

A Multi-Stakeholder Collaboration Model For A Sustainable Innovation Ecosystem in The Silk Industry of South Sulawesi

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Abstract

South Sulawesi has long been recognized as Indonesia's leading centre of natural silk (persuteraan alam) production, yet the sector continues to face stagnating productivity, fragmented institutional support, and weak coordination among its stakeholders. This conceptual paper develops a multi-stakeholder innovation ecosystem model for sustainable silk industry development in South Sulawesi by synthesising literature on innovation ecosystems, helix-based collaboration theory, and regional sericulture studies. Employing a qualitative literature-synthesis method, the paper integrates the Quintuple Helix framework with innovation-ecosystem governance theory to propose a collaborative structure involving government, academia, industry, farming communities, and civil society/media, embedded within the natural environment as a fifth helix. The model positions coordinated governance, inter-actor trust, and role clarity as prerequisites for ecosystem maturation. The paper contributes a theoretical framework intended for future empirical validation and offers policy directions for revitalising South Sulawesi's silk value chain toward greater sustainability, cultural preservation, and rural economic resilience.

Keywords: Innovation Ecosystem; Multi-Stakeholder Collaboration; Quintuple Helix; Sustainable Sericulture; South Sulawesi.

1 Introduction

Silk weaving occupies a distinctive place in the economic and cultural life of South Sulawesi, particularly in Wajo, Soppeng, and Enrekang, where natural sericulture (persuteraan alam) has been practised by rural households since the mid-twentieth century as both an inherited craft and a source of supplementary income (Harbi, Nurrochmat, & Kusharto, 2015). Despite periodic fluctuations, the province has continued to be regarded as the largest producer of natural silk in eastern Indonesia, and silk cloth from Wajo has become closely tied to Bugis cultural identity and regional trade (Taroniarta & Yahya, 2022).

Notwithstanding this long history, the productivity and competitiveness of South Sulawesi's silk sector have remained persistently low. A series of government programmes intended to increase mulberry cultivation, cocoon quality, and thread output have repeatedly fallen short of their targets, a pattern that several studies attribute less to technical constraints than to unresolved institutional issues: unclear division of interests, poorly connected actors, and fragmented policy networks across forestry, industry, and local government agencies (Ridwan, 2011; Sadapotto, 2010). Reported constraints include disease pressure on mulberry plantations, dependence on imported cocoon stock, and limited coordination between upstream cultivation and downstream weaving industries (Baso & Sudirman, 2020; Kementerian Kehutanan, 2014).

These recurring institutional shortcomings suggest that South Sulawesi's silk industry problem is best understood not merely as a matter of agronomic or technical improvement, but as a governance and collaboration challenge involving multiple, loosely connected stakeholders. Contemporary innovation studies address precisely this type of problem through the concept of the innovation ecosystem, in which value is co-created through the coordinated interdependence of diverse actors rather than through the effort of any single organisation (Adner, 2006). Complementary to this view, helix-based collaboration theories—beginning with the Triple Helix model of university-industry-government relations (Etzkowitz & Leydesdorff, 2000) and subsequently extended into Quadruple and Quintuple Helix formulations that incorporate civil society and the natural environment (Carayannis & Campbell, 2010)—offer a structured way of conceptualising who should participate in an innovation ecosystem and how their roles might be organised.

Although helix-based innovation ecosystem models have been applied productively to rural and agricultural development elsewhere in Indonesia, including a Quintuple Helix governance study in East Luwu Regency, South Sulawesi (Abdillah, Widianingsih, Buchari, Mustari, & Saleh, 2022), a systematic application of this framework to the province's silk industry has not yet been developed. Existing studies of South Sulawesi sericulture remain largely descriptive or policy-evaluative, documenting institutional weaknesses without proposing an integrative

model for coordinating the actors involved (Harbi et al., 2015; Ridwan, 2011; Sadapotto, 2010). This represents a conceptual gap that the present paper seeks to address.

Accordingly, this paper aims to develop a conceptual multi-stakeholder innovation ecosystem model for sustainable silk development in South Sulawesi, grounded in innovation ecosystem theory and the Quintuple Helix framework. The paper is organised as follows. The next section reviews the relevant literature on innovation ecosystems, helix-based collaboration theory, and South Sulawesi's silk industry. This is followed by a description of the literature-synthesis method used to build the model. The subsequent section presents the proposed model and discusses its components, governance implications, and relevance to sustainability and gender equity, before the paper concludes with a summary of its theoretical and policy contributions.

Literature Review

The concept of the innovation ecosystem originates from Moore's (1993) ecological metaphor of business competition and was subsequently formalised by Adner (2006), who defined it as a collaborative arrangement through which multiple actors combine their individual contributions into a coherent, value-creating whole. Unlike a conventional supply chain, an innovation ecosystem is characterised by decentralised, interdependent actors whose success depends on the alignment of complementary contributions rather than on hierarchical control (Adner, 2006). This perspective is particularly relevant to sectors such as sericulture, where mulberry cultivation, cocoon rearing, thread processing, weaving, and marketing are typically undertaken by different, loosely coordinated actors rather than a single integrated enterprise.

Because innovation ecosystems involve multiple interdependent but autonomous actors, their functioning depends heavily on governance. Ostrom's (2009) framework for analysing the sustainability of social-ecological systems emphasises that resource users, institutional rules, and the resource system itself must be understood as an interacting whole, a proposition later echoed in innovation-ecosystem governance research showing that ecosystems evolve through recognisable stages—from a dispersed, uncoordinated stage toward more centralised and eventually shared governance as trust and consensus develop among actors (Barbalho et al., 2024). Ecosystems in an early stage of development, characterised by low trust and unclear roles, generally require a leading or coordinating organisation before more distributed governance becomes feasible (Barbalho et al., 2024).

A complementary body of theory conceptualises the composition of innovation ecosystems through the metaphor of intertwined "helices." The original Triple Helix model described innovation as emerging from the interaction of university, industry, and government (Etzkowitz & Leydesdorff, 2000). This was subsequently broadened into the Quadruple Helix by incorporating civil society and media as a fourth strand representing public interest and grassroots knowledge, and further extended into the Quintuple Helix, which adds the natural environment as a fifth helix to explicitly account for ecological sustainability within innovation processes (Carayannis & Campbell, 2009, 2010). These successive extensions reflect a growing recognition that innovation in resource-dependent and rural sectors cannot be adequately understood without accounting for both community participation and environmental constraints.

Helix-based and innovation-ecosystem frameworks have been increasingly applied to agricultural and rural development contexts. Hoeffcker's (2021) middle-range conceptual model of inclusive innovation in agricultural systems highlights the importance of recognising diverse, often informal actor roles—including community members, knowledge generators, and connectors—when designing innovation-support interventions for smallholder-dominated sectors. In a related vein, Ferrari, Jugend, Armellini, Barbalho, and de Carvalho (2023) examined how actor boundaries can be crossed to build circular innovation ecosystems in the organic food sector of an emerging economy, underscoring the relevance of these frameworks to commodity sectors, such as sericulture, that combine agricultural production with artisanal or small-scale processing.

Within the Indonesian context specifically, Abdillah et al. (2022) demonstrated the applicability of the Quintuple Helix model to rural governance in East Luwu Regency, South Sulawesi, showing how multi-stakeholder interaction can support socio-ecological resilience and sustainable innovation in a rural, resource-based setting. Their study is instructive for the present paper both because it is set within the same province and because it illustrates how a helix-based model can be adapted to address rural governance challenges that, as in the silk sector, involve fragmented institutional authority and limited inter-actor trust.

Turning to the silk sector itself, several South Sulawesi-focused studies document the specific institutional and social challenges that a multi-stakeholder model would need to address. Harbi et al. (2015) found that the natural silk business in Wajo Regency suffers from an unstable supply of quality cocoon seed and limited access to processing infrastructure, while Sadapotto (2010) compared institutional arrangements across Enrekang, Soppeng, and a Chinese sericulture cluster to argue that stronger, better-coordinated local institutions are a

precondition for improved sector performance. Baso and Sudirman (2020) similarly emphasise the government's underdeveloped facilitating role, while Syukur, Dharmawan, Sunito, and Damanhuri (2014) describe how Bugis-Wajo weavers have had to adapt their traditional practices to modern market pressures, often without adequate institutional support. Taroniarta and Yahya (2022) add a gender dimension, showing that women in Wajo increasingly bear the entire burden of silk production—from mulberry cultivation to weaving—as men shift to more commercially attractive crops, a shift that threatens the sustainability of the sector's labour base and social forestry livelihoods.

Taken together, this body of literature indicates two things relevant to the present study. First, innovation ecosystem and helix-based frameworks provide a theoretically robust and, in the case of Abdillah et al. (2022), regionally proven approach for organising multi-actor collaboration in rural South Sulawesi. Second, the silk-sector literature reveals persistent and well-documented institutional fragmentation, weak governance, and social vulnerabilities that closely match the problems these frameworks are designed to address, echoing Sen's (1999) broader argument that sustainable development ultimately depends on expanding people's real capabilities and agency rather than on production targets alone. Yet, no existing study has combined these two literatures into an integrated model specific to the silk industry. This gap motivates the conceptual model developed in this paper.

2. METHOD

This paper adopts a qualitative, conceptual research design based on literature synthesis rather than empirical fieldwork. Conceptual or theory-building papers of this kind are appropriate when the objective is to integrate previously disconnected bodies of theory and context-specific evidence into a coherent, testable framework, rather than to test hypotheses against newly collected primary data. Accordingly, the model developed here should be understood as a propositional framework intended to guide, and to be refined through, subsequent empirical research, rather than as a validated description of current practice in South Sulawesi.

The literature underlying the model was drawn from two complementary streams. The first comprises theoretical and empirical works on innovation ecosystems and helix-based collaboration frameworks, including foundational contributions (Adner, 2006; Etzkowitz & Leydesdorff, 2000; Carayannis & Campbell, 2009, 2010) and their more recent applications to agricultural, rural, and Indonesian settings (Abdillah et al., 2022; Barbalho et al., 2024; Ferrari et al., 2023; Hoffecker, 2021; Ostrom, 2009). The second stream comprises context-specific studies of South Sulawesi's natural silk industry, spanning institutional, economic, and social-gender perspectives (Baso & Sudirman, 2020; Harbi et al., 2015; Kementerian Kehutanan, 2014; Ridwan, 2011; Sadapotto, 2010; Syukur et al., 2014; Taroniarta & Yahya, 2022). Sources were identified through targeted searches of academic databases and institutional repositories and were selected for their direct relevance to innovation ecosystem theory, helix-based governance, or the South Sulawesi silk value chain.

The two literature streams were analysed thematically and then integrated through a conceptual mapping procedure. First, recurring institutional problems identified in the silk-sector literature (for example, fragmented policy coordination, unclear actor roles, and gendered labour burdens) were extracted and grouped into thematic categories. Second, these categories were mapped onto the actor and governance components of the Quintuple Helix and innovation-ecosystem governance frameworks—government, academia, industry, community, and civil society/media, together with the natural environment as a cross-cutting fifth helix. Third, the resulting actor–function mapping was used to construct a proposed collaborative model, together with governance recommendations informed by the ecosystem life-cycle and governance-effectiveness principles described by Barbalho et al. (2024). This synthesis constitutes the analytical basis for the model presented in the following section.

3. RESULTS

Mapping South Sulawesi's silk-sector actors onto the Quintuple Helix framework produces five interlocking domains. The government helix comprises provincial and district forestry, industry, and trade agencies responsible for mulberry land allocation, extension services, and market facilitation; the persistent policy shortfalls documented by Ridwan (2011) and Kementerian Kehutanan (2014) suggest that this helix currently operates with limited cross-agency coordination. The academic helix includes universities and research institutions capable of improving mulberry varieties, silkworm breeding, and reeling technology, functions that studies of the sector have found to be underdeveloped locally (Harbi et al., 2015; Sadapotto, 2010). The industry helix consists of cocoon processors, thread producers, and weaving enterprises, while the community helix comprises smallholder mulberry farmers and household-based weavers—predominantly women, whose central

but under-supported role is documented by Taroniarta and Yahya (2022). The civil society/media helix, comprising cooperatives, cultural organisations, and communication channels that promote Bugis-Wajo silk identity, corresponds to the actors described by Syukur et al. (2014) as mediating the sector's adaptation to modern markets. Finally, consistent with the Quintuple Helix's distinguishing feature, the natural environment—mulberry agroecology, land-use competition with commercial crops, and disease pressure—is treated as a cross-cutting fifth helix rather than an external constraint, directly reflecting the ecological vulnerabilities noted in the reviewed sericulture literature (Baso & Sudirman, 2020; Kementerian Kehutanan, 2014).

Applying the governance-maturity reasoning of Barbalho et al. (2024) to this actor mapping suggests that South Sulawesi's silk ecosystem currently resembles an early-stage, dispersed ecosystem: institutional roles are unclear, inter-actor trust appears limited, and, as Ridwan (2011) and Sadapotto (2010) both observe, coordination across agencies and value-chain stages is weak. Following the same governance logic, an ecosystem in this condition is unlikely to benefit from a fully decentralised, shared-governance arrangement; it instead requires a clearly mandated coordinating body—for example, a provincial silk development taskforce or secretariat bringing together the relevant forestry, industry, and trade agencies together with university and cooperative representatives—capable of aligning the fragmented interests that earlier studies identify as the sector's core problem (Ridwan, 2011). Over time, as trust and shared objectives develop, governance could evolve toward the more distributed, network-based coordination associated with mature innovation ecosystems.

The model also has to accommodate the specific institutional weaknesses documented in the South Sulawesi silk literature. The chronic mismatch between policy targets and outcomes described by Ridwan (2011) is, in ecosystem terms, a symptom of unclear or unfilled actor roles—precisely the condition that helix-based models are designed to make explicit by assigning each actor group a defined function (knowledge generation, financing, market linkage, production, and cultural promotion) within a single coordinating structure. Sadapotto's (2010) comparative finding that better-organised institutional clusters, such as those observed in China, achieve stronger sericulture performance further supports the proposition that formalising inter-actor coordination, rather than simply increasing production targets, is the more binding constraint on the sector's development.

A further contribution of the proposed model is its explicit attention to social equity within the community helix. Taroniarta and Yahya's (2022) finding that women in Wajo have increasingly become sole actors across the entire silk production process, from mulberry cultivation to weaving, while facing constrained access to social forestry programmes, indicates that any collaborative model for the sector must treat gender-responsive institutional access as a design requirement rather than an afterthought. Within the proposed framework, this implies that the government and civil-society helices should specifically ensure that women silk producers are represented in decision-making forums and prioritised in extension, credit, and social forestry access schemes, consistent with the broader capability-based understanding of development articulated by Sen (1999), in which sustainable outcomes depend on expanding the real opportunities available to those most directly engaged in production. Embedding the natural environment as a fifth helix, rather than treating ecological conditions as background context, also carries direct implications for sustainability. Because mulberry cultivation competes with more commercially attractive crops such as maize (Taroniarta & Yahya, 2022) and remains vulnerable to pest and disease pressure (Baso & Sudirman, 2020), the proposed model treats agroecological support—improved mulberry varieties, integrated pest management, and land-use incentives that make sericulture competitive with alternative crops—as a core ecosystem function rather than a peripheral technical issue. This is consistent with Hoffecker's (2021) argument that inclusive agricultural innovation must attend to the practical, resource-constrained realities faced by smallholders, and with the circular-ecosystem reasoning of Ferrari et al. (2023), which suggests that environmentally embedded value chains are more resilient over the long term than those that treat ecological inputs as externally supplied and unlimited.

Taken together, the proposed model suggests that revitalising South Sulawesi's silk industry depends less on isolated technical or promotional interventions than on establishing a coordinated, multi-helix governance structure that clarifies actor roles, builds inter-institutional trust, protects the position of women producers, and treats environmental sustainability as an integral ecosystem function rather than an external constraint. Because the model has been developed through literature synthesis rather than field validation, its propositions—particularly the specific governance mechanisms and the sequencing from centralised to shared governance—should be treated as hypotheses for future empirical testing, for instance through stakeholder surveys, social network analysis of the type employed by Barbalho et al. (2024), or participatory case studies in Wajo, Soppeng, and Enrekang. Such empirical work would allow the conceptual model presented here to be refined into an operationally validated framework for policy design.

5. CONCLUSION

This paper has developed a conceptual multi-stakeholder innovation ecosystem model for the sustainable development of South Sulawesi's natural silk industry, integrating the Quintuple Helix framework with innovation-ecosystem governance theory and the sector-specific evidence available in the literature. The model identifies government, academia, industry, community, and civil society/media as five interdependent actor domains, embedded within the natural environment as a cross-cutting fifth helix, and proposes a governance pathway that begins with centralised coordination and evolves toward shared, trust-based collaboration as the ecosystem matures. By explicitly incorporating institutional fragmentation, gender equity, and agroecological sustainability—three issues repeatedly documented in prior South Sulawesi sericulture research—the model offers both a theoretical contribution, by extending helix-based innovation ecosystem theory to a previously unexamined artisanal commodity sector, and a practical one, by outlining concrete coordination mechanisms that provincial and district authorities could pursue. As a conceptual synthesis rather than an empirically validated study, the model's propositions should be tested through future field research; nonetheless, it provides a structured starting point for both scholars and policymakers seeking to revitalise South Sulawesi's silk value chain in a manner that is institutionally coordinated, socially inclusive, and environmentally sustainable.

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