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Intergenerational adaptation in a shifting landscape through Traditional Ecological Knowledge (TEK) and forest beekeeping

ANDI RIDHA YAYANK WIJAYANTI[1,♥], ANDI ARAFAT[1], NURHIKMAH[2]

[1]Department of Forestry, Faculty of Agriculture and Forestry, Universitas Sulawesi Barat. Jl. Prof. Dr. Baharuddin Lopa, S.H Talumung, Majene, West Sulawesi, Indonesia. Tel./Fax. +62-422-22559, ♥email: andi.yayank@unsulbar.ac.id

[2]Departement of Forestry, Faculty of Agriculture, Universitas Khairun. Jl. Jusuf Abdulrahman Kampus II, Gambesi, Ternate, North Maluku, Indonesia

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Abstract. *Wijayanti ARY, Arafat A, Nurhikmah. 2026. Intergenerational adaptation in a shifting landscape through Traditional Ecological Knowledge (TEK) and forest beekeeping. Asian J For 10 (1): r100114. https://doi.org/10.13057/asianjfor/r100114.* This article aims to analyze how Traditional Ecological Knowledge (TEK) related to forest beekeeping livelihoods is inherited, transformed, and negotiated across generations under social forestry arrangements. Focusing on the Buttu Puang community forest farmers group (KTH) in Tappina Village, Binuang Sub-district, Polewali Mandar District, West Sulawesi, Indonesia, the study employs a qualitative case study approach grounded in Berkes' corpus-praxis-cosmos framework. Data were collected through in-depth interviews, participant observation, and document analysis to examine intergenerational dynamics of ecological knowledge, forest management practices, and symbolic values amid socio-ecological change, involving 26 community members engaged in forest beekeeping, processing, and related activities. The findings indicate that TEK in forest beekeeping is not a static knowledge system but a dynamic and adaptive process shaped by changes in forest access, market rationalities, and shifting intergenerational values. While core ecological knowledge regarding forest flora and honeybee behavior remains relatively stable, intergenerational differences are evident in the modification of management practices and the reinterpretation of symbolic meanings. Knowledge transmission occurs through selective, situational, and negotiated processes rather than linear inheritance. These patterns indicate that continuity and change coexist within TEK, mediated through ongoing intergenerational negotiation rather than simple erosion or preservation. The study contributes to forestry and ethnobiology scholarship by demonstrating that the resilience of forest-based livelihoods under social forestry arrangements depends on maintaining social and ecological spaces that enable intergenerational learning and knowledge negotiation. Policy implications suggest that social forestry initiatives should move beyond preservation-oriented approaches and actively support adaptive, intergenerationally grounded knowledge systems to sustain community-based forest management.

Keywords: Forest beekeeping, forest management, intergenerational negotiation, traditional ecological knowledge, value transmission

INTRODUCTION

Traditional Ecological Knowledge (TEK) refers to a cumulative body of knowledge, practices, and belief systems developed through long-term interactions between human communities and their natural environments. Beyond functioning as a repository of ecological information, TEK provides a practical framework through which forest-dependent communities organize resource use and sustain their livelihoods (Berkes et al. 2000; Albuquerque et al. 2021). Within forestry contexts, TEK plays a critical role in maintaining forest-based livelihoods while linking ecological management to culturally embedded practices.

Forest beekeeping represents a significant expression of TEK in tropical forest landscapes. In Indonesia, the harvesting of wild honey from *Apis dorsata* remains an important livelihood activity for communities living adjacent to forest areas (Kahono et al. 2018). This species contributes more than 80% of national honey production, underscoring its economic and ecological importance (Schouten et al. 2020). However, forest beekeeping practices are increasingly challenged by ecological degradation and socio-economic change. Climate variability, declining floral resources, pesticide exposure, and forest loss directly affect bee populations and honey yields (Quiroga-Murcia et al. 2017; Buchori et al. 2022). In West Sulawesi alone, primary forest loss reached approximately 93.2 thousand hectares by 2024, accounting for 36% of total tree cover loss and posing significant risks to forest honey ecosystems (Global Forest Watch 2025).

Alongside ecological pressures, intergenerational social change has emerged as a critical challenge to the continuity of TEK. Younger generations increasingly distance themselves from forest-based practices perceived as physically demanding, economically uncertain, or incompatible with modern aspirations (Cristancho and Vining 2009). This process, often described as value resistance, disrupts intergenerational knowledge transmission and contributes to the selective erosion of traditional ecological practices. Similar dynamics have been documented across diverse contexts, including Bolivia (Gruberg et al. 2022), Hawai'i (McMillen et al. 2017), Vietnam (Tran et al. 2025), and India (Koteswara 2024), suggesting that such challenges are structurally embedded within broader development trajectories.

Scholarly debates further complicate understandings of TEK persistence. Some authors argue that TEK survives

primarily due to limited livelihood alternatives and structural poverty, cautioning against its romanticization (Abdullah and Khan 2023; Hartel et al. 2023). In contrast, others emphasize TEK as an expression of epistemic sovereignty, cultural identity, and adaptive resistance to external pressures, particularly in Global South contexts (Albuquerque et al. 2023; Nakagawa et al. 2025). This study positions TEK within this contested terrain, conceptualizing it as an arena where intergenerational adaptation and negotiation unfold in response to shifting socio-ecological and institutional conditions.

Tappina Village in Polewali Mandar District, West Sulawesi, Indonesia, provides an illustrative case of these dynamics. The community continues to practice traditional forest beekeeping, supported by detailed ecological knowledge of flowering cycles, nesting trees, and sustainable harvesting techniques transmitted through the *pangoro wani* (bee handler). However, younger community members increasingly disengage from these practices, echoing patterns observed in other Indonesian regions such as Bengkulu and Sumbawa (Schouten et al. 2020; Suminar 2023). While existing studies on forest beekeeping in Indonesia have largely emphasized technical, ecological, or economic dimensions (Harianja et al. 2023; Kahono et al. 2023), the intergenerational, symbolic, and social processes shaping TEK transmission within forest-based livelihoods remain insufficiently explored.

Against this backdrop, this study aims to analyze how TEK embedded in forest beekeeping practices in Tappina Village is maintained, transformed, and negotiated across generations amid ecological pressures and shifting social values. To achieve this, we employ the corpus-praxis-cosmos framework (Berkes et al. 2000) not as static categories, but as a lens to examine intergenerational dynamics. In this model, corpus refers to locally grounded ecological knowledge of species and habitats; praxis encompasses resource management techniques developed through experiential learning; and cosmos captures the symbolic or spiritual values guiding human-environment relations.

Crucially, we conceptualize knowledge inheritance not as linear transmission, but as a socially mediated and situational process shaped by power relations, aspirations, and institutional contexts (Giacchi et al. 2016; Bautzer and Roger 2020). Within social forestry contexts, these dynamics influence how younger generations selectively adopt, modify, or disengage from established ecological practices. Consequently, the central research question guiding this study is: how is traditional ecological knowledge in forest beekeeping maintained, transmitted, and negotiated under conditions of ecological change and intergenerational transformation?

This study proceeds from the hypothesis that traditional ecological knowledge in forest beekeeping is not transmitted through linear inheritance but is selectively maintained and reworked through intergenerational negotiation. It further hypothesizes that ecological knowledge remains more stable than harvesting practices and symbolic values under conditions of market integration and social forestry governance. To ensure a systematic analysis, this framework is operationalized through specific observation indicators; Table 1 summarizes these analytical dimensions, providing a clear conceptual grounding for the subsequent empirical investigation.

MATERIALS AND METHODS

Study area

The study was conducted in Tappina Village, Binuang Sub-district, Polewali Mandar District, West Sulawesi, Indonesia (Figure 1). Fieldwork was carried out between June and November 2025, covering both the late dry season and the early rainy season. The village is situated adjacent to protected forest areas characterized by tropical lowland forest ecosystems that support diverse flora, including key nectar-producing tree species essential for forest beekeeping. The local forest landscape provides seasonal floral resources that shape honey production cycles and influence the timing of harvesting activities.

Forest use in Tappina Village is predominantly oriented toward non-timber forest products, particularly forest honey harvested from *A. dorsata*. Community members rely on forest beekeeping as a complementary livelihood strategy, integrated with small-scale agriculture and other subsistence activities. Beekeeping practices are closely linked to ecological indicators such as flowering phenology, weather patterns, and forest structure, reflecting a strong dependence on forest ecological integrity. During the period of fieldwork, no atypical climatic events were reported that significantly altered local flowering cycles or honey harvesting activities.

Table 1. Analytical dimensions of traditional ecological knowledge

TEK dimension	Conceptual description	Observation indicators (Operational focus)
Corpus	Local ecological knowledge concerning seasonal cycles, bee habitats, and species-specific behaviors	Identification of forage tree species, seasonal flowering cycles, and bee nesting behaviors across different age groups.
Praxis	Harvesting and management techniques are transmitted through local knowledge and adaptive practices	Documentation of specific honey harvesting methods, use of traditional tools, and observation of intergenerational variations in technical approaches.
Cosmos	The belief systems, symbolic meanings, and spiritual uses embedded within TEK practices	Analysis of community perceptions of bees, symbolic or medicinal values of honey, and spiritual norms guiding forest interactions.

Source: Berkes et al. (2000), with modifications by the author

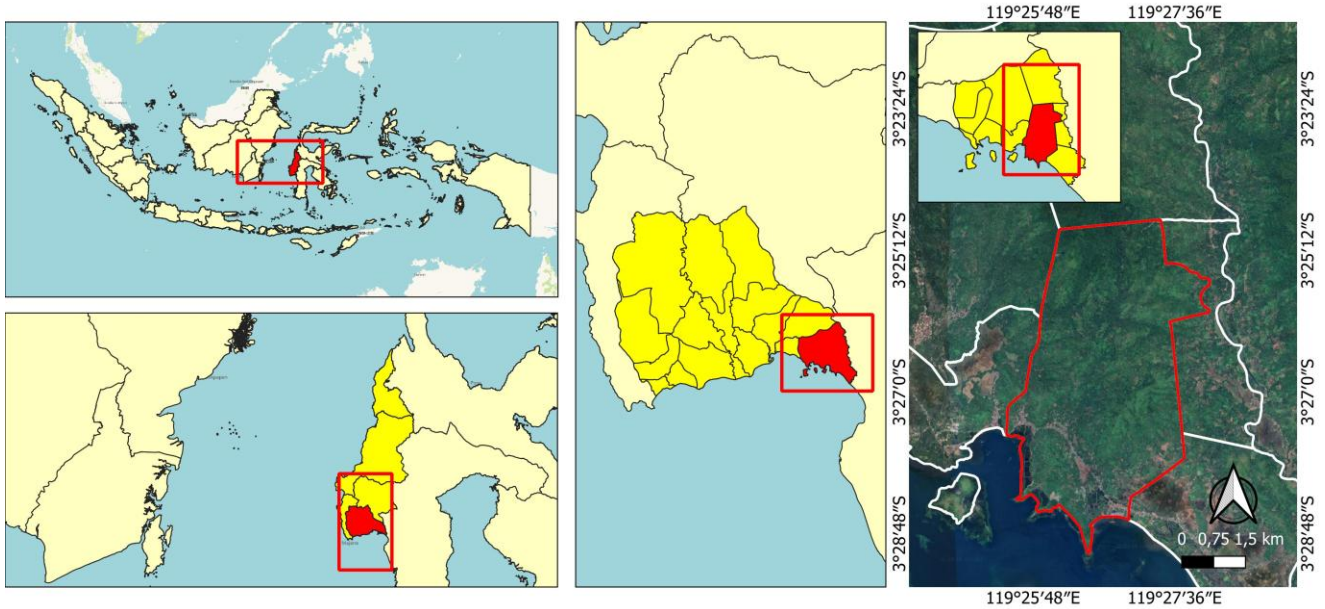

Figure 1. Study area

The forest area utilized by the community is formally recognized under Indonesia's Social Forestry scheme (*Hutan Kemasyarakatan*, HKm). While this institutional arrangement provides a governance framework for forest use, this study focuses primarily on the ecological characteristics of the forest and the ways in which local communities engage with forest resources through traditional beekeeping practices.

Informant selection and positionality

Informant selection was guided by explicit consideration of how social position and institutional roles shape access to knowledge, authority in decision-making, and narrative framing during data generation. Purposive sampling was employed not to achieve representativeness but to capture analytically relevant differences in how forest beekeeping practices and Traditional Ecological Knowledge (TEK) are interpreted and articulated.

A total of 26 informants participated in this study. This included 15 individual semi-structured interviews and two Focus Group Discussions (FGDs) involving 11 participants. Interviewees consisted of senior honey harvesters (n=7) [coded as SH], customary leaders and experienced *pangoro wani* (n=4) [coded as CL], and younger community members engaged in processing, marketing, or alternative beekeeping practices such as *Trigona* cultivation (n=4) [coded as YM]. Participants ranged in age from 21 to 68 years, with 18 men and 8 women. To ensure data traceability while maintaining anonymity, all informants are identified in the findings by these role-based codes followed by a unique number (e.g., SH-01, CL-02).

Senior Harvesters (SH), Customary Leaders (CL), and experienced *pangoro wani* occupy positions of symbolic authority and ecological expertise. Their narratives tend to emphasize continuity, moral responsibility toward the forest, and the legitimacy of established practices. In contrast, Younger Members (YM) and individuals involved in processing, marketing, or alternative beekeeping practices often articulated more pragmatic or ambivalent perspectives shaped by market exposure, formal education, and aspirations for livelihood diversification. These positional differences influence not only the content of knowledge shared but also the meanings attached to ecological change and the perceived relevance of traditional practices.

Gendered roles further mediate access to specific forms of knowledge. Women involved in honey processing and marketing (n=8) [coded as WL] provided insights into post-harvest practices and value chains that are often less visible in narratives dominated by male harvesters. Recognizing these positional dynamics, the study treated informants' accounts as situated interpretations rather than neutral representations of TEK. Divergent narratives were intentionally preserved and analytically compared to examine how knowledge transmission and intergenerational negotiation unfold across differentiated social positions.

Data collection

Data collection focused on generating empirical material relevant to understanding how traditional ecological knowledge is structured, transmitted, and transformed, rather than documenting procedural sequences of activities. Participant observation, semi-structured interviews, and focus group discussions were employed as complementary strategies to access different dimensions of TEK.

Participant observation was conducted over approximately 45 fieldwork days, allowing for the documentation of embodied practices and everyday interactions through which ecological knowledge is enacted

and negotiated. Observations were recorded through detailed field notes compiled on a daily basis.

A total of 15 semi-structured interviews were conducted with key informants. Interviews typically lasted between 60 and 90 minutes and were audio-recorded with participants' consent. All interviews were subsequently transcribed verbatim to support systematic analysis.

In addition, two intergenerational Focus Group Discussions (FGDs) were organized, involving 11 participants in total. Each FGD lasted approximately 120 minutes and was facilitated to surface collective deliberations, points of tension, and areas of alignment between actors with differing experiential backgrounds. Audio recordings and supplementary field notes were used to document group interactions. Together, these methods enabled triangulation across practice, discourse, and shared meaning-making processes. All participant provided informed consent prior to interview and discussions.

Data analysis

Data analysis followed an iterative thematic analysis process. Coding was conducted primarily by the first author, with regular analytical discussions involving all co-authors to refine code definitions, resolve ambiguities, and ensure analytical consistency.

All interview transcripts, FGD transcripts, and field notes were coded manually using spreadsheet-based coding matrices to facilitate systematic organization and retrieval of empirical material. Initial open coding was applied to identify recurring patterns related to ecological knowledge, harvesting practices, symbolic meanings, and intergenerational interactions. Codes were then refined through constant comparison across age groups, gender, and institutional positions.

To enhance analytical rigor, coding decisions and emerging themes were iteratively reviewed through peer debriefing among the research team. Discrepant interpretations were discussed until consensus was reached. An audit trail was maintained through coding memos and reflexive notes documenting analytical decisions throughout the research process. Themes were subsequently consolidated by examining how empirical patterns related to broader socio-ecological processes such as livelihood change, governance arrangements, and value negotiation. Throughout the analysis, commonly used TEK dimensions, including knowledge corpus, practices, and underlying worldviews, functioned as sensitizing concepts rather than as a predefined analytical framework, allowing themes to emerge inductively from the data.

RESULTS AND DISCUSSION

Ecological knowledge of bees and their environment (Corpus)

Detailed, experience-based interpretations of seasonal patterns, vegetation, and bee behavior characterize the ecological knowledge of the Tappina community regarding forest bees. Community members identify the flowering of specific tree species, such as durian (*Durio zibethinus*), langsat (*Lansium domesticum*), guava (*Psidium guajava*), nato, and breadfruit, as reliable indicators of the onset and intensity of the honey-harvesting season. As explained by a local harvester:

"When the forest trees begin to flower, usually durian, the bees will start building their nests; that is the sign we usually look for." (SH-02)

These floral cues are utilized not only to anticipate honey availability but also to plan harvesting activities and labor allocation.

Local interpretations of *A. dorsata* behavior further extend to micro-environmental indicators. Informants explained that hive placement varies according to wind conditions: during calm seasons, hives are commonly found higher in tree canopies, whereas in periods of strong winds, they tend to be located at lower positions.

"We pay attention to the wind direction," noted an elder, *"because if it is a windy season, the bees build their nests on lower branches for safety."* (CL-01)

Such observations guide harvesters in predicting hive locations and adjusting climbing strategies, thereby reducing physical risk during harvesting. Several senior harvesters described using the flight direction of bees as a practical navigation tool to locate hives deep within the forest. Rather than relying on mapped coordinates or external markers, harvesters follow recurring flight paths observed during peak foraging times. One harvester commented:

"We simply need to follow their flight path; that is what we use." (SH-05)

This knowledge, accumulated through repeated encounters with forest landscapes, demonstrates a form of ecological orientation embedded in everyday practice. Despite the continued relevance of this knowledge among senior practitioners, interviews indicate a growing gap in understanding among younger community members. Many younger individuals are unable to identify key forage tree species or interpret ecological indicators related to bee behavior.

"Young people today enter the forest merely for leisure or tourism," a senior practitioner observed. *"Since they spend more time outside the forest, their attention to the relationship between trees and bees is very minimal."* (WL-03)

Reduced time spent in forest-based activities, combined with increasing engagement in non-forestry livelihoods, has limited opportunities for experiential learning. Consequently, ecological knowledge once acquired through routine forest interaction is now unevenly distributed across generations, with significant implications for the continuity of forest beekeeping practices.

Management practices and honey harvesting techniques (Praxis)

Forest beekeeping practices in Tappina are structured around a shared set of harvesting principles that emphasize minimizing disturbance to bees and maintaining honey quality. Across generations, harvesters recognize the importance of controlled smoke derived from natural materials to calm bees during extraction. While specific

smoking materials may vary, the underlying principle-avoiding excessive heat and contamination-remains consistent.

"The smoke is only to calm them; we create it by burning vegetation. We do not use oil to generate thick smoke," explained a practitioner. *"If it is too hot, the bees will die, and the honey will taste different."* (SH-01)

Assessment of hive readiness also reflects a common ecological logic. Harvesters rely on situational indicators, such as hive stability and bee aggressiveness, to determine appropriate harvesting times. These indicators function as decision-making tools that reduce the risk of premature harvesting and colony weakening. An experienced harvester noted:

"We do not rush; we wait until the bees are calm, which indicates the honey is ready." (SH-07)

These practices illustrate a shared practical understanding of bee behavior and forest conditions. Intergenerational differences emerge primarily in how these practices are evaluated and prioritized, rather than in their basic logic. Senior harvesters tend to emphasize caution, patience, and ecological attentiveness, viewing prolonged time in the forest as integral to responsible harvesting. In contrast, younger members increasingly assess practices through the lenses of efficiency, physical safety, and time investment, particularly when exposed to techniques introduced through external training or alternative beekeeping models. A young harvester admitted:

"We want to finish quickly and safely; we cannot stay in the forest as long as our parents did in the past; being fast and productive is better." (YM-01)

Rather than a complete shift away from traditional practices, the observed pattern is one of selective modification. Younger harvesters often retain core principles-such as avoiding contamination and preventing colony damage-while adjusting techniques to accommodate labor availability, risk perception, and market demands.

"We still use the old ways," added another youth, *"but we also have to think about how quickly the honey can be sold."* (YM-03)

Consequently, harvesting practices in Tappina reflect an evolving praxis in which sustainability and change coexist, shaped by generational priorities and practical constraints.

Symbolic values and bee cosmology (Cosmos)

In Tappina, symbolic meanings attached to bees and honey are closely intertwined with broader socio-ecological conditions shaping forest use and livelihoods. Among senior community members, bees are understood as morally charged forest beings whose presence reflects ecological balance and social order. Practices such as using honey or honeycomb for healing and protection are embedded in a worldview that links forest health, human well-being, and ethical conduct.

These symbolic values also function as informal governance mechanisms regulating access to forest resources. Customary prohibitions against harvesting marked hives and ethical considerations regarding harvest timing reinforce collective norms of restraint and reciprocity. Such norms have historically supported sustainable engagement with forest ecosystems in contexts where formal regulation was limited, and livelihood security depended on long-term forest integrity.

However, shifts in forest governance, market integration, and livelihood strategies have reshaped the conditions under which these symbolic meanings are reproduced. The formalization of forest access through social forestry arrangements, combined with increased market demand for honey, has altered how forest resources are valued and utilized. Within this changing context, younger community members increasingly frame bees and honey in economic and functional terms, emphasizing income generation, efficiency, and product quality rather than spiritual or moral attributes.

This symbolic reorientation reflects broader socio-ecological transformations rather than a simple erosion of tradition. As forest-based livelihoods become more diversified and embedded in market networks, meanings attached to honey are recalibrated to align with new forms of legitimacy and value. Spiritual idioms give way to secular narratives-such as branding honey as a "natural" or "healthy" product-that resonate with contemporary markets while retaining traces of older ethical concerns regarding purity, responsibility, and sustainability.

Thus, changes in the cosmological dimension of beekeeping practices mirror shifts in forest access, governance, and economic orientation. Symbolic values are not disappearing but are being selectively reworked in response to evolving socio-ecological realities. Bee-related cosmologies in Tappina therefore represent a dynamic site where moral frameworks, livelihood strategies, and forest governance intersect, revealing how communities negotiate continuity and change within forest-based knowledge systems.

Discussion

Intergenerational negotiation and the future trajectory of TEK

The findings demonstrate that Traditional Ecological Knowledge (TEK) related to forest beekeeping in Tappina Village persists not as a fixed heritage, but as a relational and negotiated system linking humans, forest ecosystems, and bees. Across the three dimensions of TEK, continuity is evident but uneven. Ecological knowledge regarding bee behavior and seasonal indicators (corpus) remains most strongly retained among senior practitioners; harvesting techniques and management practices (praxis) show increasing variation across age groups; while symbolic meanings and ethical values (cosmos) are undergoing the most pronounced reinterpretation.

Intergenerational negotiation emerges as a central mechanism shaping these dynamics. Rather than a linear process of knowledge transfer, TEK inheritance in Tappina unfolds through selective adoption, reinterpretation, and hybridization. Younger community members do not entirely abandon local knowledge but tend to recalibrate it in response to shifting livelihood aspirations, market integration, and formal education. This is reflected, for example, in the preference for efficiency-oriented

harvesting techniques and in the reframing of honey from a spiritually charged substance to a health-oriented commodity with economic value.

These patterns indicate that continuity and change coexist within TEK, structured by broader socio-ecological transformations. Changes in forest access arrangements under social forestry schemes, diversification of income sources, and growing engagement with external markets have reshaped the conditions under which local knowledge is valued and practiced (Sirimorok et al. 2024). As a result, certain dimensions of TEK-particularly symbolic and ethical frameworks-are more vulnerable to reinterpretation, while others remain anchored in direct ecological experience.

From an analytical perspective, the future trajectory of TEK in Tappina depends less on the preservation of specific techniques than on the maintenance of social and ecological spaces that enable intergenerational interaction and negotiation. Where such spaces persist, through collective forest management, shared harvesting activities, and community institutions, TEK retains the capacity to adapt and regenerate. Conversely, when these spaces diminish, knowledge risks becoming fragmented or reduced to its instrumental components. In this sense, TEK in forest beekeeping should be understood not as a declining tradition, but as a dynamic knowledge system whose sustainability is closely tied to forest governance arrangements and livelihood opportunities.

Traditional ecological knowledge as a negotiated socio-ecological system

The findings of this study reinforce and extend existing scholarship that conceptualizes Traditional Ecological Knowledge (TEK) not as a static inheritance, but as a dynamic and negotiated socio-ecological system. Similar to studies on forest-based livelihoods in Southeast Asia (Dressler et al. 2017; McElwee et al. 2020), the case of forest beekeeping in Tappina illustrates that TEK is continuously reshaped through interactions between ecological conditions, livelihood imperatives, and institutional arrangements.

Unlike early formulations that emphasized TEK primarily as a repository of conservation-oriented values, the evidence from Tappina aligns with more recent perspectives that view TEK as internally differentiated and context-dependent. The uneven persistence of corpus, praxis, and cosmos across generations reflects findings from etnobotanical research among the Mien in community forestry in Thailand and Vietnam (Panyadee et al. 2024), as well as da Silva et al. (2019) on the Fulni-ô in Northeast Brazil, where experiential ecological knowledge tends to persist longer than symbolic or ritual dimensions under conditions of market integration and livelihood diversification.

This interpretation suggests that the sustainability of TEK cannot be assessed solely by the retention of symbolic traditions, but must be understood in relation to the social and ecological spaces that enable ongoing negotiation. In this sense, TEK operates less as a bounded cultural asset and more as a relational system whose continuity depends on its capacity to remain relevant within changing socio-ecological contexts.

Social forestry, livelihood transformation, and intergenerational negotiation

The case of Tappina contributes to broader debates on social forestry in Southeast Asia by illustrating how formalized forest tenure reshapes not only access and governance, but also knowledge systems. Consistent with studies from Indonesia (Toumbourou et al. 2025), and the Philippines (Chechina et al. 2018), social forestry arrangements tend to stabilize land access and community governance. Meanwhile, evidence from Laos (Phimmavong and Keenan 2020) highlights how collaborative agroforestry models can increase market exposure and diversify livelihood opportunities for participating households.

In Tappina, these shifts have created new arenas for intergenerational negotiation. Younger community members increasingly engage with forest beekeeping through economic rationalities-prioritizing efficiency, safety, and marketability-while older generations emphasize ethical restraint, ecological balance, and customary authority. Similar patterns have been documented in community forestry initiatives in Kalimantan (Omar et al. 2025) and Northern Thailand (Apipoonyanon et al. 2020), where youth participation often hinges on the perceived economic viability of forest-based activities (Robson et al. 2020; Bamwesigye et al. 2024; Le and Shinjo 2025).

These findings suggest that social forestry programs inadvertently act as catalysts for knowledge transformation. By integrating communities into formal governance and market systems, such programs reshape what kinds of knowledge are valued and reproduced. TEK is not displaced, but selectively reconfigured, with implications for how sustainability is enacted in practice.

Implications for social forestry practice

The findings offer several practical insights for social forestry implementation. First, programs that focus exclusively on technical training risk privileging efficiency-oriented knowledge while marginalizing ethical and relational dimensions of TEK. Incorporating intergenerational learning spaces, such as collective harvesting activities or mentoring between senior and junior practitioners, can help sustain negotiated forms of knowledge transmission.

Second, recognizing forest-based livelihoods as cultural as well as economic practices allows social forestry initiatives to better align sustainability goals with community values. In the context of forest beekeeping, this entails supporting not only market access but also the social institutions that regulate harvesting norms and ecological restraint.

Finally, social forestry policies should acknowledge that knowledge transformation is inevitable. Rather than aiming to "preserve" TEK in fixed forms, interventions should facilitate adaptive continuity, enabling communities

to reinterpret their knowledge while maintaining its ecological grounding.

Research limitations and reflexivity

This study is subject to several limitations. As a single-case qualitative study, its findings are not statistically generalizable. However, the analytical insights offered are transferable to similar socio-ecological contexts where forest-based livelihoods intersect with social forestry governance. Temporal limitations also apply, as fieldwork captured a specific phase of the beekeeping cycle. Longitudinal research would be valuable to assess how intergenerational negotiations evolve. Additionally, the researcher's positionality, as an external observer with academic affiliation, may have influenced how informants articulated knowledge and values, particularly in discussions involving authority and tradition. Reflexive engagement and triangulation were employed to mitigate these effects, yet they cannot be fully eliminated.

In conclusion, this study contributes to the literature on traditional ecological knowledge by demonstrating that TEK in forest beekeeping operates as a dynamic and negotiated socio-ecological system rather than a static inheritance. Drawing on qualitative evidence from 26 informants (15 semi-structured interviews and 2 intergenerational focus group discussions), the analysis shows that intergenerational negotiation is central to how knowledge, practices, and values are selectively maintained and transformed under social forestry arrangements. Empirical findings indicate uneven continuity across TEK dimensions. Ecological knowledge related to flowering cycles, forage tree identification, and *A. dorsata* behavior (corpus) remains most strongly retained among senior practitioners, particularly experienced *pangoro wani*. In contrast, harvesting and management practices (praxis) show increasing modification among younger actors, who prioritize efficiency, physical safety, and market responsiveness. The symbolic and ethical dimensions of beekeeping (cosmos) exhibit the greatest degree of reinterpretation, with younger generations increasingly framing honey as an economic and health-oriented commodity rather than a spiritually charged forest resource.

The findings highlight that changes in forest governance and market integration do not simply erode TEK but reshape its forms and meanings. In the context of social forestry, TEK persists through adaptation, provided that social and ecological spaces for intergenerational interaction remain intact. These insights underscore the importance of recognizing knowledge negotiation as a key mechanism linking forest-based livelihoods, sustainability, and community-based forest management. The case, therefore, offers a robust empirical basis for comparative debates on how indigenous knowledge systems navigate the pressures of market integration and formalized conservation. Future research should employ longitudinal designs to trace intergenerational knowledge change over time and comparative analyses across multiple social forestry sites to examine how governance arrangements influence TEK trajectories. Integrating qualitative insights with ecological and livelihood performance indicators would further strengthen the understanding of how negotiated knowledge systems shape long-term sustainability.

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