

A quantitative and network analysis of traditional ecological knowledge on seagrass ecosystems in the Philippines

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Abstract. Amores AE, Aguilar SNA. 2026. A quantitative and network analysis of traditional ecological knowledge on seagrass ecosystems in the Philippines. *Asian J Ethnobiol* 9: y090104. <https://doi.org/10.13057/asianjethnobiol/y090104>. Traditional Ecological Knowledge (TEK) plays a crucial role in sustaining biodiversity, guiding resource stewardship, and supporting the long-term resilience of coastal communities. Within this knowledge system, seagrass ecosystems hold particular importance because they underpin fisheries, carbon storage, and shoreline stability. This study provides a novel quantitative framework for assessing TEK structure, offering insights for its documentation and conservation in rapidly modernizing coastal communities. Focusing on Barangay Lawigan in Davao Oriental, Philippines, the research examines how ecological awareness, traditional practices, and management actions interact to shape seagrass ethnobiology and local trusteeship. Structured surveys were administered to 344 residents and evaluated using a five-point Likert scale. Radar plot and network analysis were employed to map inter-indicator relationships, and demographic correlations were examined. The result revealed that ecological awareness has the highest mean score of 4.7, demonstrating a strong environmental understanding, reflecting a high level of awareness regarding ecological concerns of seagrass, however, moderate management/conservation practices, and lower traditional practices/uses. Ecological awareness was identified as the most central and well-integrated TEK component, whereas other indicators appeared more dispersed. Moreover, long-term residency exhibited only a weak correlation with short-term residency ($r = 0.07$), but showed a strong association with gender ($r = 0.945$) and a moderate correlation with income ($r = 0.465$). It also revealed a strong correlation between ecological awareness and management practices, but weaker ties with traditional uses, suggesting risks of cultural erosion. These findings reveal a core-periphery TEK structure in Lawigan, where high cognitive awareness is not fully translated into traditional practice. To strengthen TEK-based conservation, strategies should promote intergenerational learning programs, participatory policy-making, and gender-inclusive documentation with an adaptive co-management framework could enhance ecological resilience, offering a potential model for seagrass conservation throughout the broader Davao region.

Keywords: Barangay Lawigan, network analysis, Philippines, seagrass diversity, traditional ecological knowledge

Abbreviations: EA: Ecological Awareness, MCP: Management and Conservation Practices, TEK: Traditional Ecological Knowledge, TPU: Traditional Practices and USES

INTRODUCTION

Seagrass ecosystems rank among the most vital and productive habitats in coastal waters, providing essential ecological functions that include stabilizing shorelines, storing carbon, cycling nutrients, and supporting diverse marine life such as fish and invertebrates (Cotas et al. 2023; Kirsten 2023). Despite their ecological and economic importance, seagrass meadows are increasingly threatened by anthropogenic activities, including destructive fishing practices (Turschwell et al. 2021), coastal development, pollution, and climate change (Tang and Hadibarata 2022). A study by Sudo et al. (2021) that analyzed seagrass beds in nine countries in Southeast Asia reported a 60% decline of seagrass beds at an average rate of 11% year⁻¹, whereas 20% of beds increased at an average rate of 8% year⁻¹, leading to an overall average decline of 5% year⁻¹.

Amid escalating pressures on marine ecosystems, integrating Traditional Ecological Knowledge (TEK) into conservation strategies has become increasingly vital (Robinson et al. 2021). In the Philippines, where coastal cultures and marine biodiversity are both exceptionally rich, TEK related to seagrass ecosystems remains under-documented and is still predominantly examined through qualitative accounts (Quevedo et al. 2020). By addressing this gap, the present study advances the quantitative and structural understanding of TEK systems, offering a level of analytical resolution that is rarely applied in ethnobiology and essential for shaping evidence-based, community-grounded conservation efforts. This lack of quantitative assessment limits understanding of how well communities identify seagrass species, perceive ecosystem services, and apply management practices, thereby constraining efforts to design effective, culturally grounded co-management frameworks. TEK offers long-term ecological insights often overlooked by

conventional science (Cilliers et al. 2021), yet it is frequently undervalued or detached from its cultural roots in governance systems (Singleton et al. 2023; Ricketts 2024). Quantifying TEK is therefore essential to move beyond anecdotal accounts, strengthen ecological monitoring, and promote community-based conservation grounded in local knowledge and custodianship (Rai et al. 2024; Tran et al. 2025).

Moreover, this study advances TEK assessment in the Philippines by applying a novel mixed-methods approach that integrates structured surveys with quantitative scoring and network analysis. Rather than treating TEK as purely anecdotal or intangible, a five-point Likert scale is used to quantify ecological awareness, traditional uses, and conservation practices among residents of Barangay Lawigan, City of Mati, Davao Oriental. These values are visualized through radar plots to illustrate strengths and gaps across key TEK dimensions. Complementing this, network analysis maps the structural relationships among indicators and demographic variables, offering a systems-level view of how cognitive and practical aspects of seagrass-related knowledge interact within the community. This approach addresses a notable gap in Southeast Asian ethnobiological research, where TEK is seldom examined through quantitative or structural methods.

The novelty of this study lies in two contributions. First, it demonstrates a method for quantifying TEK at the community level, generating numerical data that allows for comparisons across groups and over time. This approach moves beyond descriptive accounts and provides a baseline for measuring knowledge erosion or growth. Second, by applying network analysis, the study reveals how TEK components are interconnected, identifying which indicators act as central nodes and which are more peripheral. This systemic mapping offers insights not only into what people know, but how different forms of knowledge and practice reinforce or weaken each other (Luxton and Sbicca 2021; Ateş and Luzzini 2024; Pusz et al. 2024).

Specifically, the study aims to assess levels of TEK in terms of ecological awareness, traditional practices, and conservation practices among Lawigan residents; to analyze the relationships among these indicators, clarifying the links between ecological awareness, traditional uses, and management practices; and to examine the role of demographic factors such as gender, income, and residency in shaping TEK patterns. By addressing these objectives, the research provides robust, quantitative insights that can inform environmental education, policy design, and co-management strategies.

MATERIALS AND METHODS

Study area

The study was conducted in the coastal community of Lawigan, Mati City, Mindanao, Philippines, in 6°49'01.1"N 126°19'25.6"E (Figure 1). This area is known for its rich marine biodiversity and reliance on coastal ecosystems for livelihoods and cultural practices.

Research design

The study employs a comparative analysis approach to examine the interrelationship and differences among ecological awareness, traditional practices and uses, and conservation and management practices across selected purok, a small-scale community, in Barangay Lawigan. The design enables the identification of patterns, gaps, and correlations by comparing how the level of ecological awareness influences the adoption of traditional uses (such as for food, fertilizer, livestock, or cultural purposes) and how these practices align with or challenge contemporary conservation and management approaches. By examining these indicators, the study seeks to highlight the roles of traditional ecological knowledge in seagrass ecosystem sustainability and identify potential pathways for integrating indigenous and local practices into a formal conservation framework.

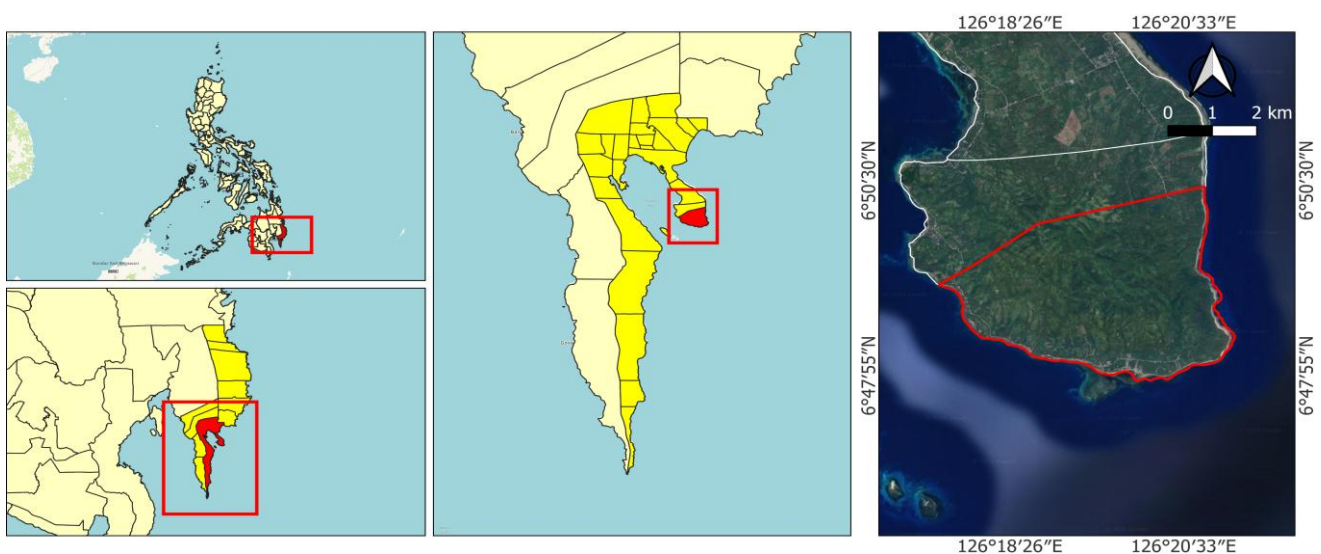


Figure 1. Map of study location in Barangay Lawigan, City of Mati, Davao Oriental, Philippines

Data gathering procedure

The survey sample size was determined using a statistical formula based on the estimated total population of 3,202 across the study communities. Employing a 95% confidence level and a 5% margin of error, the minimum required sample size was calculated to be 344 respondents. A simple random sampling technique was utilized to ensure unbiased representation, focusing specifically on residents with a minimum of 20 years of tenure in the area, thereby ensuring the inclusion of individuals with substantial temporal interaction with the local environment. Also, respondents who regularly interact with the coastal environment, such as those involved in fishing, gleaning, seaweed or oyster collection, or routine activities along the shoreline. This ensures their knowledge reflects actual ecological encounters rather than second-hand information. Community-based local guides facilitated the identification and recruitment of qualified respondents. To reduce potential response bias, interviewers underwent orientation to ensure neutrality and consistency in administering the survey. Additionally, respondents were assured that their answers would be anonymized and used solely for academic purposes.

Prior to data collection, informed consent was obtained from all participants after explaining the study's objectives, procedures, and confidentiality measures. Participation was voluntary, and respondents could withdraw at any point without penalty. Moreover, respondents were asked to rate their level of agreement with statements related to seagrass conservation. For negatively worded items, reverse coding was applied to maintain consistency, so that higher scores always indicate stronger ecological awareness or positive attitudes toward conservation. To establish reliability, internal consistency of the instrument was tested using Cronbach's alpha. Results indicated good reliability across the TEK dimensions: ecological awareness ($\alpha = 0.84$), traditional practices and uses ($\alpha = 0.78$), and management/conservation practices ($\alpha = 0.81$). The overall instrument achieved strong reliability ($\alpha = 0.86$), which falls within the acceptable range of 0.70-0.90 for social science research (Taber 2018; Karakaya and Alparslan 2022).

Ethical approval for this study was secured from the University Review Ethics Board (UREB) of Davao Oriental State University, with an exemption decision ID No. 2024-17-SNAgUILAR-Intertidal Seagrass, ensuring adherence to ethical standards for human research. In addition to reliability testing, data validation involved expert evaluation of the instrument's structure and content to confirm its relevance, clarity, and cultural appropriateness. All necessary permits and clearances from institutional and local authorities were obtained prior to data collection, ensuring compliance with ethical and administrative protocols.

Data analysis

The study employed a structured data analysis approach to evaluate the level and interrelationship of Traditional Ecological Knowledge (TEK) among community members in Barangay Lawigan. All statistical analyses, including correlation coefficients, Pearson's correlation coefficient

(r), network plot visualizations, and radar plots, were performed using PAST software.

Statistical tools

Data analyses were conducted to quantify the level of Traditional Ecological Knowledge (TEK) and to explore the relationships among its constituent indicators. Descriptive statistics (mean, standard deviation, and frequency distribution) were computed to summarize respondents' scores for each item, each TEK dimension, and the composite TEK index. The mean served as the primary indicator of the overall level of knowledge, practice, or perception, while standard deviation quantified the degree of variation among respondents.

To examine associations among TEK indicators and demographic factors, Pearson's correlation coefficient (r) was employed. This parametric test was selected to detect the strength and direction of linear relationships between paired continuous variables. Statistical significance was evaluated at $\alpha = 0.05$, permutation-based p-values were generated to increase robustness, particularly in cases of non-normal data distribution, and Bonferroni correction was applied to account for multiple comparisons, thereby minimizing the risk of Type I errors.

In addition, network plot analysis was used to visualize how individual indicators relate to one another within and across TEK dimensions. Co-occurrence matrices derived from respondents' answers were transformed into network graphs, where nodes represent specific knowledge elements or practices, like the ecological awareness items, traditional uses, or conservation actions, and edges indicate the strength of their co-occurrence in the community. This visualization provides a holistic view of how the cognitive and behavioral aspects of TEK are structurally embedded in the community's knowledge system.

Lastly, a radar plot was used to identify strengths, weaknesses, and patterns of knowledge distribution within a community. This multidimensional visualization not only facilitates the detection of disparities between indicators, such as high ecological awareness but low practice adoption, but also allows for comparative analysis across demographic groups or time periods.

RESULTS AND DISCUSSION

Demographics

Table 1 presents the distribution of traditional ecological knowledge (TEK) in terms of Ecological Awareness (EA), Traditional Practices and Uses (TPU), and Management and Conservation Practices (MCP) mean scores across demographic factors. It reveals the mean values increase progressively with age across all three indicators, with EA has the highest mean scores rising from 4.4 to 4.9 in age below 18 to 61-up group, respectively, follows MCP with similar increasing trend. However, TPU demonstrates fewer mean scores compare to the two TEK indicators. At the same time, the length of residency has a strong correlational factor. The mean scores show a steady rise across residency categories. The monotonic increase indicates a strong

positive correlation between years of residence and TEK indicators, particularly for TPU and MCP, where the gain is steeper. In gender, females and males show higher EA and MCP. Although the differences are modest, they indicate systematic, non-random variation between gender groups. This suggests that gender roles, gleaned, household environmental management, fishing, structure the distribution of TEK components. Lastly, lower-income respondents show higher TPU with the mean of 3.7 but slightly lower MCP (4.3), while the highest-income group shows lower TPU but higher MCP. This indicates a negative association between income and TPU, and a positive association between income and MCP. These patterns reflect contrasting modes of resource engagement, subsistence-based knowledge versus institutionally mediated conservation practices.

The demographic findings suggest that knowledge of seagrass ecosystems is primarily shaped by a middle-aged, male-dominated population, potentially influencing both the type and focus of ecological knowledge shared. This aligns with the findings of Okui et al. (2021) and Rollo (2025), who observed that communities with a large proportion of long-term residents tend to have strong potential for intergenerational transmission of TEK and sustained conservation practices. However, the smaller proportion of younger and short-term residents may indicate gaps in knowledge continuity, as these groups might have limited exposure to traditional ecological practices (Mekonnen et al. 2022).

The predominance of long-term residents provides a favorable condition for implementing sustained ecological initiatives (Wollschlaeger et al. 2022; Tang et al. 2023), as these individuals possess historical and contextual understanding of local environmental dynamics (Spilker et al. 2020; van Horne et al. 2023; Kharchuk 2024).

Table 1. Distribution of traditional ecological knowledge mean scores across demographic groups

Demographic factors	Category	%	EA	TPU	MCP
Age	Below 18	3	4.4	3.2	4
	18-20	0	-	-	-
	21-30	23	4.6	3.3	4.1
	31-40	23	4.7	3.4	4.2
	41-50	23	4.8	3.6	4.3
	51-60	19	4.9	3.8	4.4
Years of residence	61-up	9	4.9	3.9	4.5
	0-10	10	4.5	3.1	4
	11-20	15	4.6	3.3	4.1
	21-30	17	4.7	3.4	4.2
	31-40	13	4.8	3.6	4.3
	41-50	17	4.8	3.7	4.4
Gender	51-60	20	4.9	3.8	4.4
	61-70	5	4.9	3.9	4.5
	71-80	3	4.9	4	4.5
	Female	65	4.8	3.6	4.3
Monthly income	Male	35	4.6	3.5	4.1
	Below ₱13,000	90	4.7	3.5	4.2
	₱30,001-₱40,000	8	4.8	3.7	4.3
	₱50,000 up	3	4.9	3.8	4.4

Economic data further emphasize the need for cost-sensitive conservation programs. With most respondents earning below ₱13,000 per month, many may lack the financial capacity to adopt resource-intensive or technology-based conservation measures. Hence, ecological awareness and management programs should prioritize low-cost (Zhao et al. 2022), community-based approaches (Leach et al. 2025), and explore partnerships with higher-income stakeholders or supporting institutions (Birendra et al. 2021; Pollock et al. 2024).

Overall, the patterns, especially the lower TPU scores among younger and migrant respondents, point to a gradual weakening of biocultural diversity, since traditional ecological practices are deeply interwoven with cultural identity, livelihood strategies, and place-based knowledge. The highest TPU and MCP values appearing among elders and long-term residents suggest that biocultural memory is becoming concentrated within a narrower segment of the community rather than shared evenly across generations and social groups. Such demographic clustering heightens the risk of knowledge bottlenecks, weakened intergenerational transmission, and a decline in culturally rooted approaches to resource environmental responsibility. On the other hand, the consistently high EA scores show that cultural values and attitudes toward the environment remain strong across all groups; however, these values may not automatically translate into sustained practice unless intentionally supported, revitalized, and reinforced within the community.

Level of traditional ecological knowledge of the community members in Barangay Lawigan

Figure 2 presents the levels of Traditional Ecological Knowledge (TEK) across three indicator areas among community members of Barangay Lawigan: Ecological Awareness (EA), Traditional Practices and Uses (TPU), and Management and Conservation Practices (MCP). The results reveal notable variation among these domains.

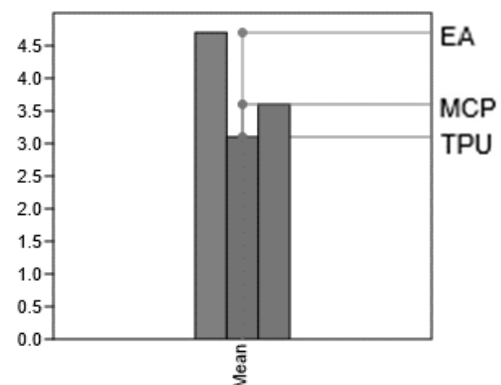


Figure 2. Level of Traditional Ecological Knowledge (TEK) in terms of Ecological Awareness (EA), Traditional Practices and Uses (TPU), and Management and Conservation Practices (MCP) among community members in Barangay Lawigan, City of Mati, Davao Oriental, Philippines

EA received the highest mean score of 4.7, indicating that participants possess a strong understanding of environmental issues and the ecological significance of seagrass habitats. This reflects a high level of cognitive and perceptual awareness of local environmental dynamics. TPU recorded the lowest mean score of 3.1, suggesting moderate engagement with or familiarity with ancestral or indigenous ecological practices. This points to a limited application or transmission of traditional ecological methods in contemporary community life. Meanwhile, MCP achieved a mean score of 3.6, indicating a fair level of participation or knowledge in conservation-related activities. This reflects a growing, yet not fully institutionalized, engagement with conservation practices within the community.

The strong EA observed among respondents aligns with findings by Gómez et al. (2025), underscoring ecological literacy as a foundational element of local resource governance in coastal ecosystems. This awareness is likely reinforced by the community's direct dependence on nearshore and seagrass-associated resources, where daily exposure to environmental change fosters practical understanding of ecosystem functions. However, the comparatively lower scores in TPU suggest that while ecological concepts remain recognized, the embodied and practice-based dimensions of TEK are undergoing transformation. This shift may be linked to localized processes such as youth out-migration for education and employment considering that the community is miles away from the city proper, which disrupts intergenerational transmission pathways, as well as the increasing influence of formal education systems that prioritize standardized environmental knowledge over locally embedded practices.

Livelihood diversification in Barangay Lawigan provides important context for observed transformation of TEK. As households increasingly move beyond small-scale fishing and gleaning in response to economic pressure and declining resource productivity, time-intensive seagrass-related practices, seasonal harvesting norms, and customary stewardship tend to be deprioritized. These shifts suggest not a complete loss of TEK, but a process of selective retention and adaptation, consistent with modernization-driven knowledge reconfiguration described by Cockerell and Jones (2021). This evolving linkage between tradition and livelihood underscores a widening gap between inherited ecological practices and contemporary survival strategies.

Despite relatively high ecological awareness, management and conservation practices remain limited and largely informal in the community. This pattern likely reflects weak institutional linkages between local knowledge holders and formal coastal governance structures (Barman et al. 2025; Rani et al. 2025), as well as constrained opportunities for community-led conservation planning (Jennings et al. 2024). Similar to findings by Maruf et al. (2024) and Olaniyi et al. (2024), conservation responses appear predominantly reactive, often prompted by visible environmental degradation rather than sustained collective management (Chan et al. 2022; Strawderman 2025). The limited integration of TEK into barangay-level decision-making further constrains the translation of knowledge into coordinated action, reinforcing a persistent divergence

between awareness and practice observed in TEK research. Bridging this gap will require context-sensitive strategies that strengthen intergenerational knowledge transmission, integrate TEK into formal education and local governance, and align conservation initiatives with evolving livelihood realities to ensure long-term community resilience and effective future-oriented care of seagrass ecosystems.

Relationship between the three indicators using network plot analysis

The relationships among the three core indicators of Traditional Ecological Knowledge (TEK) are illustrated through a network composed of 15 nodes and 59 edges (Figure 3). The nodes represent the mean responses to fifteen statements reflecting key dimensions of TEK related to seagrass ecosystems, grouped into Ecological Awareness (EA), Traditional Practices and Uses (TPU), and Management and Conservation Practices (MCP) (Table 2). The edges indicate the strength of associations derived from co-occurrence in field data, local narratives, and community knowledge systems, while variations in node size and edge thickness reflect differences in centrality and relational strength within the network.

Within the network, EA indicators form a robust central cluster, reflecting their strong internal coherence and high co-occurrence with other dimensions. This high level of internal connectivity suggests that EA may be a fundamental component of larger TEK systems, offering a framework for the development of other knowledge domains.

In contrast, MCPs show selective integration. While MCP1 to MCP3 are moderately well connected, particularly with EA components, MCP4 and MCP5 are more isolated, suggesting an uneven distribution of conservation knowledge across the community. This asymmetry may reflect varying exposure to formal conservation efforts or differences in how traditional ecological norms are practiced. It implies that targeted interventions may be required to revitalize or disseminate lesser-known conservation strategies.

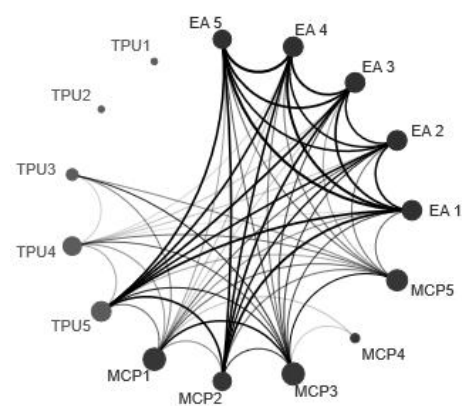


Figure 3. Network plot analysis among three core indicators of Traditional Ecological Knowledge (TEK) related to seagrass biodiversity: Ecological Awareness (EA), Management and Conservation Practices (MCP), and Traditional Practices and Uses (TPU)

Table 2. Mean responses of seagrass ecosystems: Knowledge, practices, and policy perceptions

Responses	Mean	Standard Deviation (SD)
EA1. I believe seagrass ecosystems are essential for maintaining the health of the marine ecosystem.	4.83	0.38
EA2. I think seagrasses play a critical role in storing carbon and mitigating climate change.	4.31	0.02
EA3. I am aware of the benefits the seagrass ecosystem provides for fishery productivity.	4.54	0.97
EA4. I think seagrass ecosystems are as important as coral reefs and mangroves.	4.84	0.52
EA5. I believe protecting seagrass is crucial for maintaining biodiversity.	4.91	0.28
TPU1. I have personally used seagrass or its habitat for traditional purposes, such as fishing, crafting, or fertilizer.	2.62	0.73
TPU2. I am familiar with cultural or traditional practices in my community that involve the seagrass ecosystem.	2.12	0.41
TPU3. I have observed traditional fishing methods in my area that rely on seagrass habitat.	3.07	0.57
TPU4. I have learned about the importance of the use of seagrass through traditional knowledge passed down in my community and family.	3.27	0.52
TPU5. I believe traditional practices involving seagrass should be preserved and integrated into modern conservation efforts.	4.43	0.10
MCP1. I believe there are clear policies in my area that protect seagrass ecosystems.	3.55	0.36
MCP2. I think current activities like pollution, coastal development, and destructive fishing practices threaten the seagrass ecosystem in my area.	4.53	0.86
MCP3. I think current seagrass management efforts are effective.	3.74	0.15
MCP4. I believe there is enough funding for seagrass conservation programs.	2.68	0.66
MCP5. I think the government is prioritizing seagrass protection as part of marine conservation.	3.61	0.40

The TPU cluster emerges as the most fragmented component of the TEK network in Barangay Lawigan. Among its five indicators, only TPU4 and TPU5 show moderate connections to the rest of the network, while TPU1 to TPU3 remain largely isolated. These nodes represent traditional uses of seagrass, such as for food, medicine, and crafts that were once commonly practiced but now appear to be fading from collective memory. This pattern suggests the presence of cultural erosion or generational disconnects, where practical knowledge that was once passed down informally within families or community groups is no longer being transmitted with the same strength or frequency (Withaningsih et al. 2019). It may also indicate specialization, that is, certain uses of seagrass might still exist but are limited to specific individuals or subgroups, making the knowledge less visible or accessible to the broader community (AngSinco-Jimene et al. 2003; Jones et al. 2022). Also, the gradual weakening of informal institutions in Barangay Lawigan, such as collective decision-making, shared labor arrangements, and customary sanctions, can fragment knowledge that was traditionally reinforced through daily social interaction and collective practice (Lusia et al. 2025). In addition, increasing exposure to external media, market-oriented values, and externally driven coastal programs may reframe how ecological knowledge is perceived, favoring technical or short-term solutions over experiential, place-based understanding (Stewart Jr. 2025).

This fragmentation represents a critical vulnerability within the TEK system. Traditional practices are often among the first to disappear when social conditions change, whether due to modernization, shifting livelihoods, or environmental decline (Dahlin and Svensson 2021; Konnov et al. 2022). As these practices vanish, they take with them not only cultural identity and heritage but also practical, time-tested strategies for living sustainably with local ecosystems. When such knowledge becomes siloed or is

lost altogether, the community's ability to respond to ecological change weakens (Falayi et al. 2020; Nusche et al. 2024).

The implications of these findings are significant. Strengthening linkages between EA, MCP, and TPU, particularly by bridging isolated knowledge nodes, can enhance the cohesiveness and functionality of the TEK system. Leveraging the strong core of ecological awareness through education and participatory conservation efforts may improve retention and transmission of traditional practices and management knowledge. Moreover, documenting and revitalizing isolated or declining knowledge, particularly within TPU and MCP clusters, will be essential for safeguarding the cultural heritage and ecological stewardship embedded in traditional knowledge systems.

Ultimately, Barangay Lawigan demonstrates a shared understanding of the importance of seagrass ecosystems. The challenge moving forward is to translate this collective awareness into concrete and sustained action, ensuring that advanced management tools and revived traditional practices become as familiar as the ecological truths everyone already holds dear. By reinforcing the weak links and integrating isolated knowledge, the community can keep both its meadows and its cultural wisdom thriving in the face of social and environmental change.

Correlation matrix showing the relationships among demographic and socio-economic variables of respondents

The correlation matrix in Table 3 reveals significant relationships among demographic and socio-economic variables influencing ethnobiological knowledge of seagrass ecosystems in Barangay Lawigan. Gender shows a very high correlation with both long-term residency ($r = 0.945$) and short-term residency ($r = 0.982$). Rather than suggesting that gender directly determines residency length, these correlations likely reflect the demographic

pattern in the sample, where one gender is more represented in either the long-term or short-term resident groups. This overlap means that gender and residency appear statistically linked even though the relationship is structural rather than causal. In this context, the correlation highlights how demographic clustering within the community shapes the distribution of ethnobiological knowledge, with residency duration remaining the more reliable indicator of knowledge retention. The strong correlations highlight the need for conservation strategies that are sensitive to gendered knowledge systems and economic realities.

Specifically, women and long-term residents appear to hold substantial ecological knowledge that could be leveraged in community-based conservation but may be underutilized due to socio-economic constraints. Similarly, household income below ₱13,000 is highly correlated with general economic vulnerability, with the r value of 0.956, confirming that low-income households are the most economically at risk and may face barriers to active participation in conservation practices. Moderate correlations between long-term residency and low income, with the r value of 0.465, suggest that even established households remain constrained by limited financial resources, which may restrict their ability to sustain conservation-related activities. These findings imply that socio-economic status and gender are critical determinants of Traditional Ecological Knowledge (TEK) within the community. Likewise, addressing economic vulnerability through livelihood diversification and support programs may reduce the trade-off between immediate household needs and long-term conservation goals. Integrating these demographic insights into policy and management can help ensure that conservation initiatives are both socially inclusive and ecologically effective.

These empirical patterns resonate with the work of Kaaronen et al. (2023) and align with classic TEK studies (e.g., Pollard et al. 2015; Ludwig and El-Hani 2020) which emphasize that TEK is situated, cumulative, and embedded in everyday practice: prolonged, repeated interaction with a locale produces fine-grained ecological knowledge that newcomers lack. The minimal association between long-term and short-term residents reinforces a central principle in ethnobiological theory: ecological knowledge is accretive, emerging through sustained interaction with place, species, and community practice. This divergence illustrates how TEK is unevenly distributed across residency cohorts, with long-term residents embodying deeper, place-based knowledge regimes that are not yet fully accessible to newer migrants. TEK is not instantly transferable by information alone but is learned through long-term participation and socialization (Das et al. 2022; Pipatanantakurn and Ractham 2022). This explains why long-term residents are likely the primary repositories of seagrass-related EA, TPU, and MCP in Lawigan.

In terms of the gender-related factors, a strong coupling of gender and residency categories in the matrix points to gendered knowledge regimes documented in coastal ethnobiology. Gender often determines access to particular ecological niches and practices, for example, men in fishing, women in shoreline gathering, processing, craft use

(Kyvelou and Ierapetritis 2020; Rivera-Arriaga et al. 2021), producing domain-specific TEK that may be invisible when surveys aggregate respondents. The strong associations between gender and both residency categories indicate that gender intersects with length of residence to produce distinct knowledge profiles within the community: long-term men and women may hold distinct but complementary TEK strands, while short-term residents, if predominantly of one gender or occupational group, may lack or occupy different knowledge niches. Limited ethnobiological literature warns that ignoring these gendered (Fatouros and Capetola 2021) and tenure-based differences risks under-documenting critical practices and management norms (Acevedo 2022).

Additionally, economic indicators underscore an important theoretical point: TEK persistence does not require wealth, but its application does require resources (Abdullah and Khan 2023). The high association between low income and economic vulnerability suggests that households with precarious livelihoods are a distinct social cluster; their TEK, especially EA, may remain intact because cognitive/observational knowledge is low-cost to maintain, yet their capacity to engage in MCPs is constrained, which can be reflected in Figure 4. This aligns with empirical small-scale fisheries studies showing that poverty can drive short-term extraction despite high local ecological awareness (Lammers et al. 2020; Stoll et al. 2023). Thus, conservation initiatives that rely solely on awareness will falter unless paired with livelihood support or incentive mechanisms.

Socio-demographic characteristics and three key indicators of Traditional Ecological Knowledge (TEK) related to seagrass biodiversity using a radar plot

The interaction between socio-demographic variables in terms of income, gender, length of residency, and economic vulnerability, and the relative strength of each TEK indicator through a radar plot (Figure 4). The visualization reveals that long-term residents (>20 years) demonstrate higher levels of ecological awareness, traditional practices, and conservation management knowledge compared to short-term residents (<5 years), who exhibit lower TEK levels. Gender distribution in the dataset shows a dominance of male respondents, with observable differences in Management and Conservation Practice (MCP) visibility. Additionally, Ecological Awareness (EA) remains relatively high even among respondents with lower income levels, suggesting that awareness persists despite economic constraints. However, fragmentation is evident in MCP and Traditional Practices and Uses (TPU), indicating weaker translation of awareness into practical conservation actions.

From a resilience and adaptive-management perspective, TEK functions as a dynamic, place-based capacity for responding to environmental change rather than a static repository of information (Choudhury et al. 2021). The strong TEK scores among long-term residents in Barangay Lawigan emphasizes that prolonged interaction with local ecosystems deepens environmental familiarity and supports intergenerational knowledge transfer (Rexhepi and Bajrami 2025). Conversely, the lower TEK levels among short-term residents reflect limited immersion in ecological contexts

and reduced participation in communal resource practices, as similarly observed by Tran et al. (2025) in small-scale fisheries.

The concentration of MCP visibility among males may be attributed to gendered divisions of labor, where men are more involved in harvesting and formal management roles, while women’s contributions, such as shore-based gathering, processing, and oral knowledge, are less documented. This imbalance, as noted by Basharat and Alam (2024), can obscure the full spectrum of TEK and limit inclusivity in conservation planning. Incorporating women’s ecological knowledge has been shown to enhance management frameworks and contribute detailed insights into habitat conditions (Aguilera et al. 2021).

Economic vulnerability also shapes how TEK functions within communities. While ecological awareness persists under financial strain, economic hardship may constrain households’ ability to apply this knowledge through active stewardship, restoration, or monitoring due to limited resources. Similar patterns have been documented in small-scale fisheries, where poverty often drives short-term resource extraction despite awareness of its long-term impacts (Cánovas-Molina and García-Frapolli 2022).

The socio-demographic interplay supports the ethnobiological view that TEK is both place-based and socially mediated. The persistence of ecological awareness amid economic challenges highlights system resilience, but gaps in practice-oriented knowledge transmission persist among economically vulnerable and short-term residents. Strengthening TEK for conservation thus requires institutional support, gender-inclusive participation, and livelihood-based interventions that enable communities to translate awareness into sustained ecosystem management.

Taken together, the results from the level analysis, demographic patterns, and network structure reveal a deeply interconnected narrative of how TEK is organized, transmitted, and eroding within Barangay Lawigan. The consistently high EA scores across demographic groups indicate that cognitive awareness of seagrass ecology is widespread, providing a strong conceptual foundation for stewardship. Yet the demographic gradients, particularly the steep increase of TPU and MCP with age and residency length, and the lower values among youth, short-term residents, and higher-income groups, demonstrate the

embodied and practice-based knowledge is unevenly distributed and increasingly concentrated among long-term, older residents. Moreover, based on the network plot, awareness is cohesive and widely shared, conservation knowledge is emerging but uneven, and traditional practices are the most vulnerable to loss. Which means, the study result portrays a socio-ecological system where biocultural diversity is strongest in shared ecological understanding but weakest in the practical knowledge that historically tied people to seagrass ecosystems through subsistence, craft, and cultural practices. The system remains resilient at the level of values and perception, but the erosion of TPU among younger and transient populations signals weakening intergenerational transmission, threatening the long-term continuity of place-based knowledge that sustains adaptive capacity. Thus, the levels, demographics, and network analyses collectively reveal a TEK system that is cognitively robust yet structurally imbalanced, with critical implications for both conservation planning and the biocultural future of the community.

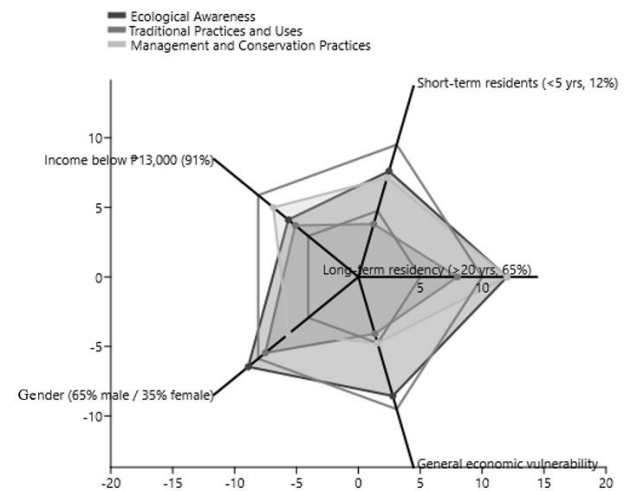


Figure 4. The radar plot illustrates the interaction between socio-demographic characteristics and three key indicators of Traditional Ecological Knowledge (TEK) related to seagrass biodiversity

Table 3. Correlation matrix showing the relationships among demographic and socio-economic variables of respondents in Barangay Lawigan, in relation to their ethnobiological knowledge of seagrass ecosystems. Variables include residency status, household income, gender distribution, and general economic vulnerability. Values represent correlation coefficients

Demographic factors	Long-term residency (>20 yrs, 65%)	Short-term residents (<5 yrs, 12%)	Income below ₱13,000 (91%)	Gender (65% male / 35% female)	General economic vulnerability
Long-term residency (>20 yrs, 65%)		0.073186	0.46508	0.945	0.57851
Short-term residents (<5 yrs, 12%)	0.073186		0.53826	0.98181	0.50533
Income below ₱13,000 (91%)	0.46508	0.53826		0.47993	0.95641
Gender (65% male / 35% female)	0.945	0.98181	0.47993		0.47648
General economic vulnerability	0.57851	0.50533	0.95641	0.47648	

In conclusion and recommendation, this study highlights a clear structural pattern in Barangay Lawigan's Traditional Ecological Knowledge system, where ecological awareness functions as a unifying and widely shared foundation, while traditional practices and management actions remain less connected and unevenly integrated. Although environmental understanding is strong across the community, its translation into sustained practice is constrained by structural and social factors, including limited institutional support, uneven participation, gendered knowledge gaps, and differences in household stability and long-term residency. These dynamics shape how knowledge circulates, who influences decision-making, and which forms of TEK are most visible or sustained within the community. Bridging this imbalance requires deliberate efforts to strengthen connections between shared awareness and everyday practice through intergenerational learning, inclusive knowledge documentation, and the meaningful integration of TEK into local governance and conservation planning, alongside livelihood support mechanisms. By reinforcing these linkages, Barangay Lawigan can convert widely held ecological understanding into coordinated, community-driven stewardship of seagrass ecosystems. More broadly, this structural perspective offers a useful lens for examining how knowledge and influence flow within coastal communities, providing a transferable approach for designing more equitable and effective community-based conservation strategies in similar socio-ecological contexts.

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