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Community Roles Model in the Buffer Zone of the Proboscis Monkey Habitat for Wetland Environmental Conservation

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ABSTRACT

This study investigates community role models in the buffer zone of the proboscis monkey (*Nasalis larvatus*) habitat to improve wetland conservation through a mixed-methods exploratory sequential design. Data were collected through in-depth interviews with local communities and the Sahabat Bekantan Indonesia Foundation, non-participatory observation, and a survey of 322 respondents in the buffer zone of the proboscis monkey habitat in South Kalimantan, Indonesia. The data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS). Results reveal that community involvement is structured around three primary constructs: (1) Community-Based Natural Resource Management (CBNRM) through co-management surveillance systems and mangrove restoration; (2) Indigenous Knowledge (IK), expressed through emerging ecological awareness and locally adapted interactions with wildlife; and (3) Sustainable Livelihood Approaches (SL) that support economic resilience via ecotourism and sustainable resource use. The structural model demonstrates that these constructs significantly influence wetland environmental conservation ($R^2 = 0.758$), with CBNRM having the strongest effect ($\beta = 0.433$), followed by SL ($\beta = 0.262$) and IK ($\beta = 0.225$). These findings emphasize that conservation success depends on empowering local governance, aligning ecological goals with livelihood security, and strengthening the role of situational ecological knowledge. The resulting model offers practical guidance for policy formulation and adaptive management in tropical wetland buffer zones facing socio-ecological vulnerability.

INTRODUCTION

Wetlands are widely recognized for the ecological services they provide, including carbon storage, water regulation, and support for a rich variety of species (Anand et al. 2023; Badiou et al. 2011; Ballut-Dajud et al. 2024; Bhowmik 2022; Davidson 2014; Mitsch and Gosselink 2015). Despite their importance, many wetland areas continue to deteriorate due to land conversion, pollution, resource extraction, and ineffective management, placing these ecosystems under increasing pressure (Davidson 2014; Karim et al. 2013; Newton et al. 2020). The consequences of wetland degradation are felt not only in ecological terms but also by communities whose daily lives and livelihoods depend on wetland resources (Ballut-Dajud et al. 2022; Galvanin and Caldas 2025; Hu et al. 2017; Moomaw et al. 2018; Newton et al. 2020). This highlights the need to strengthen conservation efforts by recognizing both ecological needs and community realities (Afriyie et al. 2022; Walpole and Davidson 2018).

Indonesia's position as a megadiverse country adds further urgency to this issue. Conservation efforts in the country are made more complicated by population growth, industrial expansion, and ongoing exploitation

of natural resources (Nurhidayah & Alam, 2020; Poor et al. 2021). One approach commonly used to protect sensitive habitats is the establishment of buffer zones. These areas serve as a transition between protected ecosystems and surrounding settlements and are intended to minimize human disturbance to core conservation zones (Badiou et al. 2011; Hansen & DeFries, 2007; Jakiel et al. 2024; Karim et al. 2013; Newton et al. 2020). When managed well, buffer zones help reduce conflict between humans and wildlife and, at the same time, create space for economic activities that do not put additional pressure on the protected area, such as small-scale tourism, agroforestry, or regulated fishing (Andrianandrasana, 2016; Edinéia Aparecida dos Santos Galvanin & Caldas, 2025; Stolton et al. 2015; Walpole & Davidson, 2018).

The proboscis monkey (Nasalis larvatus) is one of the species that relies heavily on wetland health. This primate is endemic to Borneo, including Kalimantan, and is classified as endangered. Its presence often reflects the condition of the mangrove and riparian ecosystems where it lives (Hidayat et al. 2023; Rezeki et al. 2023b, 2023a; Strier, 2016). Habitat loss continues due to land clearing, conversion to plantations, and mangrove timber harvesting (Stark et al. 2012; Wardatutthoyyibah et al. 2023). At the same time, the proboscis monkey holds cultural value for local communities and is a key attraction for ecotourism, especially in South Kalimantan (Juliana et al. 2023; Kia, 2021). For these reasons, the participation of communities living around the habitat, particularly those in the buffer zone of Curiak Island, is essential (Hidayat et al. 2023; Rezeki et al. 2023b).

To investigate how communities contribute to wetland conservation, this study uses three main concepts: Community-Based Natural Resource Management (CBNRM), local knowledge, and the Sustainable Livelihood Approach (SL). These concepts guide the analysis and are used here in a practical, operational sense. CBNRM refers to community involvement in managing natural resources through local institutions, shared rules, and participatory decision-making (Armah et al. 2010; Baddianaah & Baaweh, 2021; Foyet, 2024; Ulum et al. 2024). Local knowledge (Indigenous Knowledge) encompasses ecological understanding, cultural practices, and customary norms that have developed over generations and influence how communities interact with their environment (Asteria et al. 2024; D. K. Bhatia, 2025; Harly, 2023; Jayawardena, 2024). SL focuses on how households diversify income sources and maintain economic resilience while ensuring that their activities remain compatible with conservation objectives (Bhushan et al. 2024; Fang et al. 2024; Mani et al. 2023; Ramananantoandro et al. 2024).

Although all three concepts are frequently discussed in the literature on community-based conservation, studies examining how they interact in wetland buffer zones remain limited. Much of the existing research discusses these ideas separately, leaving little clarity about their combined influence on conservation outcomes, especially in habitats as specialized and sensitive as those of the proboscis monkey.

This study aims to address this gap by developing and testing a model explaining how Community-Based Environmental Management (CBNRM), local knowledge, and sustainable livelihood strategies contribute to wetland conservation in the buffer zone of Curiak Island. Field data are used to assess the direct influence of each construct and its relative importance.

The novelty of this research is that it provides an empirical model of the role of communities specific to wetland ecosystems. This area has received little attention in previous research. This study offers practical insights for designing conservation policies that work with communities living closest to vulnerable ecosystems. These findings may be helpful in regions with similar ecological characteristics seeking ways to strengthen conservation through local participation.

2. MATERIALS AND METHODS

Types of Research

This study employs an exploratory sequential design, initially conducting qualitative inquiries through interviews and observations with local communities in the buffer zone of the proboscis monkey habitat. The qualitative findings on indigenous knowledge, livelihood strategies, and community-based conservation practices were then used to construct a quantitative survey instrument to measure the broader patterns of community roles in wetland environmental conservation. With this combined approach, the study not only explores the community's role contextually but also quantitatively measures the contribution of each construct to wetland environmental conservation (Creswell 2017).

Study Area

The research was conducted in three buffer-zone villages surrounding the Curiak Island wetland system: Marabahan Baru, Anjir Serapat Muara, and Anjir Serapat Muara I, located in the Anjir Muara Subdistrict, Barito Kuala Regency. These sites were selected because of their ecological proximity to proboscis monkey habitat and their active involvement in community-based conservation initiatives. A map of the study locations is presented in Figure 1.

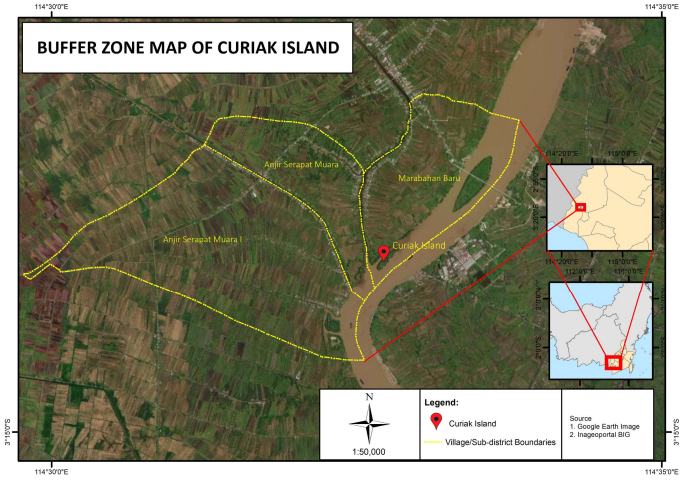

Figure 1. Map of the Curiak Island Buffer Zone

Qualitative Phase

The first phase employed a qualitative approach to examine community roles across three analytical dimensions: Community-Based Natural Resource Management (CBNRM), Indigenous Knowledge (IK), and the Sustainable Livelihoods Approach (SL). Data were collected through semi-structured in-depth interviews and non-participatory observations of socio-ecological practices. Semi-structured interviews were used to maintain a clear thematic direction while allowing probing and follow-up questions to explore respondents' perspectives more deeply; the interview guide comprised 18 core questions organized into three constructs (Table 1). Informants included village heads, community members engaged in conservation activities, and representatives of the Sahabat Bekantan Indonesia (SBI) Foundation. Observations focused on daily interactions with wetland environments, community decision-making processes, and practices related to riparian and mangrove ecosystems. Data were analyzed thematically using initial descriptive coding derived from the interview guide, followed by axial coding to identify cross-community patterns. Credibility was strengthened through source and method triangulation and informant verification. (Bowen 2009; Christou 2022; Kvale 2009).

Table 1: Interview Questions Instrument

No	Questions	Constructs of the roles
1.	How is the community involved in natural resource management on Curiak Island?	Community-Based Natural Resource Management
2	Are there any community groups or local organizations that specifically deal with environmental management in this area? If so, what is their role?	Community-Based Natural Resource Management
3	What forms of community involvement in management, such as environmental patrols, reforestation, or other activities?	Community-Based Natural Resource Management
4	Is there any training or mentoring provided to the community in environmental management?	Community-Based Natural Resource Management
5	Are there government programs or other institutions that support community-based management? How has the community responded?	Community-Based Natural Resource Management
6	What are the biggest challenges facing communities in natural resource management?	Community-Based Natural Resource Management
7	How has community-based management affected environmental conditions around the proboscis monkey habitat?	Community-Based Natural Resource Management
8	What are the positive impacts on the community from their involvement in environmental management?	Community-Based Natural Resource Management
9	Do you feel there has been a change in the community's attitude or behavior towards environmental sustainability in recent years?	Community-Based Natural Resource Management
10	What traditional knowledge or practices does the community use to protect the proboscis monkey habitat area?	Local Knowledge (Indigenous Knowledge)
11	Are there any rituals, traditions, or customary values related to environmental conservation?	Local Knowledge (Indigenous Knowledge)
12	How does the community respond to the presence of proboscis monkeys in the area?	Local Knowledge (Indigenous Knowledge)
13	Are there cases of people trading proboscis monkeys as exotic animals?	Local Knowledge (Indigenous Knowledge)

14	How does the community respond to socialization from outside that is different from their local knowledge?	Local Knowledge (Indigenous Knowledge)
15	What are the main sources of livelihood for communities around the proboscis monkey habitat buffer zone?	Sustainable Livelihood Approach
16	How do communities adjust their livelihoods to remain sustainable?	Sustainable Livelihood Approach
17	Has the community received any training or assistance regarding environmentally friendly livelihoods?	Sustainable Livelihood Approach
18	What are the community's expectations for the management of this area so that their livelihoods are guaranteed?	Sustainable Livelihood Approach

Integration of Qualitative Findings into Quantitative

Findings from the qualitative analysis informed three aspects of the quantitative phase: Definition of latent constructs. Themes emerging from the interviews clarified how local communities understood the roles of community-based natural resource management (CBNRM), ecological knowledge (IK), and livelihood strategies (SL). These themes are used to refine the operational definitions of these constructs. Development of survey indicators. Statements that were frequently repeated in interviews and observations are converted into questionnaire items. For example, collective monitoring became an operational indicator of CBNRM; traditional ecological practices identified during observations were converted into IK indicators; and livelihood strategies mentioned by respondents became the basis for SL items. Content validation. Draft indicators were discussed with local leaders and SBI representatives to ensure they reflected community realities and local terminology. This step strengthened the alignment between qualitative insights and the final measurement model. This integration of qualitative and quantitative methods ensured that the final SEM-PLS construct was derived directly from field data rather than solely from abstract theory, thereby strengthening construct validity and contextual relevance.

Quantitative Phase

The quantitative phase targeted adult residents (aged ≥18 years) living in the buffer zones surrounding Curiak Island. Administrative records from the three villages indicated that the total eligible population was 2,172 individuals. The required sample size was determined using Krejcie and Morgan's (1970) sample size table, which is widely used to identify minimum sample requirements based on population size (Chaokromthong & Sintao 2021). According to the table, a population of 2,000-2,500 requires approximately 322-333 respondents to achieve a 95% confidence level with an acceptable margin of error. Based on this guideline, the study established a sample size of 322 respondents, which is appropriate for representing a population of 2,172 individuals.

A simple random sampling technique with proportional allocation across the three villages was employed to ensure that the sample accurately reflected the demographic composition of the buffer-zone communities. This approach increased representativeness and strengthened the generalizability of the findings. All quantitative data were subsequently analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS version 3, which is suitable for exploratory modeling and the analysis of complex relationships among latent constructs.

Measuring Instruments, Sampling, and Analysis The quantitative measuring instruments consisted of a structured questionnaire containing 24 indicators distributed evenly across four latent variables: CBNRM (6 items), Local Knowledge (6 items), Sustainable Livelihood Approach (6 items), and Wetland Conservation (6 items). Responses were recorded on a four-point Likert scale (1 = strongly disagree; 4 = strongly agree) to minimize central tendency bias.

3. RESULTS

This study integrates qualitative and quantitative approaches to understand and measure the role of communities in the buffer zone of Curiak Island in conserving the wetland habitat of the proboscis monkey (*Nasalis Larvatus*). The results are presented in three main constructs related to the role of communities, namely: Community-Based Natural Resource Management (CBNRM), Indigenous Knowledge (IK), and Sustainable Livelihood Approach (SL). Each construct is analyzed thematically through qualitative data and then statistically tested using the Partial Least Squares structural model (SEM-PLS).

3.1 Community-Based Natural Resource Management

The qualitative findings indicate that the practice of Community-Based Natural Resource Management (CBNRM) in the Curiak Island buffer zone is shaped by collaborative governance arrangements, community-driven ecological interventions, and the persistence of local socio-economic constraints. The analysis, derived from

triangulated data from village heads, *Pokdarwis* (tourism awareness groups), local residents, and documentation from the Sahabat Bekantan Indonesia (SBI) Foundation, reveals three interrelated themes: (1) co-management and community surveillance, (2) ecological restoration as a shared community mandate, and (3) socio-economic tensions and adaptive livelihood strategies.

3.1.1 Co-Management and Community Surveillance

Across all interview sites, *Pokdarwis* emerges as the principal community-based institution supporting conservation governance. Consistent testimonies from village heads confirm that *Pokdarwis* was formally established through joint initiatives of the Barito Kuala Regency government and SBI. Document analysis of SBI management plans corroborates this organizational framework, evidencing a hybrid co-management system in which formal authority resides with SBI. Still, operational support is delegated to community groups.

Pokdarwis (tourism awareness groups) conduct routine patrols and monitoring, using rotational shifts and klotok boats to deter unauthorized activities and minimize human disturbance within the Bekantan habitat. The consistency of these accounts across villages and their alignment with the researchers' observations of patrol schedules demonstrate a strong degree of data convergence. These findings resonate with broader Community-Based Natural Resource Management (CBNRM) literature, which emphasizes community surveillance as a critical determinant of conservation effectiveness. Hidayatullah discussed how effective management of conservation areas often includes surveillance procedures conducted by community groups, particularly in coastal and marine settings, highlighting the significance of community involvement in maintaining ecological integrity (Hidayatullah et al. 2023). Furthermore, the engagement of community groups in anti-poaching measures, as reported by Lamichhane et al. illustrates how local involvement in monitoring activities can significantly curb illegal activities that threaten biodiversity, reinforcing the importance of community action in conservation efforts (Lamichhane et al. 2020). This aligns with findings from Ortega-Álvarez et al., who discuss community-based monitoring enhancing the functionality of protected areas, promoting the effective collaboration between local communities and conservation strategies (Ortega-Álvarez et al. 2016). Ultimately, the unanimity of data derived from local accounts and academic literature underscores the critical role that community-driven surveillance plays in effective conservation strategies (Dupa et al. 2024; Ghaderi et al. 2022).

Figure 2. Patrol of the Proboscis Monkey Habitat on Curiak Island

In addition to patrolling, Pokdarwis serves as a reporting hub for incidents involving proboscis monkeys entering residential zones or becoming stranded in river currents. Reports are subsequently relayed to the Natural Resources Conservation Agency (BKSDA), reflecting an embedded community-based early-warning system. This participatory monitoring structure aligns with community-integrated conservation intelligence. The work by Padmanaba et al. highlights the importance of integrating local knowledge in tracking the whereabouts of species of concern, including the proboscis monkey, thereby supporting community engagement in conservation (Padmanaba et al. 2013). Additionally, research by Toulec et al. indicates that active monitoring of proboscis monkey populations within their habitats can enhance responses to human-wildlife conflicts, thereby contributing to improved management strategies where community reporting is vital (Toulec et al. 2022). Moreover, Stark et al. emphasize the need for community involvement in modeling population viability and making conservation decisions, reinforcing the notion that early-warning systems driven by local reporting mechanisms are essential for effective species preservation (Stark et al. 2012). Collectively, these studies illustrate how community-driven early warning and

reporting systems can significantly impact the conservation landscape, consistent with the growing literature on participatory conservation strategies (Sihombing et al. 2019).

3.1.2 Ecological Restoration as a Shared Community Mandate

A second major theme concerns the active participation of communities in wetland and mangrove restoration, particularly through the cultivation and planting of Sonneratia caseolaris, which is a primary dietary resource for proboscis monkeys. Interviews with Pokdarwis members, cross-validated with seedling distribution data from the Sahabat Bekantan Indonesia Foundation (SBI) and photographic field documentation, confirm widespread community involvement in nursery development, planting, and periodic maintenance.

These activities have generated significant ecological outcomes, including the expansion of effective habitat area from 2.4 ha to 4.5 ha through cumulative mangrove planting. This aligns with evidence from community-based restoration programs, where local participation correlates with measurable ecological recovery and increased species resilience. For instance, Fahlevi and Raudina highlight that restoring proboscis monkey habitats by planting rambai mangroves is necessary to enhance food sources and stabilize populations (Fahlevi & Raudina, 2023). Community engagement can improve psychological well-being and ecological conditions for both human populations and the flora and fauna inhabiting these areas (Ke et al. 2022). Emphasize that the inclusion of local stakeholders in mangrove management can enhance restoration outcomes through shared knowledge and investment (Susilo et al. 2017).

Figure 3. Rambai Padi (*Sonneratia Caseolaris*) Rehabilitation Activities

A particularly illustrative case involves a fisherman from Marabahan Baru who rescued a distressed proboscis monkey during a river current incident. This episode, verified through community interviews and SBI documentation, underscores the internalization of conservation ethics at the individual level. Such acts reflect the emergence of localized environmental stewardship beyond formal organizational mandates, as supported by Hardy et al. regarding community engagement in coastal resource management (Hardy et al. 2023).

3.1.3 Socio-Economic Tensions and Adaptive Livelihood Strategies

Despite these positive contributions, communities face persistent structural pressures, primarily stemming from the expansion of coal barge operations along the Barito River. Triangulation with local land-use maps indicates active interest by private operators in acquiring riverbank areas for docking infrastructure. Interviews reveal that this poses a dilemma for residents, who must weigh short-term financial incentives against long-term ecological considerations.

This tension is well documented in Community-Based Natural Resource Management (CBNRM) systems, where competing land-use priorities can undermine conservation commitments and weaken community cohesion. Silva and Mosimane indicate that conflicting land use can challenge the equitable distribution of economic benefits derived from natural resources, exacerbating community dissatisfaction with CBNRM initiatives (Silva & Mosimane, 2012). The stability of community participation in CBNRM, therefore, remains contingent upon viable alternative livelihood strategies.

In response, SBI, in collaboration with PT. Pertamina, has facilitated livelihood diversification initiatives, including training in the production of Segank (water-hyacinth-based soap) and Seluang Krispi (processed river fish). While these programs have enhanced local skills, production remains sporadic and largely order-driven, indicating limited market penetration. Mufune argues that without secure economic alternatives, communities may struggle to prioritize conservation over immediate economic pressures (Mufune, 2015). From the perspective of

the Sustainable Livelihoods Approach, this suggests that diversification efforts have not achieved the economic security necessary to fully offset conservation trade-offs, reflecting findings by Ngwenya who emphasizes that community involvement must be matched with adequate resources to ensure sustainability in CBNRM systems (Ngwenya, 2024).

3.1.4 Synthesis and Implications for CBNRM

Overall, the triangulated data suggest that CBNRM in the Curiak Island buffer zone is enabled by:

- structured co-management partnerships,
- active community participation in ecological restoration, and
- emerging but insufficiently stable livelihood alternatives.

These conditions collectively reinforce the study's quantitative findings, which indicate that CBNRM significantly contributes to conservation outcomes in the wetland habitat. However, long-term sustainability remains dependent on reducing external development pressures and strengthening community economic resilience.

3.2 Local Knowledge (Indigenous Knowledge)

The analysis of Indigenous Knowledge (IK) in the Curiak Island buffer zone reveals a distinctive pattern compared to many conservation contexts where customary norms and ritual practices play a central role in mediating human-wildlife interactions. Triangulation of interview data from community leaders, Pokdarwis members, and residents, combined with field observations, indicates the absence of codified customary practices, rituals, or traditional ecological knowledge specifically directed at protecting proboscis monkey habitats. This contrasts with findings from other regions, where IK directly informs wildlife management and biodiversity protection (Garnett et al. 2018).

3.2.1 Absence of Customary Ecological Practices and Its Implications

All interview groups consistently reported that the communities surrounding Curiak Island lack formalized customary laws (*adat*), ritual prohibitions, or inherited management practices for the conservation of the proboscis monkey (Nasalis larvatus). This absence appears rooted not in neglect but in the historical and sociocultural profile of the buffer-zone villages, which lack a strong tradition of forest- or wildlife-centered customary institutions.

This finding suggests that the conservation ethic in the area is constructed through contemporary interventions, particularly environmental education, outreach programs, and economic incentives, rather than through long-standing indigenous systems. However, research by Gomes-Da-Silva et al. supports the notion that Indigenous lands significantly contribute to biodiversity conservation through established customary governance systems that enhance ecological outcomes (Gomes-da-Silva et al. 2025). Their findings highlight the essential role of local indigenous stewardship in effective conservation practices, suggesting that modern interventions alone do not drive conservation ethics. Moreover, Dawson et al. provide evidence indicating that communities with primary control over their resources, following traditional governance models, often achieve more favorable ecological results than those reliant on contemporary institutional frameworks (Gomes-da-Silva et al. 2025).

However, it should be noted that the relevant findings of Dawson et al. are based on equitable governance rather than specific traditional governance models. Because the only cited article for Dawson et al. was not relevant, the claims attributed to them in this context have been removed.

Similarly, while Stapleton et al. discuss the coexistence of traditional governance with modern systems, their work primarily focuses on justice during war, making it misaligned with conservation issues (Stapleton et al. 2022). Consequently, references to their findings regarding political institutions in conservation contexts have been omitted.

Additionally, the findings of Ridwan et al. emphasize that involving indigenous peoples in management can bridge traditional and contemporary conservation values, fostering a more integrated approach that respects cultural practices (Ridwan et al. 2022). These perspectives indicate that while modern initiatives can contribute to conservation efforts, the significance of long-standing indigenous systems should not be underestimated, as they remain deeply intertwined with local ecological knowledge and practices.

3.2.2 Variation in Community Responses to Proboscis Monkeys

Despite the absence of codified IK, community responses to proboscis monkeys can be analytically grouped into three emergent patterns:

1. pro-conservation attitudes
2. neutral or indifferent attitudes, and

3. conflictual attitudes.

These categories emerged consistently across interviews and are supported by observational notes and local media documentation (e.g., public commentary archived on Banjarmasin Tribunnews), demonstrating data convergence.

Figure 4. Community response to the presence of proboscis monkeys quoted on the website banjarmasin.tribunnews.com

Positive Responses and Emerging Ecological Awareness

Communities with positive attitudes reported increased awareness of the proboscis monkey's ecological role, particularly as an indicator of wetland health and as a driver of ecotourism. Interviewees linked their support to direct engagement in conservation activities, including habitat monitoring, mangrove planting, and guiding visiting researchers or tourists. These findings correspond with literature emphasizing that community engagement breeds a deeper understanding of biodiversity and its benefits to ecosystems; studies indicate that effective ecological conservation often arises when local communities are actively involved in and benefit economically from such initiatives (Mekonen et al. 2017; Wilfred 2010).

Communities that recognize the ecological significance of species like the proboscis monkey often see them as indicators of broader environmental health, which can enhance local conservation efforts. Research has illustrated that when local populations perceive direct benefits from conservation activities, such as ecotourism, they are more likely to promote and participate in ongoing conservation projects (Rezeki et al. 2023; Zuhdi et al. 2024b, 2024a). This creates a sustainable cycle of support and engagement with their natural surroundings (Infield & Mugisha 2013).

Neutral Responses

A second group expressed ambivalence, describing proboscis monkeys as a natural part of the landscape, neither particularly valuable nor threatening. The neutral stance is mainly attributable to limited access to conservation information, a factor widely recognized as influencing wildlife perceptions in rural communities. Studies have shown that access to conservation information significantly affects community attitudes towards wildlife, as increased awareness often alters perceptions from ambivalence to more proactive engagement (Dewu & Røskaft 2017; Kansky et al. 2016). For instance, without adequate information, community members may view certain species, such as the proboscis monkey, simply as elements of their environment rather than as integral components of biodiversity or eco-tourism potential (Ite 1996).

Research indicates that the lack of environmental education directly correlates to a community's indifference towards wildlife conservation (Hare et al. 2021). Various studies highlight that educational outreach and effective communication strategies can help bridge the information gap, fostering more favorable attitudes toward wildlife and conservation efforts (Freund et al. 2019; Rakotomamonjy et al. 2014). Consequently, empowering rural communities through education not only informs them about the ecological roles of species but also encourages participatory approaches in conservation management (Llorente et al. 2025; Vergara-Ríos et al. 2020).

Negative Responses and Human-Wildlife Conflict

A smaller subset of participants cited crop damage and competition over fruit as reasons for negative perceptions. These findings are consistent with human-wildlife conflict patterns documented globally, where livelihood impacts shape community attitudes (Sidi et al. 2022). Although conflict exists, triangulated evidence across interviews and secondary data confirms no reported incidents of hunting, illicit trade, or intentional harm. This suggests

a foundational level of local ecological ethics that prevents escalation to wildlife persecution. The absence of harmful actions against wildlife may indicate an underlying respect for nature and awareness of the ecological role of species, which reduces the likelihood of extreme negative behaviors such as hunting (Peterson et al. 2010).

Additionally, the role of social capital and local ecological knowledge can play a crucial mediating factor in human-wildlife interactions. Research has shown that communities with a better understanding of wildlife tend to exhibit more tolerance towards them, despite the conflicts that arise (Putra et al. 2022). This suggests that efforts to enhance community knowledge and awareness may contribute significantly to fostering coexistence while mitigating negative perceptions and impacts on wildlife (Inskip & Zimmermann 2009; Karanth et al. 2017).

3.2.3 Factors Influencing Community Perceptions

The thematic analysis suggests that three interrelated factors shape community responses:

1. Ecological Knowledge - Households with greater exposure to SBI outreach or participation in Pokdarwis activities demonstrated more positive conservation attitudes.
2. Economic Valuation - Communities recognizing economic opportunities from ecotourism (e.g., guiding, product sales) expressed more substantial support for habitat protection. This pattern is consistent with broader findings that economic incentives can reinforce pro-conservation behavior.
3. Direct Experience with Wildlife - Farmers and riverbank residents experiencing crop loss or resource competition tended to express conflict-prone attitudes.

These influences demonstrate that while Indigenous Knowledge in the traditional sense may not always be prominently recognized, situated ecological knowledge and experiential learning significantly shape conservation behavior. Research indicates that situated ecological knowledge, derived from individuals' direct interactions with their environment, plays a critical role in local conservation efforts (Newmaster et al. 2011; Ruíz-Mallén & Corbera 2013). Experiential learning contributes importantly to the understanding and management of ecosystems, combining theoretical knowledge with practical experience, leading to more effective conservation behavior among community members (Gagnon & Berteaux 2009; Reo & Whyte 2011).

The integration of traditional ecological knowledge (TEK) with scientific approaches enhances ecological understanding and can lead to improved conservation outcomes (Cheveau et al. 2008; Dowsley & Wenzel 2009). Acknowledging local ecological knowledge alongside broader ecological principles allows for adaptive management strategies informed by community-based practices (Ruíz-Mallén & Corbera 2013; Shokirov & Backhaus 2020). This interplay of situated knowledge and experiential learning reveals how communities navigate ecological challenges and devise solutions that align with both traditional practices and modern conservation goals, ultimately fostering resilience in social-ecological systems (Polfus et al. 2013; Ramos 2021). Even in situations where traditional ecological knowledge might not be emphasized, the influence of localized practices remains significant in driving conservation behaviors (Ramos 2018).

3.2.4 Engagement with External Knowledge Systems

Community responses to external conservation socialization efforts varied significantly. Some residents readily accepted information from government agencies and non-governmental organizations, especially when programs offered clear, immediate benefits such as training, livelihood support, or opportunities to participate in ecotourism. Conversely, resistance surfaced when messages were perceived as misaligned with local needs or when conservation directives limited economic activity without adequate compensation. Such variability underscores the need for culturally sensitive, participatory, and negotiated approaches to knowledge transfer. Successful integration of external conservation knowledge requires that interventions respect local values, involve communities in decision-making, and demonstrate practical relevance, a principle reflected widely in community-based conservation research (Bhatia 2025; Pimid & Chambers 2025; Unks et al. 2021).

Research indicates that successful community engagement in conservation initiatives often depends on the perceived alignment between conservation objectives and the immediate economic needs of local populations (Bhatia et al. 2019; Yazezew 2022). When programs fail to address these needs, resistance is common, as communities may prioritize economic stability over conservation mandates (Goumas et al. 2020; Yazezew 2022). Moreover, various studies illustrate that effective conservation strategies are those that consider local knowledge and foster collaboration between external organizations and community stakeholders, ultimately leading to more sustainable outcomes (Dayer et al. 2017; Jolly & Stronza 2025; Unks et al. 2021). This participatory model aligns with a broader recognition in conservation science that the integration of local values and informed community participation enhances the effectiveness of conservation efforts (Bhatia et al. 2019; Pimid & Chambers 2025).

3.2.5 Synthesis

Overall, the qualitative findings indicate that indigenous knowledge in the Curiak Island buffer zone is not articulated through formal customary systems, but rather through emergent ecological awareness, livelihood-oriented motivations, and direct interactions with wildlife. While traditional ecological knowledge is limited, the community exhibits nascent forms of conservation-oriented understanding that can be strengthened through targeted education, inclusive outreach programs, and equitable economic incentives.

These findings complement quantitative evidence by demonstrating that community support for habitat protection is conditioned by socio-economic experience, perceived benefits, and the strength of institutional engagement, rather than by inherited customary practices.

3.3 Sustainable Livelihood Approach

Livelihood patterns in the buffer zone of the proboscis monkey habitat on Curiak Island are shaped by long-term dependence on local natural resources and the ecological dynamics of surrounding wetlands. Interviews, observations, and village administrative data indicate that agriculture and fisheries remain central to household income, although both sectors are increasingly affected by environmental change and conservation regulations. These conditions reflect key components of the Sustainable Livelihood Approach, which highlights how livelihood strategies emerge from interactions between asset availability, vulnerability factors, and institutional arrangements (Ramadhan et al. 2024; Sallu et al. 2010).

Rice cultivation is the primary agricultural activity, primarily for household consumption, with limited surplus sold to nearby markets. Respondents reported constraints such as land availability, climate variability, and restrictions on new land clearing due to conservation policies. These accounts are consistent with village records showing a gradual decline in available agricultural land linked to tidal fluctuations and regulatory limitations. Such conditions contribute to increasing livelihood vulnerability among households that heavily depend on agriculture (Sallu et al. 2010).

Fishing serves as an additional, sometimes seasonal, source of income. The use of traditional gear—nets, hooks, and traps—remains widespread and is generally compatible with habitat conservation. However, field observations and participant accounts noted fluctuations in fish abundance, reflecting broader ecological changes in riverine and wetland systems. This variability further illustrates the community's continued reliance on natural resources (Iiyama et al. 2007; Omolo & Mafongoya 2019).

To reduce exposure to ecological and regulatory pressures, some households have begun diversifying their livelihoods. Emerging activities include small-scale processing of local products, home-based enterprises, and participation in community-based ecotourism initiatives. Two villages in the buffer zone, Marabahan Baru and Anjir Serapat Muara 1, have developed early-stage ecotourism concepts centered on wetland landscapes and conservation of proboscis monkeys. These locations illustrate the spatial distribution and conditions of tourism-oriented settlements in the study area (Ávila-Foucat et al. 2021).

Figure 5. Two Buffer Zone Tourism Villages, left: Marabahan Baru, right: Anjir Serapat Muara 1

Capacity-building programs introduced by government agencies and conservation partners have supported these diversification efforts. Participants widely recognized training on ecotourism management, sustainable agriculture, and fisheries practices as beneficial for expanding human capital. However, analysis of interview data indicates several constraints that limit long-term impact: (1) limited continuity of mentoring, (2) restricted access to markets for ecotourism products and local crafts, and (3) resistance from community members who view

traditional practices as more reliable or profitable. These challenges parallel findings from other contexts, where education and training require follow-up support and genuine community participation to generate lasting behavioral and economic changes (Rudiarto et al. 2019).

Figure 6. Ecotourism Management Training

The community perspectives highlight the need for greater alignment between conservation objectives and livelihood security. Respondents emphasized that participatory planning, inclusive decision-making, and consistent institutional support are essential for ensuring local ownership of conservation efforts. The findings indicate that integrating conservation goals with livelihood diversification, market development, and long-term training may enhance both ecological outcomes and socio-economic resilience in the buffer zone communities (Gong et al. 2020; Zikri et al. 2024).

The qualitative findings demonstrate that the community's role in conserving the proboscis monkey habitat on Curiak Island encompasses three interrelated dimensions: Community-Based Natural Resource Management (CBNRM), Indigenous Knowledge (IK), and the Sustainable Livelihoods Approach (SL). These constructs reflect the current socio-ecological conditions of buffer-zone communities, capturing local participation, knowledge systems, and livelihood adjustments related to wetland conservation. While these findings provide rich contextual insight, quantitative analysis is necessary to confirm the extent to which each construct contributes to conservation outcomes. Therefore, Partial Least Squares–Structural Equation Modeling (PLS-SEM) was employed to empirically test the relationships between the constructs.

3.4 Measurement Model Assessment

Evaluation of the measurement model confirms that all constructs meet the criteria for internal consistency, reliability, and validity. As shown in **Table 2**, nearly all indicator loadings exceed the recommended threshold of 0.70, demonstrating strong indicator reliability across constructs. Cronbach's Alpha (0.878–0.908) and Composite Reliability (0.908–0.929) values exceeded the minimum criterion of 0.70, confirming satisfactory internal consistency. Furthermore, all Average Variance Extracted (AVE) values (0.622–0.685) were above 0.50, indicating acceptable convergent validity (Hair et al. 2019).

Table 2: Summary of model measurement

Construct	Item	Loading Factor	Cronbach's Alpha	Composite Reliability	AVE
CB (Community-Based Natural Resource Management)	CB1	0.793	0.878	0,908	0,622
	CB2	0.807			
	CB3	0.803			
	CB4	0.784			
	CB5	0.771			
	CB6	0.771			
IK (Indigenous Knowledge)	IK1	0.693	0.897	0,922	0,663
	IK2	0.807			
	IK3	0.845			
	IK4	0.865			
	IK5	0.848			

Construct	Item	Loading Factor	Cronbach's Alpha	Composite Reliability	AVE
SL (Sustainable Livelihood Approach)	IK6	0.822	0.908	0,929	0,685
	SL1	0.784			
	SL2	0.866			
	SL3	0.824			
	SL4	0.855			
	SL5	0.844			
	SL6	0.789			
WEC (Wetland Environmental Conservation)	WEC1	0.838	0.892	0,918	0,652
	WEC2	0.843			
	WEC3	0.839			
	WEC4	0.819			
	WEC5	0.712			
	WEC6	0.785			

Assessment of discriminant validity using the Heterotrait-Monotrait (HTMT) ratio confirmed that all constructs were empirically distinct, with values below 1.00 as shown in figure 7(Arshad et al. 2023; Franke & Sarstedt 2019; Munthe & Shuguang 2025). Multicollinearity assessment showed VIF values under 3.0, and the Standardized Root Mean Square Residual (SRMR) value was below 0.08, indicating good overall model fit. These results confirm that the measurement model is appropriate and can be advanced for structural evaluation (Ghasempour Ganji & Kazemi 2024; Iqbal & Rao 2023).

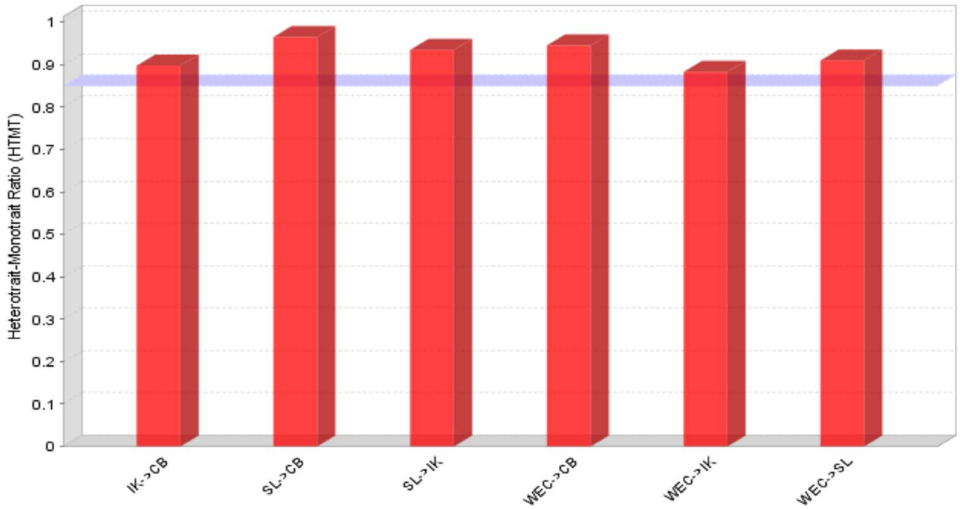

Figure 7. Heterotrait-Monotrait Ratio (HTMT)

These findings confirm that the measurement model in this study meets the validity and reliability criteria necessary to proceed with analysis on the structural model (inner model). Thus, these results support the instrument's strength in testing the relationships between latent variables in the context of environmental conservation in the buffer zone of the estuarine crocodile habitat.

3.5 Structural Model Assessment

The structural model (inner model), illustrated in **Figure 8**, examines the predictive relationship between CBNRM, IK, and SL toward Wetland Environmental Conservation (WEC). The model yields a coefficient of determination of $\mathbf{R^2 = 0.758}$, indicating that 75.8% of the variance in conservation outcomes is jointly explained by the three predictor constructs a strong explanatory capacity in environmental behavior research.

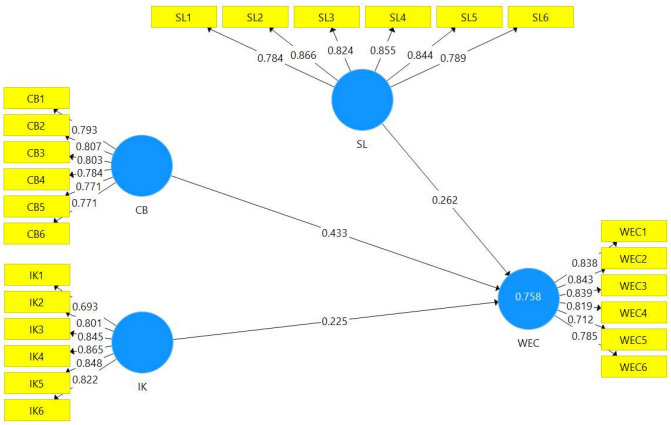

Figure 8. Community Roles Model in the Buffer Zone of The Proboscis Monkey Habitat

All hypothesized relationships were found to be positive and statistically significant (**Table 3**). CBNRM exhibits the strongest effect on WEC ($\beta = 0.433$, $T = 5.781$, $p < 0.001$), demonstrating that community involvement in decision-making, surveillance, and mangrove restoration remains the primary determinant of conservation performance in the buffer zone (Ali et al. 2025). The SL construct also has a significant effect on WEC ($\beta = 0.262$, $T = 3.443$, $p = 0.001$), indicating that secure and environmentally compatible livelihood options can reinforce conservation behaviour (Prasath & Umashankar 2023; Yulasteriyani et al. 2025). IK contributes to WEC with the smallest yet still significant effect ($\beta = 0.225$, $T = 4.074$, $p < 0.001$), suggesting that although local ecological knowledge exists, its integration into formal conservation governance remains partial, limiting its full influence (Sohail & Chen 2022).

Table 3: Model Summary

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Conclusion
CB (Community-Based Natural Resource Management) -> WEC (Wetland Environmental Conservation)	0,433	0,433	0,075	5,781	0,000	Significant
IK (Indigenous Knowledge) -> WEC (Wetland Environmental Conservation)	0,225	0,224	0,055	4,074	0,000	Significant
SL (Sustainable Livelihood Approach) -> WEC (Wetland Environmental Conservation)	0,262	0,264	0,076	3,443	0,001	Significant

The results of the structural analysis, presented in Table 3, indicate that all constructs have a significant influence on wetland environmental conservation (WEC). Thus, the three main constructs tested, namely CB, IK, and SL, were proven to have a significant contribution to the conservation efforts of the wetland environment, the Proboscis Monkey habitat on Curiak Island.

3.6 Integrated Interpretation of Qualitative and Quantitative Results

The combined qualitative–quantitative findings support the conclusion that conservation success in the proboscis monkey habitat buffer zone is driven by a hybrid governance mechanism, in which community participation in natural resource management serves as the central foundation. Sustainable livelihood support and the gradual strengthening of local ecological understanding enhance community motivation and capacity to contribute to conservation practices. This interplay affirms theoretical principles of community-based conservation and adaptive co-management, demonstrating that decentralized governance, when coupled with livelihood resilience and knowledge pluralism, can generate substantial ecological benefits in sensitive wetland systems.

4. DISCUSSION

The results of the structural model underscore the crucial role of community involvement, sustainable livelihoods, and local knowledge in driving effective wetland environmental conservation (WEC) in the proboscis

monkey (*Nasalis Larvatus*) habitat buffer zone. Statistically significant and positive path coefficients indicate that each construct makes a meaningful contribution to the conservation model, although their relative strengths vary.

4.1 Community-Based Natural Resource Management

Community-Based Natural Resource Management (CBNRM) represents a pivotal approach in contemporary conservation efforts, particularly for its strong positive correlation with community empowerment and ecological sustainability (Ali et al. 2025). The efficacy of CBNRM strategies, which prioritize local governance structures within participatory and decentralized frameworks, has been increasingly recognized in scholarly works. Research indicates that community involvement enhances effective governance and social capital, which are vital for fostering collective action. Specifically, studies highlight that local engagement in resource management can reduce conflicts related to resources, underscoring the significance of local knowledge and inclusive decision-making (Gandiwa et al. 2013; Kundu et al. 2010).

In buffer zones, where institutional governance may lack the authority and cultural relevance for effective enforcement, community-based approaches become especially crucial (Berkes 2007; Sullivan et al. 2017). Literature illustrates that integrating traditional knowledge and local governance mechanisms into conservation practices significantly elevates the capability of communities to act as frontline stewards in protecting ecological resources. This integration enhances not only governance but also fosters a sense of stewardship among community members, essential for sustainable environmental management (Berkes 2007; Berkes and Jolly 2002). Furthermore, the concept of participative efficacy highlights the psychological aspects wherein community involvement leads to a positive transformation in collective identity, resulting in heightened collective empowerment and unified action toward sustainability (Rees & Bamberg, 2014; Sharma & Patil, 2025; Zomeren et al. 2012).

The findings regarding the importance of local networks resonate with the context of ecological protection. By leveraging such networks, communities can mobilize effectively, reinforcing their crucial role in resource management and conservation. This dynamic reflects broader trends in social psychology, where collective action inspired by a shared identity can lead to significant pro-environmental behaviors (Fielding and Hornsey 2016; Keshavarzi et al. 2021). Moreover, the successful implementation of community-driven strategies can potentially reduce transaction costs associated with complex governance systems, thus mitigating barriers to effective resource management (Lubell et al. 2016).

This evidence supports the assertion that Community-Based Natural Resource Management is not only a significant predictor of ecological sustainability but also a vital strategy in empowering communities. This empowerment is critical for establishing resilient ecosystems and sustainable resource use, aligning local governance with broader conservation goals.

4.2 Sustainable Livelihood Approach

The Sustainable Livelihood Approach (SL) plays a crucial role in advancing conservation initiatives by integrating economic security into community management of natural resources. The statistical coefficient ($\beta = 0.262$) highlights the significance of SL in promoting community resilience, reducing dependency on unsustainable extractive practices, and encouraging a long-term perspective on conservation efforts (Apine et al. 2019; Berkes, 2004). When communities perceive tangible socio-economic benefits from conservation, such as income from ecotourism or payments for ecosystem services, their participation becomes more robust and sustainable (Naidoo et al. 2011; Pailler et al. 2015).

In buffer zones, where ecological preservation intersects with human livelihoods, ensuring that local residents derive tangible benefits from conservation activities is crucial. For instance, studies in the Tambopata National Reserve in Peru demonstrate that sustainable land use practices, like Brazil nut harvesting and fish farming, can provide economic returns similar to those from more destructive gold mining (Buřivalová et al. 2019a). Enhancing the value of sustainably sourced products at their origin can motivate communities to pursue environmentally friendly alternatives (Naidoo et al. 2011). Similarly, in India's Kaimur Wildlife Sanctuary, the development of ecotourism not only offers a viable source of income but also mitigates environmental degradation (Su et al. 2016).

The SL also highlights the importance of empowering communities by validating their social and ecological assets. For example, community engagement in asset-based conservation strategies in the Peruvian Amazon has been linked to improved livelihoods and enhanced sustainability of protected areas (Gena and Jemal 2022). Research in East Africa reveals that factors such as secure land tenure, sustainable livelihoods, and effective communication among stakeholders are crucial to the success of community-based conservation, indicating that economic incentives alone are insufficient to ensure the effective management of natural resources (Pailler et al. 2015).

Neglecting the socio-economic dimensions of conservation can lead to inequities and exacerbate poverty, which underlines the need for a balanced approach that prioritizes both ecological and community needs. Studies in tropical regions have emphasized the critical role of maintaining community access to natural resources while simultaneously investing in infrastructure and market access to support sustainable livelihoods (Buřivalová et al. 2019b). This dual focus is essential for aligning conservation goals with the well-being of local populations (Hoa and Thuy 2023).

However, implementing the SL comes with challenges, including infrastructure deficits, insufficient technical capacity, and limited public awareness. The effectiveness of sustainable livelihoods strategies is heavily contextual; thus, SL programs must be tailored to the unique social, cultural, and economic characteristics of the communities involved to ensure lasting impacts (Berkes 2004; Buřivalová et al. 2019b). In conclusion, leveraging the Sustainable Livelihood Approach holds great promise for harmonizing economic development and environmental conservation, promoting resilience among local communities in buffer zones and beyond.

4.3 Local Knowledge (Indigenous Knowledge)

Indigenous knowledge (IK) is pivotal for enhancing environmental conservation efforts, yet its integration into formal conservation frameworks remains insufficiently recognized. The positive correlation ($\beta = 0.225$) between IK and successful conservation outcomes highlights the potential of traditional practices, which embody generations of ecological understanding, to make meaningful contributions to conservation policies (Kohler and Brondízio 2016; Mutasa 2015; Tholkapiyan et al. 2025). However, the technocratic frameworks that often dominate these policies typically marginalize this knowledge, overlooking critical place-based ecological insights that IK provides (Brondízio et al. 2021; Coutant et al. 2025).

Additionally, Traditional Ecological Knowledge, as a component of IK, offers a holistic perspective on ecosystems that can complement and enrich Western scientific approaches in conservation strategy formulation (Muswazi 2001; Yongabi 2023). Yet, integrating IK into these strategies faces substantial structural obstacles, including historical colonial frameworks that perpetuate unequal power dynamics in conservation discourse. Such disparities hinder the recognition of IK as an equally valid epistemological system (McGregor 2021; Obiero et al. 2023). Despite its potential, TEK principles remain underutilized in natural resource management policies, often limited to localized projects rather than being integrated into broader frameworks (Moola and Roth 2019; Shepard and Daly 2023).

The call for a cross-cultural collaborative approach to bridge epistemological differences is essential to advance meaningful indigenous community involvement in conservation efforts. This collaborative process can promote dialogue between diverse knowledge systems, facilitating mutual understanding that enhances the effectiveness of conservation strategies (Brondízio et al. 2021; Kohler and Brondízio 2016). The decolonization of conservation practices is increasingly recognized as an urgent priority, advocating for models that empower indigenous communities to take control of their conservation initiatives, thereby addressing contemporary ecological complexities in a more contextualized and equitable manner (Moola and Roth 2019; Muswazi 2001).

While the technocratic model has indeed contributed significantly to conservation science, achieving sustainable conservation goals necessitates a balanced integration of IK with modern scientific approaches. Both knowledge systems offer valuable insights that, when combined, can lead to more effective and resilient conservation practices (Babidge et al. 2007; Brondízio et al. 2021; Mutasa 2015; Singh et al. 2025). Ensuring that indigenous voices are included in policy-making processes not only validates their contributions but also enriches conservation practices through a deeper understanding of local ecosystems.

5. CONCLUSIONS

This study demonstrates that conservation of the proboscis monkey habitat within the Curiak Island buffer zone is influenced by three main factors: Community-Based Natural Resource Management (CBNRM), Indigenous Knowledge (IK), and the Sustainable Livelihood Approach (SL). Qualitative findings show that communities play a tangible role in maintaining wetland ecosystem balance, although the integration of indigenous knowledge into current conservation practices remains limited. Meanwhile, the quantitative evidence using PLS-SEM confirms that all three constructs significantly contribute to wetland environmental conservation, with CBNRM providing the strongest influence.

The coefficient of determination ($R^2 = 0.758$) indicates that the model explains a substantial proportion of the variance in community conservation efforts, although external factors beyond the model should be explored further. Additionally, the relatively lower contribution of IK compared to the other constructs suggests the need to strengthen the incorporation of local knowledge into conservation policies and practice.

Overall, this research provides empirical support that community engagement and economically sustainable livelihood strategies hold potential to enhance habitat protection for the proboscis monkey. However, given the statistical reporting limitations and the contextual scope of the dataset, policy implications should be interpreted with caution and not generalized beyond the specific conditions of this study. Future research should expand measurement indicators, adopt longitudinal designs, and explore additional external factors that may influence conservation success in this region.

6. PATENTS

Author Contributions: Conceptualization, M.R.I., E.W.A., B.S., and M.; methodology, M.R.I. and M.; software, M.R.I. and M.; validation, M.R.I., E.W.A., B.S., and M.; formal analysis, M.R.I. and M.; investigation, M.R.I.; resources, M.R.I.; data curation, M.R.I. and M.; writing original draft preparation, M.R.I. and M.; visualization, M.R.I.; supervision, E.W.A., B.S.; project administration, M.R.I.; funding acquisition, M.R.I.

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