theory (ANT) perspective further strengthens this understanding by emphasizing that both human and non-human actors play active roles in shaping socio-technical change. Innovation is therefore seen as the outcome of heterogeneous networks, where technologies, institutions, and social actors interact relationally and dynamically. Rather than being fixed entities, these elements are continuously constructed and reconfigured through practice. Recent applications of ANT in sustainability and agricultural innovation studies demonstrate that the success of innovation depends on the stability and alignment of these networks (Aka, 2025; Castella et al., 2022). Thus, socio-technical transitions in rural contexts should be understood as processes of network formation, negotiation, and stabilization involving multiple interacting actors.

Method

This study adopts a qualitative approach with a case study design to examine socio-technical transformation and the processes of community-based innovation in Girimekar Village. Qualitative case studies are particularly suitable for exploring complex social phenomena, as they allow researchers to capture meanings, practices, and interactions among actors within their real-life contexts (Yin, 2017). Village innovation, as a socio-technical process, cannot be fully understood through quantitative indicators alone but requires in-depth interpretation of actors' experiences, social relations, and institutional dynamics.

The research was conducted from 13 to 19 October 2025 in Girimekar Village, Cilengkrang Subdistrict, Bandung Regency. Data were collected using three primary methods: in-depth interviews, participatory observation, and document analysis. In-depth interviews were conducted with 15 informants consisting of representatives from the Girimekar Village Government, Village-Owned Enterprise (BUMDes), Tourism Awareness Group (Pokdarwis), Village Representative Body (BPD), youth organization (Karang Taruna), initiators and administrators of the Girisenang Forest Farmer Group (KTH Girisenang), the head of the Girisenang Forest Farmer Producer Cooperative, coffee farmers, local coffee milling business owners, surrounding community members, representatives from the Bandung Regency Agricultural Office, and PT Perhutani KPH Bandung Utara.

This approach enabled the collection of rich qualitative data regarding actors' perspectives, experiences, and interpretations of the innovation process. Interviews also provided insights into how actors exercise agency and negotiate change within the socio-technical system. Participatory observation was conducted through direct involvement in agricultural activities, farmer group meetings, and technical assistance sessions, allowing the researcher to capture actual practices and social interactions in situ. In addition, document analysis was conducted by reviewing village archives, program reports, policy documents, and farmer group records to strengthen the historical and institutional understanding of the case.

Data analysis was conducted using thematic analysis to identify patterns related to socio-technical transition processes, including actor roles, strategies, network relations, innovation dynamics, and changes in production systems. The coding process followed a systematic procedure involving open, axial, and selective coding to develop and refine analytical categories (Akramul Kabir, 2024; Nowell et al., 2017). To interpret the findings, the study employed the multi-level perspective framework to analyze interactions between niche, regime, and landscape levels (Geels, 2020; Köhler et al., 2019). This framework was complemented by actor-network theory, which enables the analysis of relational dynamics between human and non-human actors within the innovation process (Aka, 2025; Castella et al., 2022). The integration of these approaches allows the analysis to focus on socio-technical configurations as evolving and negotiated systems, rather than merely observing changes in commodities or production outputs.

To ensure the credibility and validity of the findings, this study applied data triangulation and method triangulation by cross-checking interview data with observations and documentary evidence (Yin, 2017). Member checking was also conducted with selected informants to validate the interpretations and ensure alignment with local meanings. Ethical considerations were carefully addressed by obtaining informed consent from participants, ensuring confidentiality of informant identities, and conducting research activities in a manner that did not disrupt local livelihoods. Through this methodological approach, the study aims to provide a comprehensive and in-depth understanding of how community-based innovation emerges through socio-technical transition processes in Girimekar Village, as also reflected in the empirical findings of this research.

Results and Discussion

This part analyses the different types of innovations and processes that have occurred in Girimekar Village. The discussion starts by outlining the different types of initiatives created by the community, including those that emerge from everyday activities and those that result from partnerships with different actors. The analysis is deepened by the multi-level perspective framework and examines how innovation transitions are created from the interplay of the different types of landscape pressures, regime shifts, and the availability of innovative voids at the niche level. The last section, which focuses on the village, describes how the village optimizes its ecological, social, and institutional resources as a fundamental base to enhance community-driven innovations.

Identification of Various Initiatives by Girimekar Village Residents

The initiatives developed in Girimekar Village demonstrate that rural innovation is not a singular or linear event, but rather a cumulative and evolving process shaped by the interaction of social, institutional, cultural, and ecological dimensions. Innovation in this context emerges through continuous experimentation, learning, and adaptation, where different initiatives are interconnected and mutually reinforced over time. This perspective highlights that innovation is embedded within local socio-technical systems and cannot be separated from the broader context in which it is produced. Contemporary studies emphasize that rural innovation should be understood as a systemic and relational process, involving multiple actors, feedback mechanisms, and institutional arrangements that co-evolve dynamically (Gardeazabal et al., 2023).

From a social innovation perspective, the identification of initiatives in Girimekar allows for a deeper understanding of how local actors collectively respond to structural challenges and opportunities. Innovation is inherently collective, emerging from collaboration, shared learning, and the co-production of knowledge among diverse actors. In rural contexts, these processes are strongly influenced by social capital, trust, and the density of local networks, which facilitate coordination and reduce uncertainty in adopting new practices. Empirical evidence suggests that the effectiveness of rural innovation systems depends not only on technological inputs but also on the quality of social interaction and institutional support that enable actors to learn and adapt (Polzin et al., 2016). As reflected in the case of Girimekar, the active involvement of farmers, youth groups, village institutions, and external facilitators has created a collaborative network that serves as a platform for generating, testing, and scaling new ideas. This networked structure strengthens the village's capacity to innovate by fostering knowledge exchange, collective action, and shared responsibility.

Furthermore, the identification of initiatives reveals the importance of innovation mechanisms and catalysts in shaping local transformation processes. Rural innovation is often triggered by a combination of internal and external pressures, including ecological degradation, economic instability, market opportunities, and regulatory changes. Rather than being passively affected by these pressures, local communities actively interpret and respond to them, transforming constraints into opportunities for innovation. Recent literature on sustainability transitions highlights that innovation often emerges when existing systems become unsustainable, prompting actors to explore alternative practices that are more resilient and adaptive (El Bilali, 2019; Köhler et al., 2019). In Girimekar, this dynamic is evident in how the community responds to environmental and economic challenges by developing new agricultural and socio-economic initiatives that improve both livelihoods and ecological sustainability.

The analysis also shows that innovation in Girimekar encompasses both social and socio-technical dimensions that are closely intertwined. Social innovation is reflected in the strengthening of community engagement, the development of collective institutions, and the enhancement of social cohesion. At the same time, socio-technical innovation is evident in the adoption, adaptation, and diffusion of technologies that improve production efficiency, product quality, and market access. Importantly, these two dimensions are not separate but mutually reinforcing. Recent studies argue that rural innovation often takes hybrid forms, combining traditional knowledge with modern technologies to create solutions that are both contextually appropriate and economically viable (Ollivier et al., 2018). In Girimekar, this hybridization process is clearly visible in the integration of local agricultural knowledge with new post-harvest techniques, market-oriented practices, and technological tools. Such hybrid innovations not only enhance productivity but also ensure that new practices remain culturally embedded and socially acceptable.

Another important finding from the identification of initiatives is the central role of local socio-economic conditions and cultural values in shaping the sustainability of innovation. Local knowledge, norms, and collective practices function as key resources that guide decision-making processes and influence the direction of innovation. Rather than being replaced by modern practices, local wisdom is often reinterpreted and integrated into innovation pathways. This aligns with recent literature, which

highlights that successful rural innovation is deeply rooted in local contexts and supported by strong social capital and institutional embeddedness (Neumeier, 2017; Steiner et al., 2023; Steiner & Teasdale, 2019). In the case of Girimekar, values such as cooperation, shared responsibility, and ecological awareness play a crucial role in sustaining innovation processes and ensuring their long-term acceptance within the community.



Figure 1 Various Community Initiatives in Girimekar Village
Source: Analysis Results, 2026

Moreover, the staged identification of initiatives from emergence to development to consolidation illustrates that innovation is a dynamic and iterative process rather than a static outcome. Each stage involves different actors, resources, and institutional arrangements, which evolve as the innovation matures. Early stages are often characterized by experimentation and uncertainty, while later stages involve stabilization, scaling, and institutionalization of practices. This process reflects the broader understanding of innovation as a non-linear trajectory shaped by continuous negotiation, learning, and adaptation among actors (Köhler et al., 2019; Polzin et al., 2016). In Girimekar, the expansion of initiatives demonstrates how local innovations can evolve from small-scale experiments into more structured and coordinated systems that contribute to broader socio-economic transformation. This conceptualization is the foundation to derive various initiatives from Girimekar; it is also the basis for the next section.

Table I Community Innovation Initiatives in Girimekar Village

Variables	Activity I: Coffee Farming	Activity II: Food Security and Living Pharmacy	Activity III: Nyawang Bulan	Activity IV: Waste Management
Actor Involvement	Fulfilled	Fulfilled	Fulfilled	Fulfilled
Cross-Sector Collaboration	Fulfilled	Fulfilled	Fulfilled	Fulfilled
Institutional Mechanisms	Fulfilled	Not Fulfilled	Not Fulfilled	Not Fulfilled
Sources of Innovation Triggers	Fulfilled	Fulfilled	Fulfilled	Fulfilled
Social Innovation	Fulfilled	Fulfilled	Fulfilled	Fulfilled
Technological Innovation	Fulfilled	Fulfilled	Not Fulfilled	Fulfilled
Utilization of Local Potential	Fulfilled	Fulfilled	Fulfilled	Fulfilled
Local Wisdom in Innovation	Fulfilled	Not Fulfilled	Fulfilled	Not Fulfilled

Activity I: Coffee Farming

Among all initiatives, coffee farming is the most advanced, as all the indicators are reinforcing each other. The multi-actor network involving farmers, farmer groups, village governments, Perhutani, and external facilitators is aligned with the agricultural innovation systems framework. Collaboration across sectors, all the way from production to market, has generated a knowledge and value stream that leads to improvement and economic access. Farmer group associations function as innovation intermediaries, leading and coordinating activities in the areas of nurseries, cultivation, post-harvesting, and training. The most significant catalyst is the post-fire land loss, which has led a number of residents to select coffee as an ecological and economic response. Social innovation is demonstrated in the development of a network of farmers and in the establishment of a community of practice, and also in the processing and cultivation of modern techniques, which have been adopted from outside. The combination of local resources and traditional knowledge has been instrumental in the development of a hybrid innovation that has ecological, social, and economic value, thus justifying the attainment of the maximum score for this activity.

Activity II: Food Security and Living Pharmacy

A score of 6 suggests that this initiative has some considerable strengths but is not fully developed in terms of the structuring of its institutional framework and the embedding of local value systems. There is extensive household engagement, as evidenced by the use of household yards for the cultivation of vegetables as well as some medicinal plants. There is only informal and peripheral collaboration with the village government. Given the absence of formal institutions, work is individually done and in an uncoordinated manner, even though in social innovation, the presence of institutions is crucial for sustaining and replicating the initiative. The most notable aspects are the stress caused by the pandemic and the need for food at the household level, which caused a social rejuvenation in the form of an improved level of food self-sufficiency. Still, the primary local technology and innovation utilized were rudimentary; thus, there is a need to enhance local systems and values for the initiative to be sustainable.

Activity III: Nyawang Bulan

Nyawang Bulan is strong in socio-cultural aspects but weak in technology and formal institutions. The participation of residents, cultural communities, and the support of the village government demonstrate social legitimacy. Social renewal is evident in the strengthening of identity, community cohesion, and the revival of Sundanese traditions. The utilization of local potential and cultural wisdom is the main driver, while also opening opportunities for the creative economy. However, the absence of formal organizations and the lack of need for new technology keep the two indicators low. Nevertheless, cultural strength makes this initiative relevant as a tradition-based innovation.

Activity IV: Waste Management

This theme was scored as medium in strength, given the relative strengths and weaknesses of community/technical versus institutional/local values. Residents, waste banks, village governments, and district networks were engaged in a multi-sectoral partnership. Innovation was driven by growing amounts of waste and the requirement for its systematic handling. The application of maggots and waste banks is one of the most important technological innovations. Yet institutionalization has only taken place in some small groups, and local wisdom has not yet been absorbed into practice, despite the potential to boost participation and social legitimacy. Thus, this initiative still requires strengthening of organizational structures and revitalization of local values to develop more consistently.

Transition to the Formation of Girimekar Village Innovation

The transition of innovation in rural areas extends beyond technological substitution and involves broader transformations in social structures, actor configurations, cultural practices, power relations, and historically embedded value systems. In this context, Girimekar Village illustrates how innovation emerges through complex socio-technical interactions among actors, institutions, and ecological conditions. The shift from vegetable farming to coffee cultivation is not merely a change in commodity but represents a deeper process of system reconfiguration, where production practices, knowledge systems, and institutional arrangements are continuously reshaped. Contemporary literature on sustainability transitions emphasizes that such transformations are multi-dimensional and occur through dynamic interactions between technological, social, and institutional elements (Geels, 2020; Köhler et al., 2019).

The multi-level perspective provides a useful analytical framework to understand this process. Rather than viewing change as linear, MLP conceptualizes transitions as the result of interactions between three analytical levels: landscape (macro-level pressures), socio-technical regime (established systems), and niches (spaces for innovation). Recent developments in MLP highlight that transitions are driven by increasing misalignment between these levels, where pressures at the landscape level destabilize existing regimes and create opportunities for niche innovations to emerge and expand (Geels, 2020; Köhler et al., 2019). In the case of Girimekar, the transition toward coffee cultivation reflects this dynamic interplay, where external pressures, internal tensions, and local experimentation converge to reshape the agricultural system.

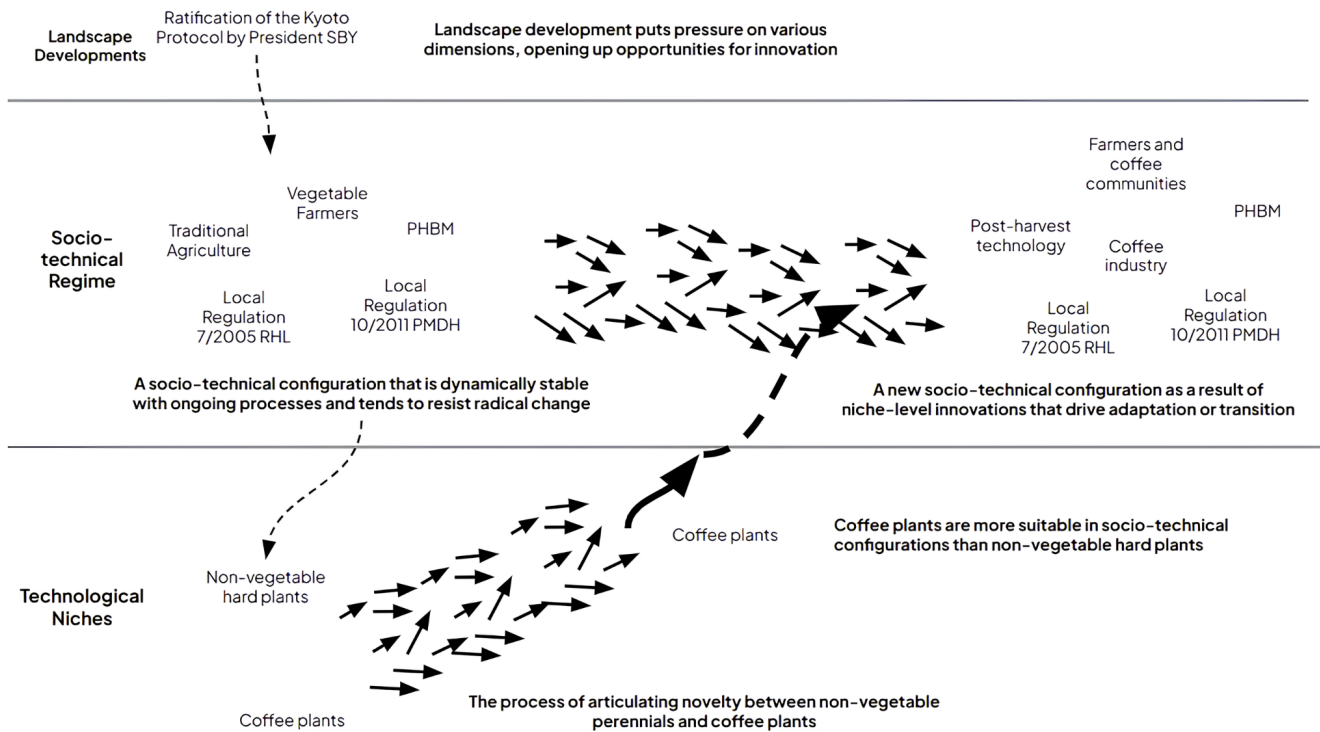


Figure 2. Transition of Coffee Innovation Formation in Girimekar Village

Source: Analysis Results, 2026

Landscape Level: Macro Pressures Driving New Space for Innovation

At the landscape level, transitions are influenced by broad structural forces that are beyond the direct control of local actors but significantly shape local development trajectories. These include global environmental changes, national policy frameworks, economic transformations, and shifting socio-cultural values (Köhler et al., 2019). In Girimekar, these pressures are not abstract but are concretely manifested through policy shifts, market dynamics, ecological degradation, and generational change.

A key turning point in Indonesia's environmental governance was the ratification of the Kyoto Protocol during the presidency of Susilo Bambang Yudhoyono (SBY), which signaled a national commitment to climate change mitigation and sustainable land management. This policy shift marked the beginning of stronger environmental governance frameworks that gradually penetrated local contexts, including forest-adjacent rural areas such as Girimekar. As also reflected in this study, the implementation of sustainability-oriented policies led to tighter regulations on forest utilization, increased emphasis on reforestation and land rehabilitation, and the strengthening of collaborative forest management schemes such as PHBM. These institutional changes reduced the feasibility of environmentally degrading practices, including intensive vegetable farming that relies heavily on chemical inputs and contributes to soil erosion on sloping lands.

Beyond regulatory pressure, economic dynamics play a critical role in destabilizing the existing agricultural regime. Vegetable farming in Girimekar has long been characterized by high market volatility, influenced by seasonal production cycles, fluctuating demand, input price increases, and dependence on intermediary traders. This condition creates structural vulnerability, where farmers are exposed to unstable income and limited bargaining power. From a socio-technical perspective, such conditions represent regime instability, where established systems are no longer able to provide economic security to their actors. In contrast, the expansion of specialty coffee markets driven by global demand for sustainable, traceable, and high-quality products offers an alternative economic pathway. This shift reflects broader

transformations in agri-food systems, where value creation is increasingly linked to quality differentiation, sustainability standards, and market narratives (El Bilali, 2019; Polzin et al., 2016).

Ecological pressures further intensify the transition process. Long-term dependence on intensive horticulture has resulted in soil degradation, declining fertility, and increased vulnerability to erosion and landslides, particularly in highland environments with steep topography and high rainfall intensity. These environmental constraints not only reduce agricultural productivity but also increase the cost and risk of farming. Within the socio-technical framework, such ecological conditions can be interpreted as active non-human actors that shape decision-making processes and constrain the viability of existing practices. In contrast, coffee cultivation, especially when integrated within agroforestry systems, offers a more ecologically adaptive alternative. Coffee plants contribute to soil stabilization, improve water retention, and support biodiversity, thereby aligning agricultural practices with environmental sustainability objectives.

Another critical dimension of landscape pressure is the transformation of socio-cultural dynamics, particularly the role of younger generations. Increased access to digital technologies, social media, and broader market networks has reshaped how rural youth perceive agriculture. In Girimekar, younger actors no longer view farming solely as a subsistence activity but increasingly see it as part of a diversified economic ecosystem that includes processing, branding, tourism, and digital entrepreneurship. Coffee, in this context, is not just a crop but a gateway to participating in the creative economy. Recent studies highlight that youth engagement, digital connectivity, and access to knowledge networks are key drivers of rural innovation, as they facilitate experimentation, knowledge diffusion, and market integration (Polzin et al., 2016; Townsend et al., 2017). The emergence of youth-led initiatives in coffee processing, marketing, and community building thus acts as a significant catalyst that accelerates the transition process.

Importantly, these landscape pressures do not operate independently but interact and reinforce one another. Policy shifts create regulatory constraints, market dynamics reshape economic incentives, ecological degradation limits existing practices, and socio-cultural changes introduce new aspirations and capabilities. The convergence of these factors generates what transition scholars describe as a “window of opportunity,” where the stability of the existing regime is disrupted, and space is created for alternative practices to emerge (Geels, 2020; Köhler et al., 2019). In Girimekar, this window of opportunity is clearly reflected in the gradual shift toward coffee cultivation, which is perceived not only as an economic alternative but also as a more sustainable and socially desirable practice.

Overall, the landscape level in Girimekar illustrates that socio-technical transitions are driven by the alignment of multiple external pressures that collectively destabilize the existing system and enable the emergence of new configurations. The transition toward coffee is therefore not a spontaneous change, but the outcome of long-term interactions between policy frameworks, market transformations, ecological conditions, and evolving social dynamics. This understanding provides a strong foundation for analyzing how these pressures interact with regime-level structures and niche-level innovations in shaping the broader transformation of rural agricultural systems.

Regime Level: Stability, Tensions, and Negotiation in the Agricultural System of Girimekar Village

The regime level represents a stable socio-technical configuration composed of established practices, institutional arrangements, infrastructures, market relations, and shared cognitive routines that guide actors' behavior over time. In the context of agriculture in Girimekar Village, the vegetable farming regime is deeply embedded, shaped by long-standing horticultural practices, the presence of stable market channels mediated by middlemen, basic agricultural infrastructure, and the continuity of local institutions such as the village government and Perhutani. These elements together form what transition scholars describe as a “ruleset” that stabilizes expectations, reduces uncertainty, and reinforces path-dependent development trajectories (Geels, 2020; Köhler et al., 2019).

Social trust and collective experience accumulated over time further strengthen this regime. Farmers in Girimekar have developed shared knowledge regarding planting cycles, input use, and market timing, which creates a sense of predictability and reduces perceived risks. As a result, vegetable farming is not only an economic activity but also a socially legitimized practice that is considered the most “reasonable” and secure livelihood option. This aligns with recent literature on agricultural innovation systems, which highlights that stability in rural production systems is often maintained through the co-evolution of social norms, institutional arrangements, and market structures (Capello & Nijkamp, 2019; Polzin et al., 2016).

However, this stability also generates resistance to change. Established regimes tend to exhibit what is referred to as regime rigidity, where actors are locked into existing practices due to cognitive routines, institutional constraints, and economic dependencies. Farmers’ familiarity with vegetable cultivation, reliance on short-term income, and dependence on middlemen networks create strong incentives to maintain the status quo. Innovation, in this context, is often perceived as uncertain and risky, particularly when it involves switching to unfamiliar crops or production systems. Recent studies emphasize that such lock-in conditions are common in agricultural systems, where habits, market structures, and institutional frameworks reinforce inertia and limit the adoption of alternative practices (Köhler et al., 2019; Polzin et al., 2016).

Although the vegetable farming regime appears stable, it is in fact characterized by underlying vulnerabilities. Its sustainability is highly dependent on intensive chemical inputs, labor-intensive practices, and volatile market conditions. This creates a form of structural fragility, where the system remains functional in the short term but becomes increasingly unsustainable in the long run. Contemporary transition literature describes this condition as a socio-technical lock-in, where established systems persist despite declining performance because actors remain embedded in existing networks and institutional arrangements (Geels, 2020; Köhler et al., 2019). In Girimekar, these lock-in mechanisms are evident in farmers’ dependence on input-intensive practices, entrenched relationships with traders, and regulatory environments that historically did not directly discourage vegetable cultivation.

Institutional factors at the local level also play a crucial role in shaping and, eventually, destabilizing the regime. Policies such as Local Regulation No. 7/2005 on Forest and Land Rehabilitation (RHL) and Local Regulation No. 10/2011 on Community-Based Forest Management (PHBM/PMDH) were initially designed to promote forest sustainability. However, their implementation has indirectly constrained conventional vegetable farming practices in forest-adjacent areas. Increased regulation of land use, stricter monitoring by Perhutani, and obligations to maintain ecological functions have reduced the flexibility of farmers to continue intensive horticultural practices. As observed in this study, these institutional arrangements have transformed PHBM into a negotiation space, where farmers and state actors interact to redefine acceptable land-use practices. Within this space, alternative crops such as coffee, perceived as more compatible with agroforestry systems, gain legitimacy and support.

Beyond external pressures, internal tensions within the regime further accelerate its destabilization. Ecologically, prolonged use of chemical fertilizers and pesticides has led to soil degradation, declining fertility, and increased vulnerability to erosion. Economically, rising input costs and unstable commodity prices reduce profit margins and increase farmers’ exposure to risk. Socially, intensive labor demands and uncertain returns have reduced the attractiveness of vegetable farming, particularly among younger generations. These conditions collectively weaken the resilience of the regime and expose its structural limitations.

From an MLP perspective, these dynamics illustrate a process of regime destabilization, where the alignment between technologies, institutions, and actor practices begins to erode, creating opportunities for alternative systems to emerge. Recent studies emphasize that destabilization does not occur abruptly but unfolds gradually through the accumulation of internal tensions and external pressures (Geels, 2020; Köhler et al., 2019). In Girimekar, this process is evident in the increasing mismatch between the ecological requirements of sustainable land management, the economic expectations of farmers, and the institutional frameworks governing forest use. Importantly, the weakening of the vegetable farming

regime does not immediately lead to its replacement but instead creates a space for negotiation and experimentation. Farmers begin to explore alternative practices while still partially relying on existing systems, resulting in a hybrid and transitional phase. Institutional arrangements such as PHBM facilitate this process by providing a platform for dialogue, adaptation, and gradual transformation. This reflects the broader understanding that socio-technical transitions involve not only disruption but also negotiation, learning, and reconfiguration of relationships between actors and institutions (Aka, 2025; Castella et al., 2022; Polzin et al., 2016).

Niche Level: The Emergence of Coffee Innovation as a Socio-Technical Experiment

Under conditions of a weakening socio-technical regime, protected spaces for experimentation begin to emerge at the niche level, allowing alternative practices to be developed and tested. In the multi-level perspective, niches are understood as incubation spaces where actors can experiment with innovative ideas, build networks, and develop innovations shielded from dominant market pressures and institutional constraints (Geels, 2020; Köhler et al., 2019). In the context of Girimekar Village, coffee cultivation represents such a niche, emerging as a socio-technical experiment in response to ecological, economic, and institutional pressures affecting the existing vegetable farming regime.

In its early phase, the introduction of coffee was not driven solely by profit motives but functioned as a process of local experimentation and learning. Farmers began to explore coffee cultivation as a perennial alternative that is better suited to steep topography, requires lower maintenance than intensive horticulture, and offers higher long-term economic potential. These initial trials were characterized by uncertainty and gradual adoption, reflecting what transition literature describes as the exploration phase of niche development, where innovation emerges through trial-and-error and experiential learning (Geels, 2020). External actors, including coffee communities, facilitators, and non-governmental organizations, played a key role in supporting this process by providing technical knowledge, training, and exposure to broader market opportunities.

Over time, these individual experiments evolved into a collective learning process involving multiple actors. Farmers organized themselves into informal and formal groups to share knowledge and develop technical skills, including pruning techniques, organic fertilization, pest and disease management, and post-harvest processing methods such as washed, natural, and honey processes. This process reflects the importance of interactive learning and knowledge co-production in agricultural innovation systems, where innovation emerges through continuous interaction between actors rather than through linear knowledge transfer (Ollivier et al., 2018; Polzin et al., 2016). In MLP terms, this stage can be understood as a process of articulation and alignment, where actors gradually refine their expectations, preferences, and innovation strategies through social interaction and shared experience (Geels, 2020).

Importantly, this learning process not only enhanced technical capacity but also contributed to the transformation of farmers' identities. Farmers who previously identified themselves as horticultural producers began to reposition themselves as part of the specialty coffee ecosystem. This shift reflects a broader socio-cultural transformation, where innovation reshapes not only practices but also values, aspirations, and collective identities. Recent studies highlight that identity formation and social recognition are key elements in sustaining rural innovation, as they strengthen actors' commitment to new practices and reinforce the legitimacy of emerging systems (Steiner et al., 2023; Steiner & Teasdale, 2019).

At this stage, non-human actors such as pulping machines, roasting equipment, post-harvest technologies, and certification standards played a critical role as mediators of change within the innovation network. From an actor-network theory perspective, these technologies are not merely tools but active elements that shape relationships, practices, and outcomes within the system. The introduction of post-harvest technologies enabled farmers to improve product quality, standardize processes, and access higher-value markets. At the same time, quality standards and certification schemes introduced new norms and expectations that guided production practices. This interaction between human and non-

human actors contributed to the stabilization and maturation of the coffee niche (Aka, 2025; Castella et al., 2022).

However, the findings also reveal certain limitations of actor-network theory in explaining the broader structural dimensions of rural transformation. While ANT is effective in capturing relational dynamics among actors and technologies, it tends to underemphasize issues of power asymmetry, economic inequality, and institutional dominance that shape innovation processes in rural contexts. In Girimekar, access to technology, market networks, and institutional support was not equally distributed among actors, indicating that innovation processes were also influenced by unequal capacities and authority relations. Furthermore, ANT's relational focus is less capable of fully explaining how broader political-economic structures such as state regulations, market dependency, and land governance influence local innovation trajectories. Therefore, this study suggests that ANT needs to be complemented by broader socio-technical and political-economic perspectives to better understand the complexity of rural innovation and transformation processes.

As the niche matured, its capacity to challenge and influence the existing regime increased. MLP literature suggests that transitions occur when niche innovations gain sufficient momentum, align with landscape pressures, and exploit the weaknesses of existing regimes (Geels, 2020; Köhler et al., 2019). In Girimekar, this dynamic is clear. Increasing environmental constraints, market instability in vegetable farming, and institutional shifts under PHBM created favorable conditions for the expansion of coffee cultivation. As also reflected in this study, farmers became more willing to experiment with alternative practices as the existing system lost its ability to provide economic and ecological security.

The role of PHBM as an institutional pathway is particularly important in facilitating niche-regime interaction. Through PHBM, farmers gained access to forest land under a collaborative management scheme, which encouraged the adoption of agroforestry practices compatible with conservation objectives. Coffee, as a perennial crop, was perceived as more aligned with these institutional requirements, thereby gaining legitimacy within the regulatory framework. This institutional support enabled niche innovations to gradually scale up and integrate into the broader production system, illustrating how governance structures can mediate transition processes (Polzin et al., 2016).

At this stage, the transition in Girimekar can be interpreted as following a substitution pathway, where a mature niche replaces an increasingly unstable regime under sustained landscape pressure (Geels, 2020). Vegetable farming, once dominant, becomes less viable due to ecological degradation, economic instability, and institutional constraints, while coffee emerges as a more adaptive and competitive alternative. However, this transition is not instantaneous but occurs through a gradual process of hybridization, where elements of the old and new systems coexist before a more stable configuration is achieved.

The impacts of this niche development are multidimensional. Ecologically, coffee-based agroforestry contributes to soil conservation, reduces erosion, and enhances biodiversity. Economically, it provides opportunities for more stable income and higher value-added through post-harvest processing and market differentiation. Socially, it strengthens collective action, enhances the role of youth, reinforces local institutions, and fosters a new sense of identity and pride within the community. These outcomes align with recent findings that highlight the potential of niche innovations to generate transformative impacts when supported by strong actor networks, institutional alignment, and favorable landscape conditions (Ollivier et al., 2018; Steiner et al., 2023; Steiner & Teasdale, 2019).

Local Context and Utilization of Village Strengths in Girimekar Village Innovation

The utilization of local strengths constitutes a fundamental pillar in shaping rural innovation, particularly in agrarian contexts where socio-cultural, ecological, and institutional characteristics are deeply intertwined. Rather than being limited to production efficiency or cost advantages, local strengths represent the capacity of communities to transform place-based resources into sustainable socio-economic value.

Recent studies emphasize that rural innovation is inherently territorial and context-specific, emerging from the interaction between local assets, actor networks, and institutional environments that shape development trajectories (Khairullina et al., 2025). In this sense, Girimekar Village exemplifies how local strengths are not static endowments but dynamic resources that are continuously reinterpreted and mobilized through socio-technical processes.

The formation of these strengths is closely linked to the interaction between ecological endowment, human capabilities, and institutional support systems. Contemporary literature highlights that local knowledge plays a central role in enhancing rural resilience and innovation capacity, particularly in the face of environmental change and market uncertainty. Local knowledge systems enable communities to adapt agricultural practices to specific ecological conditions while maintaining sustainability and cultural relevance (Fadhol & Samputra, 2025). In Girimekar, such knowledge is reflected in farmers' understanding of soil conditions, rainfall patterns, and highland cultivation systems, which form the basis for adaptive and context-specific innovation strategies.

From the perspective of absolute advantage, Girimekar possesses unique ecological and cultural assets that are difficult to replicate elsewhere. The suitability of its highland environment for coffee cultivation, combined with accumulated tacit knowledge among farmers, provides a solid foundation for agroecological innovation. Recent studies on agroforestry and local species integration show that locally adapted plant systems significantly enhance ecological resilience, improve soil conservation, and support sustainable production systems (Talantan et al., 2025). This indicates that absolute advantage in rural contexts is not merely derived from natural resources but from the co-evolution of ecological conditions and locally embedded knowledge systems.

In addition to ecological advantages, the role of human capital and experiential learning is critical in transforming these resources into productive outcomes. Innovation in rural areas is often driven by learning-by-doing and collective experimentation, where farmers continuously adapt their practices based on experience and interaction. Recent research emphasizes that agricultural innovation is a socially negotiated process, shaped by communication, trust, and knowledge exchange among actors (Amalia & A'zdom, 2025). In Girimekar, this process is evident in the way farmers collectively refine cultivation techniques, adopt post-harvest innovations, and build a shared understanding of quality standards. Thus, absolute advantage is strengthened through the integration of ecological suitability and socially embedded knowledge systems.

From the perspective of comparative advantage, Girimekar demonstrates how collaboration, institutional support, and network formation enhance production efficiency and reduce structural constraints. Farmer groups, training programs, and facilitation mechanisms enable the diffusion of knowledge and innovation while also reducing transaction costs and risks. This aligns with the agricultural innovation systems perspective, which highlights that innovation emerges through interactions between farmers, institutions, markets, and knowledge intermediaries (Amalia & A'zdom, 2025; Castella et al., 2022). Moreover, recent studies show that rural innovation is strongly influenced by territorial factors such as accessibility, institutional support, and network density, which collectively determine the capacity of communities to innovate and compete (Khairullina et al., 2025).

Institutional arrangements further reinforce this comparative advantage. In Girimekar, the presence of PHBM and collaboration with Perhutani provide access to land, resources, and governance frameworks that enable sustainable agroforestry practices. Institutional support not only reduces uncertainty but also creates enabling conditions for innovation by facilitating coordination and aligning local practices with broader sustainability goals. This reflects broader findings that governance structures and institutional flexibility are key drivers of rural innovation and transformation (Djeflat, 2026).

From the perspective of competitive advantage, Girimekar has successfully leveraged its local strengths to position its coffee products within higher-value markets. The development of Kopi Palasari as a single-origin product illustrates how value creation in modern agri-food systems increasingly depends on differentiation, storytelling, and identity. Recent literature highlights that the integration of

local culture, branding, and product narratives significantly enhances market competitiveness by creating symbolic and experiential value (Steiner et al., 2023; Steiner & Teasdale, 2019). In addition, the adoption of post-harvest innovations and digital marketing strategies enables farmers to access broader markets and capture greater value from their products.

The role of youth and digitalization further strengthens this competitive advantage. The integration of digital tools, social media, and market platforms allows rural producers to overcome traditional barriers such as limited market access and information asymmetry. Recent studies emphasize that digital transformation in agriculture plays a crucial role in enhancing productivity, efficiency, and value chain integration in rural areas (Mandal et al., 2024). In Girimekar, the involvement of younger generations in marketing, branding, and innovation activities contributes to the development of a more dynamic and competitive rural economy.

The interaction between absolute, comparative, and competitive advantages in Girimekar reflects the emergence of a territorial innovation system, where local resources, actor networks, and institutional arrangements interact synergistically. This system is characterized by the integration of ecological sustainability, social capital, and economic value creation, forming a resilient and adaptive rural innovation ecosystem. Recent research emphasizes that such systems are essential for achieving sustainable rural development, as they enable communities to respond effectively to environmental, economic, and social challenges (Köhler et al., 2019; Ollivier et al., 2018).

Furthermore, the case of Girimekar highlights that rural innovation is inherently contextual and cannot be replicated without considering local socio-ecological conditions. The strengths observed in this village are the result of long-term interactions between people, the environment, and institutions, which collectively shape the trajectory of innovation. As also reflected in this study, the ability of Girimekar to mobilize and integrate its local strengths is a key factor in explaining the emergence and sustainability of its innovation processes.

The Absolute Advantage of Innovation in Coffee Production

The absolute advantage of Girimekar Village in coffee production is rooted in the synergistic interaction between culturally embedded human capabilities and highly favorable ecological conditions. While classical economic thought associates absolute advantage with the ability to produce goods more efficiently due to unique resource endowments, contemporary perspectives extend this concept to include the integration of local knowledge systems, ecological suitability, and socio-cultural practices that collectively shape production quality and sustainability (Lyu et al., 2021; Ollivier et al., 2018). In this context, Girimekar's advantage lies not only in its natural resources but also in the co-evolution of human and environmental systems that enable the production of high-quality coffee.

From a human perspective, the accumulation of intergenerational knowledge has resulted in strong tacit capabilities among farmers. This includes the ability to interpret plant conditions, manage shading systems, and determine optimal harvesting times without reliance on formal measurement tools. Such knowledge reflects what recent studies describe as experiential and embodied knowledge, which is developed through long-term interaction with the environment and is critical for sustaining agroecological systems (Lyu et al., 2021). Post-harvest practices, including fermentation, drying, and manual sorting, further demonstrate a level of craftsmanship that enhances product quality and differentiates Girimekar coffee within specialty markets. These practices are not merely technical skills but are embedded within cultural routines and collective norms that reinforce consistency and quality standards.

From a non-human perspective, Girimekar's ecological characteristics provide a solid foundation for coffee excellence. Located at an altitude of 1,200–1,400 meters above sea level, the village benefits from a stable microclimate that is highly conducive to Arabica cultivation. Volcanic soils rich in essential nutrients, combined with agroforestry systems supported by Perhutani forests, create optimal growing conditions that enhance flavor complexity and bean quality. Recent research highlights that agroecological

conditions, including soil composition, altitude, and biodiversity, play a crucial role in determining the quality and sustainability of coffee production systems (Läderach et al., 2017). Furthermore, the availability of clean water sources supports high-quality post-harvest processing, particularly for washed coffee, which is sensitive to water quality.

The convergence of culturally embedded human capital and unique ecological endowments positions Girimekar as a region with strong absolute advantage. This advantage is not easily replicable, as it depends on the integration of local knowledge, environmental conditions, and socio-cultural practices. As also reflected in this study, these factors collectively form a robust foundation for the development of coffee-based innovation that is both high-quality and ecologically sustainable.

The Comparative Advantage of Innovation

The comparative advantage of Girimekar Village in coffee development emerges from the interaction between actor networks, institutional arrangements, and supporting infrastructure that collectively reduce production costs, risks, and uncertainties. Contemporary interpretations of comparative advantage in rural development emphasize not only efficiency in production but also the role of institutional coordination, knowledge exchange, and network-based collaboration in enhancing competitiveness (Köhler et al., 2019).

From a human and institutional perspective, collaboration among farmers, Perhutani, village governments, and external actors creates a more stable and coordinated production system. The PHBM scheme plays a critical role in reducing land tenure uncertainty, enabling farmers to access forest land while maintaining ecological sustainability. Such arrangements align with recent findings that secure land access and collaborative governance significantly enhance agricultural productivity and innovation capacity (Köhler et al., 2019; McCarthy & Robinson, 2016). Farmer groups such as KTH Girisenang further facilitate the diffusion of innovation by enabling collective learning, coordination, and knowledge sharing. These processes reduce transaction costs, improve efficiency, and accelerate the adoption of improved practices, including post-harvest innovations.

In addition, the presence of cooperatives and partnerships with academic institutions strengthens knowledge flows and ensures quality consistency. This reflects the functioning of agricultural innovation systems, where innovation emerges through continuous interaction between multiple actors, including producers, institutions, and knowledge intermediaries (Polzin et al., 2016). Such systems enable farmers to access technical support, market information, and financial resources, thereby reducing uncertainty and enhancing adaptive capacity.

From a spatial and infrastructural perspective, Girimekar benefits from its strategic location and improved connectivity. The integration of coffee production with tourism activities creates additional value through experiential and place-based economic activities. Recent studies highlight that territorial embeddedness and rural tourism integration can significantly enhance the economic performance of agricultural products by linking production with experience-based consumption (Jeannerat & Crevoisier, 2022; Steiner et al., 2023; Steiner & Teasdale, 2019). Improved road infrastructure and digital connectivity further reduce logistical constraints and enable farmers to access wider markets.

The Competitive Advantage of Innovation

The competitive advantage of Girimekar Village in coffee development is reflected in its ability to strategically position itself within higher-value segments of the coffee value chain. Unlike absolute and comparative advantages, which are rooted in resource endowments and efficiency, competitive advantage is constructed through differentiation, innovation, and the ability to capture value within market systems. Contemporary literature emphasizes that competitiveness in agri-food systems increasingly depends on value addition, branding, and integration into global value chains (Gereffi, 2018; Ponte, 2019).

Institutionally, the role of cooperatives such as the Girisenang Cooperative and Gapoktan is crucial in strengthening farmers' bargaining power and ensuring that value is retained within the community. By coordinating production, processing, and distribution, these organizations enable farmers to move beyond raw material production and participate more actively in value creation processes. This aligns with recent studies showing that collective institutions are key drivers of upgrading in agricultural value chains, as they enhance coordination and reduce dependency on intermediaries (Gereffi, 2018).

Market integration further strengthens this competitive position. Collaboration with national brands such as Kopi Kenangan provides access to stable markets while simultaneously raising quality standards. Such partnerships create reputational effects that enhance product visibility and strengthen regional branding. In addition, the involvement of younger generations in branding, packaging, and digital marketing contributes to the development of a more dynamic and market-oriented production system. Recent research highlights that digitalization and youth entrepreneurship are critical factors in enhancing rural competitiveness, particularly in linking local production systems with broader market networks (Mandal et al., 2024; Townsend et al., 2017).

From a product perspective, Girimekar's competitive advantage is reinforced by its distinctive coffee characteristics, which are shaped by unique agroecological conditions. Flavor differentiation, which emerges from altitude, soil composition, and agroforestry practices, functions as an intangible asset that enhances market value. Recent studies emphasize that product differentiation and quality attributes are key determinants of competitiveness in specialty coffee markets, where consumers value uniqueness, traceability, and sustainability (Ponte, 2019).

Sustainability practices further strengthen this advantage. The use of coffee waste as organic fertilizer, the adoption of environmentally friendly cultivation methods, and the integration of agroforestry systems align with growing consumer demand for sustainable products. Products with lower environmental footprints often command premium prices, making sustainability a strategic component of competitiveness (Ollivier et al., 2018). In addition, the development of coffee-based tourism, such as plantation visits, post-harvest demonstrations, and cupping experiences, creates new revenue streams and enhances the experiential value of the product.

Finally, the integration of upstream and downstream processes within the village ensures greater control over production and quality. This reduces variability and enhances consistency, addressing common challenges faced by small-holder coffee producers. The combination of institutional coordination, product differentiation, sustainability practices, and market integration positions Girimekar as a competitive player within the specialty coffee sector.

Conclusion

This study demonstrates that the transformation from conventional vegetable farming to coffee-based agroforestry in Girimekar Village represents a broader socio-technical transformation rather than a simple shift in agricultural commodities. The emergence of community-based innovation is shaped by the interaction between ecological pressures, institutional change, local knowledge systems, market dynamics, and collaborative actor networks. Through the multi-level perspective, this study shows how landscape pressures, regime destabilization, and niche development interact to create opportunities for rural transformation, while actor-network theory helps explain how both human and non-human actors collectively stabilize innovation processes.

The findings reveal that coffee agroforestry evolved through iterative experimentation, collective learning, institutional negotiation, and the integration of post-harvest technologies and market-oriented practices. Institutional arrangements such as PHBM played a dual role as both constraints and enabling mechanisms, creating negotiation spaces that facilitated the legitimacy and expansion of coffee-based innovation. In addition, the success of innovation in Girimekar is strongly supported by the strategic

mobilization of local strengths, including agroecological suitability, embedded local knowledge, collaborative institutions, youth participation, digitalization, and value-added market strategies.

This study contributes novelty to the socio-technical transition literature by integrating a multi-level perspective, actor-network theory, and rural innovation approaches within the context of Indonesian rural transformation. Unlike previous studies that tend to emphasize technological adoption or institutional dimensions separately, this research demonstrates that rural innovation emerges through relational, territorial, and community-based processes involving the co-evolution of ecological, social, technological, and institutional elements. The study therefore offers an interdisciplinary contribution by bridging sustainability transition studies, rural sociology, agroforestry studies, and innovation governance perspectives.

However, the findings also reveal several theoretical limitations. While Actor-Network Theory is effective in explaining relational interactions between human and nonhuman actors, it is less capable of fully addressing broader structural inequalities, power asymmetries, and political-economic forces influencing rural transformation. Similarly, the multi-level perspective tends to conceptualize transitions in linear ways and pays limited attention to local contestation, unequal access to resources, and informal institutional dynamics found in rural communities. The case of Girimekar demonstrates that rural innovation processes are often non-linear, negotiated, and shaped by unequal actor capacities and governance structures.

Overall, this study highlights that rural communities should not be viewed merely as passive recipients of development policies but as active agents capable of generating adaptive and sustainable innovation pathways. These findings provide important implications for rural development policies by emphasizing the need for flexible institutions, collaborative governance, support for local experimentation, and the strengthening of community-based innovation ecosystems.

Declaration of Generative Artificialintelligence (AI) Use

"During the preparation of this work the authors used Microsoft Copilot AI to improve manuscript organization and refine the english language through translation and language editing. The authors reviewed and edited all content as necessary and take full responsibility for published article."

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