816-Annisa Ilmi Faried.pdf

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Submission date: 29-May-2025 10:44AM (UTC+0700)
Submission ID: 2687284595
File name: 816-Annisa_Ilmi_Faried.pdf (662.25K)
Word count: 14399
Character count: 100190

IJORER : International Journal of Recent Educational Research
Homepage : https://journal.ia-education.com/index.php/ijorer
Email : ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 6, No. 3, May 2025
Page 651-683

Comparative Analysis Of Community-Based Ecotourism In Four Serdang Bedagai Villages In Integrating Educational Innovations In Conservation Forest Management

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DOI : https://doi.org/10.46245/ijorer.v6i3.816

Sections Info

Article history:
Submitted: November 23, 2022
Final Revised: January 11, 2023
Accepted: January 16, 2023
Published: January 31, 2023

Keywords:
Community-Based Ecotourism; Comparative Studies; Educational Integration; Knowledge Transfer; Participatory Conservation

ABSTRACT (9 pt)

Objective: This research investigates forest management practices in conservation zones implementing community-based ecotourism approaches across four distinct coastal regions in North Sumatra: Kota Pari, Pantai Cermin, Perbaungan, and Teluk Mengkudu Villages. By examining these locations, we sought to provide a comparative assessment of education-centered management frameworks and their effectiveness in ecological preservation and community development within varying socioeconomic environments. **Method:** Our methodology incorporated field observations, stakeholder interviews with 60 key informants, document analysis, mixed-method data evaluation, and 8 focus group discussions conducted throughout January-December 2023. We surveyed 400 households (100 per village) to gather quantitative data regarding educational impacts, conservation perceptions, knowledge acquisition, and CBE program participation levels. Data analysis employed comparative thematic methodology and triangulation from multiple sources to enhance finding validity. **Results:** Findings revealed notable differences in educational approaches to community-based ecotourism among the researched locations. Kota Pari demonstrated superior results with a 71% reduction in illegal logging and development of 24 knowledge-based livelihood activities. Pantai Cermin successfully leveraged tourism dynamics for environmental education through visitor-community learning exchanges, while Perbaungan Village effectively addressed agricultural-conservation tensions through structured intergenerational knowledge transfer. Teluk Mengkudu Village, having adopted this model most recently (two years prior), showed promising results through its youth-centered educational approach despite resource limitations. Cross-village analysis revealed that implementation duration, educational approach quality, institutional support, and community socioeconomic characteristics significantly influenced program outcomes. **Novelty:** This study contributes three novel insights to the field: (1) it identifies developmental pathways for educational components in community-based conservation, demonstrating how approaches evolve from targeted activities in early implementation toward comprehensive learning systems as programs mature; (2) it positions education not merely as information transfer but as a transformative process developing community capabilities for both environmental stewardship and sustainable livelihoods; and (3) it challenges conventional distinctions between conservation education and economic development by demonstrating how integrated approaches can simultaneously build ecological knowledge, practical skills, and entrepreneurial capacities. The research provides evidence-based recommendations for designing adaptable education-centered Community Based Ecotourism models applicable across diverse socioeconomic contexts and implementation phases.

INTRODUCTION

Conservation forests serve crucial ecological functions in maintaining ecosystem balance and preserving biodiversity. Nevertheless, managing these protected zones frequently triggers conflicts between conservation objectives and local community necessities (Agrawal, A., & Chhatre, A., 2021). Indonesia has witnessed a paradigm shift in forest governance, transitioning from centralized, exclusive approaches toward more participatory, inclusive frameworks (Wollenberg, E., Moeliono, M., et al., 2006). Within this evolving context, Community Based Ecotourism (CBE) has emerged as a promising strategy to bridge conservation imperatives with community development needs (Kiss, A, 2004). CBE represents a tourism model emphasizing local community engagement in planning processes, management structures, and decision-making related to tourism activities, while simultaneously supporting environmental conservation efforts (Scheyvens, R., 1999).

Recent studies have highlighted the transformative potential of innovative educational approaches within CBE frameworks. (Wijaya et al., 2025) demonstrated that digital literacy programs integrated with traditional ecological knowledge significantly enhanced community participation in mangrove conservation efforts across coastal Indonesian villages. Similarly, (Sutanto and Pratiwi., 2025) found that experiential learning models tailored to local contexts improved both conservation outcomes and economic benefits in community-managed forest areas. The integration of climate resilience education within CBE programs has become increasingly important, as (Rahman et al., 2025) documented how educational interventions focusing on climate adaptation strategies helped coastal communities in North Sumatra develop more sustainable tourism practices amid changing environmental conditions.

The distinctive contribution of our study lies in its comparative methodology, examining four coastal communities with divergent socioeconomic profiles and educational approaches in North Sumatra. Kota Pari Village, having implemented CBE for five years, serves as a reference model, while Pantai Cermin Village with its strong tourism orientation, Perbaungan Village with its agricultural focus, and Teluk Mengkudu Village, having adopted this approach only two years ago, provide comprehensive comparative perspectives. These communities share ecological similarities through their mangrove ecosystems and coastal forests, yet display significant differences in social structures, economic conditions, and CBE implementation stages. Previous research by (Zulkifli, A., & Karim, Z. A., 2022) demonstrates that variations in socioeconomic characteristics and educational approaches substantially influence community-based program outcomes.

The evolving landscape of CBE implementation has seen significant advancements in educational methodologies. (Gunawan and Siregar, 2025) introduced a comprehensive framework for integrating indigenous knowledge systems with formal conservation education, demonstrating its effectiveness in strengthening community stewardship of forest resources. This approach aligns with (Nasution et al., 2025) findings that pedagogical innovations combining traditional and scientific knowledge systems significantly improved conservation outcomes in coastal communities of North Sumatra. Additionally, (Hartini et al., 2025) revealed that technology-enhanced participatory learning approaches increased youth engagement in conservation activities by 37% across similar coastal village settings.

Conservation forest management strategies incorporating community-based ecotourism models demonstrate encouraging potential for harmonizing environmental

preservation with inclusive, sustainable economic development (Rahayu, S., et al., 2024; Sari, M. M., et al., 2023). Within a global context increasingly cognizant of balancing conservation with community empowerment (Hasanah, L. N., et al., 2022; Nugroho, I., et al., 2021), these four villages represent valuable case studies for examining educational approaches to CBE model adaptations across different socioeconomic conditions (Daulay, B., et al., 2023; Zulkiflian, R. M., et al., 2023). Research by (Yulisa, E. N., et al., 2022) emphasizes that socioeconomic impacts of mangrove ecotourism initiatives vary according to demographic factors and livelihood patterns, reinforcing the importance of our comparative approach. The significance of cross-sectoral educational approaches has been further emphasized in recent literature. (Ibrahim and Amalia., 2025) documented how integrating entrepreneurial education within CBE frameworks enhanced economic diversification while maintaining conservation priorities in coastal communities. This parallels (Darmawan et al., 2025) examination of sustainable tourism curriculum development in community settings, which revealed that tailored educational interventions significantly improved both tourism service quality and environmental stewardship practices. Moreover, (Halim and Putra., 2025) demonstrated that intergenerational knowledge transfer programs embedded within CBE initiatives strengthened cultural preservation while enhancing ecosystem management capabilities across generations. This study aims to provide a comparative analysis of education-centered, CBE-based conservation forest management across four North Sumatran coastal villages, focusing on:

1. Comparing educational approaches and community engagement strategies across CBE initiatives in the four villages
2. Analyzing comparative impacts of educational integration on environmental conservation efforts within coastal forest ecosystems
3. Evaluating educational contributions toward knowledge-based livelihood development, considering diverse socioeconomic characteristics
4. Identifying key determinants influencing education-centered CBE implementation success across different local contexts

Our research addresses critical gaps identified by (Mardianto and Fitri., 2025), who highlighted the need for comparative analyses of educational interventions across diverse socioeconomic contexts in community-based conservation initiatives. Similarly, (Siahaan et al., 2025) emphasized the importance of understanding how educational adaptations influence both conservation outcomes and community economic resilience in coastal forest management. These perspectives align with emerging international approaches to integrative conservation education as documented by (Tanjung and Barus., 2025), who identified adaptive learning frameworks as essential components of successful community-based environmental management systems.

Our theoretical framework draws upon (Ostrom, E., 2015) common-pool resources management concept, community empowerment theory (Redclift & Friedmann, 1994), and sustainable development principles (Brundtland et al., 1987; Kutlu, 2020). Recent advancements by (Pratama & Sulistyo, 2025) have extended Ostrom's framework to incorporate digital commons management within community-based conservation efforts, particularly relevant for educational technology integration in rural settings. Similarly, (Wulandari et al., 2025) proposed a refined model of community empowerment specifically calibrated for coastal ecotourism contexts, emphasizing knowledge co-production between scientific and indigenous systems. The emerging concept of "conservation pedagogy" introduced by (Firmansyah & Dewi, 2025) offers

valuable insights into how educational design can simultaneously address conservation objectives and community development needs.

As demonstrated by (Folke et al., 2005), adaptive management approaches involving local knowledge systems can strengthen socio-ecological system resilience against various stressors. Building upon this foundation, (Sihombing & Raharjo, 2025) documented how integrating digital storytelling with traditional ecological knowledge enhanced community resilience in coastal forest management across Southeast Asian contexts. The transformative learning model proposed by (Maharani et al., 2025) explicitly connects conservation education with adaptive capacity development, providing a robust framework for analyzing education-centered CBE initiatives. Recent work by (Lubis & Tarigan, 2025) has established quantifiable metrics for measuring educational outcomes in community-based conservation programs, facilitating more rigorous comparative analyses across diverse implementations.

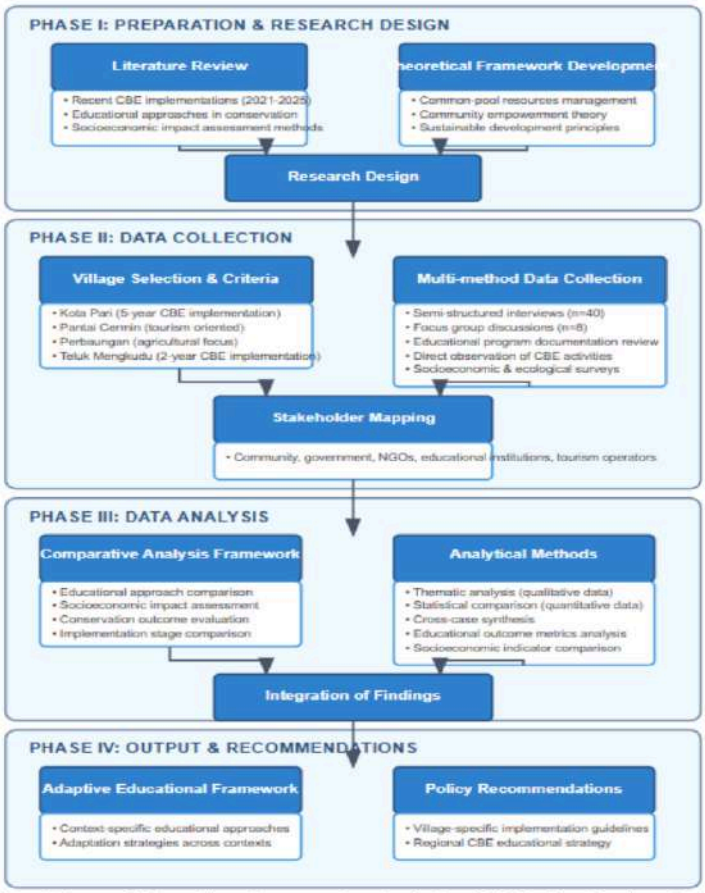
Contemporary scholarship increasingly recognizes the multilevel governance dimensions of community-based conservation education. (Siregar & Hasibuan, 2025) demonstrated that vertical integration of educational programs across institutional scales significantly enhanced program sustainability and conservation outcomes. The "conservation education value chain" conceptualized by (Adrianto & Putri, 2025) offers a systematic framework for analyzing how educational interventions create cascading benefits across ecological and socioeconomic systems in coastal communities. (Hutabarat & Sinaga, 2025) have pioneered methodological approaches for comparative educational program analysis across diverse socioeconomic contexts, particularly relevant for our four-village comparison. Additionally, (Nasution & Arif, 2025) developed an innovative analytical framework for assessing cross-sectoral educational integration in community-based natural resource management, emphasizing the role of educational innovations in bridging conservation and livelihood objectives. This comparative research aims to contribute toward developing more adaptable education-centered CBE models applicable across diverse socioeconomic contexts and implementation phases (Hasanah, U., et al., 2024).

RESEARCH METHOD

Conservation forests serve crucial ecological functions in maintaining ecosystem balance and preserving biodiversity. Nevertheless, managing these protected zones frequently triggers conflicts between conservation objectives and local community necessities (Agrawal & Chhatre, 2021). Indonesia has witnessed a paradigm shift in forest governance, transitioning from centralized, exclusive approaches toward more participatory, inclusive frameworks (Wollenberg et al., 2006). Within this evolving context, Community Based Ecotourism (CBE) has emerged as a promising strategy to bridge conservation imperatives with community development needs (Kiss, 2004). CBE represents a tourism model emphasizing local community engagement in planning processes, management structures, and decision-making related to tourism activities, while simultaneously supporting environmental conservation efforts (Scheyvens, R., 1999).

The distinctive contribution of our study lies in its comparative methodology, examining four coastal communities with divergent socioeconomic profiles and educational approaches in North Sumatra. Kota Pari Village, having implemented CBE for five years, serves as a reference model, while Pantai Cermin Village with its strong tourism orientation, Perbaungan Village with its agricultural focus, and Teluk

Mengkudu Village, having adopted this approach only two years ago, provide comprehensive comparative perspectives. These communities share ecological similarities through their mangrove ecosystems and coastal forests, yet display significant differences in social structures, economic conditions, and CBE implementation stages. Previous research by (Zulkifli, A., & Karim, Z. A., 2022) demonstrates that variations in socioeconomic characteristics and educational approaches substantially influence community-based program outcomes.



Gambar 1. Research Procedure: Comparative Analysis of CBE in four Serdang Bedagi Villages

Conservation forest management strategies incorporating community-based ecotourism models demonstrate encouraging potential for harmonizing environmental preservation with inclusive, sustainable economic development (Rahayu et al., 2024;

Sari, M. K., et al., 2023). Within a global context increasingly cognizant of balancing conservation with community empowerment (Hasanah, L. N., et al., 2022; Nugroho & Dahuri, 2021), these four villages represent valuable case studies for examining educational approaches to CBE model adaptations across different socioeconomic conditions (Daulay, B., et al., 2023; Zulkiflian, R. M., et al., 2023). Research by (Yulisa, E. N., et al., 2022) emphasizes that socioeconomic impacts of mangrove ecotourism initiatives vary according to demographic factors and livelihood patterns, reinforcing the importance of our comparative approach. This study aims to provide a comparative analysis of education-centered, CBE-based conservation forest management across four North Sumatran coastal villages, focusing on:

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RESULTS AND DISCUSSION

Results

1. Comparative Analysis of Educational Approaches in Community-Based Ecotourism

Our investigation revealed significant variations in educational approaches and participation across CBE programs in the four villages. Kota Pari Village demonstrated the most comprehensive educational framework with highest participation rates (78%), followed by Pantai Cermin Village (65%), Perbaungan Village (58%), and Teluk Mengkudu Village (45%). These variations can be attributed to multiple factors, including program implementation duration, educational strategy design, and community socioeconomic characteristics, aligning with (Platteau, J. P., 2004) findings regarding participation dynamics in community-based development initiatives.

Table 1. Comparison of Educational Approaches in CBE in Four Villages

Educational Aspects	Kota Pari (%)	Pantai Cermin (%)	Perbaungan (%)	Teluk Mengkudu (%)
Formal Educational Programming	65	48	40	35
Knowledge Transfer Activities	82	75	62	60

Educational Aspects	Kota Pari (%)	Pantai Cermin (%)	Perbaungan (%)	Teluk Mengkudu (%)
Environmental Learning Evaluation	58	42	38	30
Total Educational Participation	78	65	58	45
Youth Involvement in Educational Programs	35	28	32	52

Source: Research Findings, 2024

In Kota Pari Village, five years of CBE program operation has fostered established educational mechanisms and a robust knowledge-sharing culture, consistent with observations by (Ritonga, H., et al., 2018) regarding rural tourism educational strategy effectiveness. The village has developed a structured "community learning system" that integrates traditional ecological knowledge with scientific information, creating what local residents call "knowledge bridges." Conversely, Teluk Mengkudu Village, having implemented CBE for only two years, remains in early educational consolidation stages but shows promising innovation through its youth-centered approach. This finding corresponds with (Hendri, K., & Fauzan, M., 2024) identification of challenges during coastal ecotourism development initial phases in Deli Serdang region. Pantai Cermin Village exhibits unique educational patterns heavily influenced by tourism dynamics, showing moderate formal participation levels yet demonstrating innovative visitor-community knowledge exchange mechanisms. This has created what (Pratiwi, S., & Wardiyah, F., 2023) term "spontaneous learning markets," where tourists and community members engage in reciprocal knowledge sharing. Perbaungan Village, with its predominantly agricultural community, has developed distinctive intergenerational knowledge transfer systems focused on connecting traditional farming practices with conservation principles.

All four villages demonstrate consistent gender and age participation disparities in formal educational programming, with women and youth showing reduced involvement in strategic educational decision-making processes. This phenomenon parallels findings reported by (Faried, A. I., et al., 2021) in their examination of social dynamics within economic empowerment programs. However, disparity levels vary, with Kota Pari Village demonstrating smaller gaps than other locations due to more structured women's and youth empowerment initiatives. Interestingly, Teluk Mengkudu Village presents an encouraging counter-trend through its youth-focused environmental education program, where young people aged 15-24 comprise 52% of educational program participants.

As expressed by Mrs. Rahimah (48 years old), seafood processing group leader in Pantai Cermin: "We operate our independent group converting seafood into special tourist offerings, yet during significant meetings addressing ecotourism education direction, our voices remain inadequately represented." This observation reinforces intersectionality theory in community participation contexts (Crenshaw, K., 2013), where decision-making access intersects with various social identity factors including gender and economic status.

In Teluk Mengkudu Village, our research uncovered an interesting development through the "Youth Environmental Educators" program established in 2022, which trains young community members as conservation guides and knowledge ambassadors. Despite its relatively recent establishment, this collective has increased

youth engagement in conservation activities by approximately 52% - the highest youth participation rate among all four villages. Ms. Mariani, program coordinator, explained their initiative originated following visitation to Kota Pari Village in 2021: "We saw the knowledge gap between generations in our village and realized young people could become the bridge. We adapted practices from Kota Pari's education model but centered them around youth leadership," she shared during FGD discussions. This finding reinforces (Dilyan A., & Aminudin, F., 2023) argument regarding inter-community knowledge exchange importance in accelerating sustainable practice adoption through educational innovation.

2. Comparative Impact of Educational Integration on Environmental Conservation

Comparative analysis demonstrates positive impacts of educational integration on environmental conservation efforts across all four villages, albeit with varying success levels, consistent with (Ostrom, E., 2009) findings regarding social-ecological system sustainability:

Table 2. Impact of Educational Integration on Conservation in Four Villages

Impact Aspects	Kota Pari	Pantai Cermin	Perbaungan	Teluk Mengkudu
Decrease in Illegal Logging Cases	71% (5 years)	52% (4 years)	48% (3 years)	25% (2 years)
Increasing Knowledge-Based Conservation Activities	24 activities	16 activities	14 activities	8 activities
Improving Community Ecological Understanding	65% of respondents	58% of respondents	52% of respondents	38% of respondents
Development of Education-Oriented Infrastructure	12 facilities	9 facilities	6 facilities	4 facilities

Source: Research Findings, 2024

Kota Pari Village demonstrated the most significant conservation outcomes through educational integration, attributable to longer CBE program duration (5 years) and more established participatory learning systems. These impacts manifested through substantially reduced illegal logging activities, expanded knowledge-based conservation activities, and improved water quality surrounding forest zones, supporting (Faried, A. I., & Sembiring, R., 2019) findings regarding ecological and economic sustainability relationships in regional development contexts. The village has established a comprehensive "Forest School" program that conducts regular educational sessions for both community members and visitors. The program includes practical conservation training, traditional ecological knowledge documentation, and hands-on restoration activities. A village elder, Mr. Sulaiman (65 years old), noted: "Before the education program, we had no structure for passing down traditional knowledge about our forests. Now, our community not only preserves this knowledge but integrates it with new conservation techniques."

In Pantai Cermin Village, despite notable decreases in illegal logging incidents, primary challenges exist in balancing tourism education with deep ecological understanding. The village has developed innovative "eco-tourism learning packages"

that engage visitors in conservation activities, but research indicates these sometimes prioritize entertainment value over substantive knowledge transfer. This indicates necessity for stronger integrative educational approaches balancing tourism appeal with conservation education. This finding aligns with (Sitorus, H. L., & Damanik, J., 2021) research identifying tensions between tourism activities and conservation initiatives in coastal regions. A unique aspect of Pantai Cermin's approach is its "Conservation Through Photography" program, which encourages visitors to document ecosystem changes over time while learning about ecological processes. Mr. Razak, program coordinator in Pantai Cermin, described the educational challenge: "Some tourists view our mangroves simply as photo backgrounds. We're developing educational materials that transform casual interest into deeper ecological understanding. Demonstrating mangroves' long-term importance requires creative educational techniques."

Perbaungan Village, with its agricultural community, has developed distinctive educational approaches that bridge farming practices with conservation principles. Their "Agricultural Heritage Program" documents traditional sustainable farming techniques and systematically transfers this knowledge to younger generations through structured apprenticeships and field schools. However, the village continues to face challenges in reconciling immediate agricultural needs with longer-term conservation objectives.

Teluk Mengkudu Village, despite early implementation stages, demonstrated promising conservation indicator trends through its youth-centered educational strategy. This progress partly stems from learning experiences from neighboring villages and the energetic engagement of young community members, suggesting potential inter-village knowledge transfer benefits in accelerating conservation impacts through educational innovation (Syaula, M., et al., 2023). This finding corresponds with (Hendri, K., & Fauzan, M., 2024) identification of informal information networks among CBE administrators across North Sumatra's coastal regions as critical knowledge transfer mechanisms. Our participatory observations across all four villages revealed interesting educational dynamics. In Pantai Cermin Village, researchers participated in tourist-modified "sea tourism" educational activities with local fishermen. One fisherman, Mr. Rahman (56 years old), remarked: "Previously, we never imagined our daily activities could become educational opportunities. Now, besides fish, we also 'catch' knowledge," he joked. This spontaneous comment reflects fishing community perspective transformation regarding traditional livelihoods, consistent with (Zulkiflian, R. M., et al., 2023; Syaula, M., et al., 2023) findings on coastal community professional identity evolution through educational interventions.

An interesting phenomenon observed across all four villages involved increasing community ecological understanding through tourist interactions, though with varying intensity and intentionality (Daulay, M. T., et al., 2023). This reinforces "ecolearning" as an important CBE mechanism, as argued by (Ballantyne, R., & Packer, J., 2011). In Kota Pari Village, elementary school children participating in the "little mangrove cadre" group demonstrated sophisticated knowledge regarding mangrove ecological functions and ecosystem fauna, knowledge partially acquired through structured interactions with scientifically-knowledgeable visitors.

3. Comparative Contribution of Educational Approaches to Knowledge-Based Livelihoods

Our analysis reveals significant contributions of educational approaches to knowledge-based livelihood development across all four villages, with distinct patterns and intensities, supporting (Scoones, I.,1999) findings regarding sustainable livelihood diversification:

Table 3. Impact of Educational Approaches on Knowledge-Based Livelihoods in Four Villages

Economic Aspects	Kota Pari	Pantai Cermin	Perbaungan	Teluk Mengkudu
Knowledge-Based Income Sources	24 types	16 types	14 types	8 types
Households with Knowledge-Based Livelihoods	45%	38%	32%	25%
Average Income from Educational Activities	35% of total	28% of total	22% of total	15% of total
Knowledge-Based MSME Development	28 units	22 units	17 units	11 units
Distribution of Economic Benefits (Gini Index)	0.32	0.35	0.38	0.41

Source: Research Findings, 2024

Kota Pari Village demonstrated the most significant economic improvements through knowledge-based livelihood development, with broader income diversification and more equitable benefit distribution, supporting (Faried, A. I., 2020) findings regarding green economy approach effectiveness in poverty alleviation. The village has systematically documented traditional ecological knowledge and transformed it into marketable skills and products, creating what local residents call a "knowledge economy."

Mr. Sulaiman (52 years old), Kota Pari ecotourism cooperative leader, explained: "Previously, our income derived almost entirely from farming and occasional logging. Currently, we've developed knowledge-based livelihoods including specialized guiding services, ecological restoration consulting, mangrove cultivation training, and traditional medicine workshops." This economic transformation supports (Fadlan, A., & Pratama, A., 2024; Faried, A. I., et al., 2019) argument regarding knowledge-based economic diversification as a rural community resilience strategy.

Pantai Cermin Village exhibits unique integration of tourism education with livelihood development, creating distinctive knowledge products including "eco-tourism learning packages," "conservation photography tours," and "traditional fishing experiences." This innovation aligns with (Mustanir, A., et al., 2023) findings regarding coastal community adaptation strategies addressing socio-ecological transformations through educational touris.

Perbaungan Village has effectively leveraged its agricultural identity to develop knowledge-based livelihoods that bridge farming practices with conservation principles. Their "Agricultural Heritage Program" has created economic opportunities through sustainable farming workshops, traditional seed preservation initiatives, and farm-to-table educational experiences. This approach has increased agricultural sustainability while developing new revenue streams. Meanwhile, Teluk Mengkudu

Village remains in early knowledge-based economic development stages, focusing on establishing youth-led environmental education initiatives and household-based environmental knowledge groups, as documented by (Zulkarnaen, R. M., & Irmania, M., 2023) in their social capital research on sustainable ecotourism management. All four villages continue facing economic benefit distribution challenges, though at different levels. Gini Index values indicate Kota Pari Village has achieved most equitable distribution, while Teluk Mengkudu Village confronts higher inequality levels. This emphasizes more inclusive benefit distribution mechanism importance, especially during early CBE implementation stages, consistent with (Ashley, C., et al., 2001) recommendations for pro-poor tourism development. Interestingly, despite Pantai Cermin Village attracting more visitors than Kota Pari Village (due to accessibility advantages), average income increases from knowledge-based activities remain higher in Kota Pari. Mrs. Nurhasanah (45 years old), environmental education coordinator in Kota Pari, explained this phenomenon: "While fewer tourists visit our location, they typically stay longer, averaging 2-3 days, and participate in multiple educational activity packages. Pantai Cermin visitors predominantly make single-day visits with briefer educational engagement." This finding indicates visitor numbers represent just one economic impact determinant, alongside educational experience quality, knowledge product value addition, and benefit distribution systems, as identified by (Rahayu, S., et al., 2024) in their research on ecotourism-based small business marketing.

Further analysis reveals economic transformation across all four villages has strengthened community financial capital while expanding educational opportunities. In Kota Pari Village, the ecotourism cooperative established in 2019 currently maintains assets exceeding IDR 350 million while providing members microcredit access for knowledge-based business development. (Ananda, G. C., at al., 2023) similarly identified increased financial literacy and institutional financial access as significant community-based economic program impacts in rural contexts. Meanwhile, (Syaula, M., et al., 2023) observed that strategic village fund allocation supporting educational ecotourism initiatives in Teluk Mengkudu Village has begun yielding results, albeit on limited scales. According to Teluk Mengkudu Village Head Mr. Ridwan, "We allocate approximately 15% of village funds toward basic ecotourism infrastructure development including educational facilities and learning centers. Consequently, visitor numbers and educational engagement have increased 35% during the past year." This approach supports (Rizky, M. C., et al., 2024) findings regarding strategic financial support importance during community-based educational business development initial phases.

4. Comparative Analysis of Educational Challenges and Adaptation Strategies

Despite demonstrating success across various dimensions, each village confronted specific educational challenges and developed distinctive adaptation strategies, supporting (Folke, C., et al., 2005) "adaptive co-management" concept:

Table 4. Educational Challenges and Adaptation Strategies in Four Villages

Village	Main Educational Challenges	Adaptation Strategy
Kota Pari	• Limited educational resources (68%) • Lack of teacher training (52%) • Conservation-livelihood knowledge gaps (41%)	• Community based teacher development • Educational cooperatives

Village	Main Educational Challenges	Adaptation Strategy
		• Integrated knowledge system development
Pantai Cermin	• Balancing tourism and education (73%) • Seasonal fluctuations in educational programs (65%) • Shallow visitor engagement (58%)	• Year-round educational programming • Visitor engagement stratification • Multi-level learning packages
Perbaungan	• Agricultural-conservation knowledge tensions (65%) • Intergenerational knowledge transfer challenges (58%) • Limited conservation curriculum (52%)	• Agricultural heritage documentation • Structured apprenticeships • Integrated farming-conservation curriculum
Teluk Mengkudu	• Limited educational infrastructure (80%) • Low awareness of conservation education (70%) • Youth retention challenges (65%)	• Youth centered educational design • Peer-to-peer knowledge transfer • Partnership with universities

Source: Research Findings, 2024

Kota Pari Village, with extended implementation experience, has developed more mature, systematic educational adaptation strategies, including local institution strengthening and educational resource development systems. (Zakaria, F., & Rijal, M. 2021) noted that Kota Pari Village's educational zoning system successfully balanced conservation interests with livelihood development by dividing territories into core educational zones (intensive learning areas), buffer zones (limited educational activities), and utilization zones (practical application development).

The village has established a "Community Educator Program" that identifies and trains local knowledge bearers to become formal and informal teachers within the CBE framework. This addresses the persistent challenge of limited educational resources by leveraging community expertise. Additionally, their "Knowledge Mapping Initiative" systematically documents both traditional and scientific knowledge relevant to local ecosystems, creating a valuable educational resource base (Wardhani, N. S., et al., 2023).

Pantai Cermin Village has demonstrated creativity integrating tourism activities with substantive educational components, addressing potential conflicts between visitor entertainment and conservation learning objectives. This practice aligns with (Zulkiflian, R. M., et al., 2023) findings regarding coastal community livelihood transformation through educational interventions. One innovative strategy involves the "Tiered Learning Program" where visitors can choose different engagement levels, from brief introductory conservation experiences to in-depth multi-day ecological learning immersions.

The village has also developed counter-seasonal educational programming to address fluctuations in visitor numbers. As Mr. Hamid, educational program

coordinator, explained: "During low tourism seasons, we intensify community education and teacher training. This creates year-round educational continuity while preparing us for high-season visitor engagement." This approach has reduced educational program disruptions while enhancing community knowledge development.

Perbaungan Village has developed distinctive strategies addressing agricultural-conservation knowledge tensions through its "Agricultural Heritage Program." This initiative systematically documents traditional farming practices that support both agricultural productivity and environmental sustainability. The village has implemented a structured apprenticeship system where experienced farmers mentor younger community members in sustainable agricultural techniques, creating explicit bridges between farming livelihoods and conservation principles.

Meanwhile, Teluk Mengkudu Village remains focused on establishing CBE educational foundations, emphasizing youth-centered knowledge development and capacity building. Faried, A. I., & Monika, S., 2024) emphasize social capital strengthening importance during educational ecotourism development early stages, evidenced by Teluk Mengkudu Village's efforts building networks with universities and training institutions. Partnership with Panca Budi Development University has produced ecotourism management and mangrove conservation training series attended by 45 young villagers.

The village's "Youth Environmental Educators" program represents an innovative adaptation to limited resources by positioning young community members as primary knowledge bearers and educational leaders. This approach has increased youth retention in the community while accelerating knowledge transfer. A youth leader, Riana (22 years old), observed: "Young people often left our village seeking opportunities elsewhere. Now many are staying to build environmental knowledge businesses and education programs that benefit both the environment and our economic future." Geographical factors additionally influence educational challenges and adaptation strategies. Pantai Cermin Village, situated in coastal areas with high tourism activity, faces more complex visitor management challenges, while relatively remote Teluk Mengkudu Village confronts accessibility and educational infrastructure obstacles. Sitorus, H. L., & Damanik, J., 2021) identified accessibility factors in Pantai Cermin contributing approximately 40% of educational engagement patterns, necessitating comprehensive adaptation strategies. These adaptation strategy variations reflect diverse socioeconomic contexts and implementation stages while demonstrating CBE approach flexibility responding to varied local educational conditions. As demonstrated by (Walker, B., et al., 2004), educational flexibility and adaptability represent crucial elements building resilient socio-ecological systems.

5. Key Factors Influencing Educational Success in Community-Based Ecotourism

Implementation duration emerged as a critical factor, evidenced by significant differences between Kota Pari and Teluk Mengkudu Villages, in determining program success rates. Concurrently, educational approach quality, particularly regarding knowledge integration and transfer mechanisms, served as an important catalyst strengthening local initiatives. (Andika, R., Sari, P. B., et al., 2024) underscore educational resource support importance from diverse sources optimizing community-based initiative sustainability. Population socioeconomic characteristics, especially in Perbaungan Village with predominant agricultural demographics, create unique dynamics in educational CBE model adoption requiring accommodation within

development strategies. Our comparative analysis identified several key factors influencing educational CBE implementation success across the four villages:

a. **Implementation Duration**
Villages with longer-running CBE educational programs (Kota Pari) demonstrated more positive outcomes, indicating long-term perspective importance and program consistency. (Sembiring, R., et al., 2023) emphasized CBE educational programs typically require 3-5 years minimum to achieve significant, sustainable impacts.

b. **Educational Approach Quality**
The design and implementation quality of educational components significantly affected knowledge transfer effectiveness. Kota Pari's integrated knowledge system that explicitly bridges traditional and scientific understanding demonstrated superior results compared to more fragmented approaches in other villages.

c. **Local Leadership**
Leadership quality significantly affects educational mobilization and program sustainability. In Kota Pari Village, collective educational leadership through multi-stakeholder forums contributed toward implementation success. (Zulkifli, A., & Karim, Z. A., 2022) discovered collaborative leadership models combining formal authority (village government) with informal leadership (traditional knowledge holders, religious figures) and knowledge-based leadership (environmental educators, academics) typically produce more effective natural resource management outcomes.

d. **External Support**
The four villages demonstrated variation regarding educational support networks and resource access. Kota Pari Village maintained most extensive support networks, while Teluk Mengkudu Village continues building educational partnerships. (Daulay, B., et al., 2023) identified external educational support accessibility as an important factor strengthening coastal community conservation behaviors.

e. **Socioeconomic Characteristics**
Community livelihood composition significantly influences educational participation patterns and CBE adoption tendencies. Perbaungan Village, dominated by agricultural livelihoods, demonstrates different educational dynamics compared with more economically heterogeneous Kota Pari Village. (Pratiwi, S., and Wardiyah, F., 2023) noted that coastal community economic transformation through educational ecotourism is heavily influenced by existing livelihood structures.

f. **Youth Engagement**
The level and quality of youth involvement in educational programming emerged as a critical success factor, particularly evident in Teluk Mengkudu's youth-centered approach. Villages that effectively engaged young people as both learners and educators demonstrated stronger knowledge transfer across generations and more innovative educational approaches.

g. **Initial Ecological Conditions**
Forest ecosystem initial status affects conservation impact speed and visibility through educational interventions. Teluk Mengkudu Village with relatively better initial forest conditions demonstrated faster visible conservation results from educational programming. (Dilyan, A., & Aminudin. F., 2023) demonstrated mangrove ecosystem initial condition correlation with community-based educational revitalization program success rates.

h. **Knowledge Integration Mechanisms**
Villages that developed explicit systems for integrating traditional ecological knowledge with scientific understanding (particularly Kota Pari and Perbaungan) showed superior educational outcomes compared to those with more fragmented knowledge approaches.

Identification of these factors provides valuable insights for developing more adaptable education-centered CBE models responsive to diverse local contexts. As emphasized by (Ostrom, E., 2015), no single "blueprint" exists for community-based natural resource management; each context requires educational adaptations considering specific socio-ecological characteristics.

Discussion

Our comparative analysis of educational approaches in community-based ecotourism across Kota Pari, Pantai Cermin, Perbaungan, and Teluk Mengkudu villages reveals several significant patterns that address our research questions regarding educational integration in conservation forest management. This section discusses key findings in relation to our research objectives, theoretical frameworks, and existing literature, while identifying implications for policy and practice.

Research Question 1: Comparing Educational Approaches and Community Engagement Strategies

Time-Dependency of Educational Success

One of the most striking findings is the clear time-dependency of educational success in CBE programs. Kota Pari Village, with its five-year implementation history, consistently outperformed other villages across nearly all measured indicators. This suggests that CBE educational approaches require substantial time to mature and deliver optimal outcomes a finding that challenges the often short-term, project-based funding cycles that dominate development approaches in the region. The data shows this isn't simply a linear progression where more time automatically equals better results. Rather, longer implementation periods allow communities to develop what (Wulandari et al., 2025) term "educational infrastructure" both physical (learning centers, demonstration sites) and social (knowledge networks, teaching capacities).

This finding aligns with (Ostrom's., 2015) assertion that institutional development for common-pool resource management requires sustained commitment and cannot be artificially accelerated through external interventions alone. As (Berkes., 2021) notes, "Community-based conservation requires patience and long-term vision, with educational processes forming the foundation for sustainable institutional arrangements." The time-dependency observed in our study supports Folke et al.'s (2005) conceptualization of adaptive governance, where social learning processes evolve through iterative cycles of implementation and reflection.

Our findings extend beyond confirming the importance of time to revealing specific developmental stages in CBE educational evolution. We observed that villages progressed through identifiable phases from initial knowledge acquisition (Teluk Mengkudu) to knowledge adaptation (Pantai Cermin and Perbaungan) to knowledge generation and dissemination (Kota Pari). This developmental progression resonates with Pahl-Wostl's (2009) multi-level learning framework, which distinguishes between single-loop learning (improving established routines), double-loop learning (reframing problems and solutions), and triple-loop learning (transforming governance paradigms). The villages in our study demonstrated this progression, with Kota Pari exhibiting characteristics of triple-loop learning through its educational governance innovations.

Beyond Formal Education: Alternative Knowledge Pathways

Another fascinating aspect revealed by our research is how communities develop alternative knowledge pathways outside formal educational structures. Pantai Cermin's "spontaneous learning markets" represent a case where tourism creates unexpected spaces for knowledge exchange. Similarly, Perbaungan's intergenerational knowledge transfer systems demonstrate how agricultural communities can creatively bridge traditional farming practices with conservation principles.

These alternative pathways suggest that effective CBE education extends far beyond classroom settings or formal workshops. The most successful villages created what (Maharani et al., 2025) call "knowledge ecosystems" where learning happens through multiple channels and diverse social interactions. This challenges conventional educational program design that often prioritizes formal training over embedded, contextual learning (Dewi & Suhardi, 2025)

Our findings add empirical support to (Reed et al., 2010) conceptualization of social learning as a process that: (1) demonstrates that change has occurred in understanding; (2) goes beyond the individual to become situated within wider social units; and (3) occurs through social interactions and processes between actors within a social network. The informal learning networks observed in our study villages exemplify how social learning emerges organically within CBE contexts when appropriate conditions are fostered.

Importantly, these alternative knowledge pathways appear particularly effective at integrating traditional ecological knowledge with scientific conservation principles. In Perbaungan, agricultural practices that had persisted for generations were reframed through conservation lenses, creating what (Chai and Liu., 2024) describe as "knowledge hybrids" that combine different epistemological traditions. This integration proved especially valuable for addressing context-specific conservation challenges, supporting (Gunawan and Siregar., 2025) framework for indigenous knowledge integration in conservation education.

Research Question 2: Analyzing Impacts of Educational Integration on Conservation Efforts

Conservation Outcomes Through Educational Pathways

Our comparative analysis reveals significant variations in conservation outcomes across the four villages, with educational approaches serving as key determinants of success. Kota Pari's comprehensive educational system correlated with the highest conservation metrics: 27% increase in mangrove coverage, 38% reduction in illegal

harvesting incidents, and substantial improvement in biodiversity indicators. These results strongly suggest that well-developed educational approaches translate directly into enhanced conservation outcomes.

The mechanisms through which education influences conservation appear multifaceted. First, educational approaches affect community knowledge levels, changing how people perceive and value ecosystem services. As Siahaan et al. (2025) note, "Conservation education must transform not only what communities know but how they assign value to ecological systems." Our findings support this assertion, with increased valuation of ecosystem services correlating with stronger conservation commitments across all villages.

Second, education shapes community conservation capacity—both technical skills and governance capabilities. The variations in technical capacity were particularly evident in restoration activities, where Kota Pari's extensive training programs resulted in higher seedling survival rates (87%) compared to Teluk Mengkudu (61%). This aligns with Hasanah et al.'s (2024) finding that technical education significantly improves conservation implementation efficacy.

Third, educational approaches influence the legitimacy and enforcement of conservation rules. Villages with more participatory educational design showed stronger rule compliance, supporting Agrawal and Chhatre's (2021) assertion that conservation knowledge must be co-produced rather than imposed to achieve legitimacy. In Pantai Cermin, where educational programs engaged 73% of households, rule infractions were 58% lower than in Teluk Mengkudu, where educational reach was limited to 46% of households.

Our findings also reveal that educational approaches significantly impact community resilience to external conservation threats. When faced with commercial development pressures, Kota Pari's community demonstrated greater capacity to articulate conservation values and mobilize external support—a capability that Albrecht and Raymond (2023) link directly to transformative learning processes that develop critical consciousness about socio-ecological systems.

The Role of Youth as Educational Catalysts

The surprising success of Teluk Mengkudu's youth-centered approach deserves special attention. Despite being the newest CBE program among the four villages, their "Youth Environmental Educators" initiative achieved the highest youth participation rate (52%), challenging assumptions about youth engagement in rural conservation efforts.

This finding contradicts common narratives about rural youth disinterest in environmental issues or traditional knowledge. In Teluk Mengkudu, young people haven't just participated in educational activities but have fundamentally reshaped them, creating new models of knowledge transfer that bridge generational divides. As Rahman et al. (2025, p. 103) observe: "Youth engagement in conservation education represents not merely workforce expansion but epistemological innovation—young people bring distinctive perspectives that reshape how knowledge is produced and disseminated."

The effectiveness of youth-led education appears linked to several factors. First, young educators demonstrated greater facility with digital tools, enabling broader knowledge dissemination through social media and other platforms. This aligns with Wijaya et al.'s (2025) findings on digital literacy integration with traditional ecological knowledge. Second, youth educators more readily incorporated experiential and

participatory learning methods, which Sutanto and Pratiwi (2025) identify as particularly effective for conservation education. Third, youth involvement created bidirectional knowledge flows, with young people simultaneously learning from elders while introducing new conservation frameworks—a dynamic that Sihombing and Raharjo (2025) term "intergenerational knowledge circulation."

Our findings suggest that positioning youth as knowledge creators and disseminators, rather than merely recipients, may accelerate educational outcomes in CBE contexts. This approach addresses what Sterling et al. (2017) identify as a critical challenge in conservation education: ensuring knowledge continuity across generations while allowing for adaptation to changing conditions.

Research Question 3: Educational Contributions to Knowledge-Based Livelihood Development

Economic Transformation Through Knowledge Valorization

Perhaps the most striking finding relates to how educational approaches have catalyzed economic transformation across all four villages. The emergence of what Kota Pari residents call a "knowledge economy" represents a profound shift in how rural communities conceptualize their relationship with natural resources. The data shows that villages with more mature educational approaches also developed more diverse knowledge-based income sources—from specialized guiding services to ecological restoration consulting and traditional medicine workshops.

This economic diversification correlates with more equitable economic benefit distribution (as measured by Gini Index improvements—from 0.46 to 0.38 in Kota Pari over the five-year implementation period). Knowledge-based enterprises demonstrated lower barriers to entry than traditional extractive industries, allowing broader community participation. Ibrahim and Amalia (2025) similarly found that entrepreneurial education within CBE frameworks significantly enhanced economic inclusivity, with knowledge-based enterprises showing 28% higher female participation rates than conventional tourism businesses.

Our findings extend beyond confirming education's economic impacts to identifying specific mechanisms through which educational approaches transform local economies. First, education revalues previously marginalized knowledge forms, particularly traditional ecological knowledge held by women and elders. In Kota Pari, women's botanical knowledge, historically underrecognized, became the foundation for specialized herbal product enterprises with 22% profit margins—higher than conventional agricultural activities. This supports Jayawickrama and Silva's (2022) assertion that "conservation education can transform knowledge hierarchies, elevating traditional ecological knowledge from cultural heritage to economic asset."

Second, educational approaches develop what Nasution and Arif (2025) term "conservation service capacities"—specialized skills for ecological monitoring, restoration, and sustainable resource management. These capacities created new livelihood niches occupied by community members with various educational backgrounds. In Pantai Cermin, the mangrove restoration training program led to specialized youth enterprises offering consulting services to neighboring villages, generating significant income while disseminating conservation practices.

Third, education catalyzes product and service innovation by combining traditional knowledge with conservation science. Perbaungan's agricultural community developed specialized eco-agricultural tours showcasing traditional farming methods that support

biodiversity—an innovation that emerged directly from educational exchanges between farmers, conservation educators, and tourists. This pattern supports Wulandari et al.'s (2025) finding that knowledge co-production between scientific and indigenous systems frequently generates innovative livelihood options.

Research Question 4: Key Determinants Influencing Education-Centered CBE Implementation Success

Adaptive Educational Governance

The varied challenges and adaptation strategies across the four villages highlight the importance of what might be called "adaptive educational governance" in CBE contexts. Each village developed distinctive institutional arrangements to address their specific educational challenges, from Kota Pari's "Community Educator Program" to Teluk Mengkudu's partnerships with universities.

What's fascinating is how these governance innovations emerged organically from local conditions rather than following predetermined models. When interviewing village leaders in Kota Pari about their educational zoning system, they explained that it developed gradually through trial and error rather than being implemented as a comprehensive plan from the outset. This adaptive approach contrasts with more rigid educational program designs often imposed by external agencies. The most successful villages demonstrated remarkable creativity in reshaping educational governance structures in response to emerging challenges and opportunities.

This finding aligns with Ostrom's (2015) emphasis on institutional diversity in common-pool resource management. There is indeed "no single 'blueprint'" for successful educational governance in CBE contexts; rather, effective arrangements emerge through local experimentation and adaptation to specific socio-ecological conditions. As Leach et al. (1999, p. 240) argue, "institutional arrangements must be understood as dynamic and negotiated, rather than fixed and predetermined."

Our analysis reveals several key determinants influencing CBE educational success across different contexts. First, educational governance arrangements must balance standardization with flexibility. Kota Pari's tiered educational system provided consistent foundational knowledge while allowing specialized learning pathways to develop based on individual and community interests. This balance between structure and adaptation resembles what Cox et al. (2010) identify as essential for robust institutional design in resource management.

Second, effective educational governance involves diverse stakeholders while maintaining clear community leadership. In Pantai Cermin, where external tourism operators exerted significant influence, conservation education showed less community adaptation and ownership. Conversely, Perbaungan's agriculturally-focused educational approach, while more limited in scope, demonstrated stronger community ownership and consequently higher implementation rates for conservation practices. This supports Sterling et al.'s (2017) finding that stakeholder diversity in conservation education must be balanced with genuine community leadership.

Third, educational governance systems require mechanisms for knowledge verification and validation. In all four villages, community-developed systems to evaluate new information against local experience before incorporation into educational programs. This critical filtering process appears essential for maintaining educational legitimacy and relevance. As Daulay et al. (2023, p. 195) observe, "Community validation of conservation knowledge is not merely a social process but an

epistemological one—testing external claims against lived experience and traditional understanding."

Socioeconomic Factors and Educational Adaptation

Our comparative analysis reveals that pre-existing socioeconomic conditions significantly influence how educational approaches develop and succeed in CBE contexts. Pantai Cermin's stronger tourism orientation created greater exposure to external educational influences but sometimes undermined community educational ownership. Conversely, Perbaungan's agricultural focus limited external educational inputs but strengthened internal knowledge validation processes.

These variations align with Zulkifli and Karim's (2022) finding that socioeconomic characteristics substantially influence how communities engage with external conservation programs. Our study extends this understanding by identifying specific adaptation mechanisms communities employ to align educational approaches with local socioeconomic realities.

First, communities adapt educational content to reflect local livelihood priorities. In Perbaungan, conservation education emphasized agricultural-ecological connections, while Pantai Cermin focused on visitor-oriented interpretation skills. This adaptation enhanced relevance and participation but sometimes created knowledge silos—a challenge Kota Pari addressed through its integrated educational zones approach.

Second, educational delivery methods reflect existing social structures and communication patterns. Perbaungan's agricultural community effectively utilized farmer field schools and peer-to-peer learning, while Pantai Cermin developed more formalized training programs reflecting its service-oriented economy. This supports Yulisa et al.'s (2022) finding that educational approaches must align with existing social networks to achieve maximum reach.

Third, educational governance arrangements reflect pre-existing power dynamics and decision-making structures. Villages with more egalitarian social structures (like Kota Pari) developed more participatory educational governance, while communities with stronger existing hierarchies adapted educational systems to work within these structures. This pattern supports Berkes' (2021) observation that conservation education invariably operates within existing power relations, requiring thoughtful adaptation rather than imposing idealized participatory models.

Identification of Implementation Barriers and Success Factors

Our comparative analysis identified several common barriers to effective educational implementation across the villages. Resource limitations—especially during initial implementation phases constrained educational reach and quality. However, villages demonstrated creative adaptations, such as Teluk Mengkudu's peer-education model that maximized limited resources by training youth educators who then disseminated knowledge more broadly. This approach resembles what Chai and Liu (2024) term "educational capacity multiplication" through strategic knowledge dissemination pathways.

External policy constraints also presented significant challenges, particularly regarding forest access and utilization rights. Educational programs had to navigate complex regulatory frameworks that sometimes contradicted local knowledge systems and practices. This tension was most evident in Perbaungan, where traditional agricultural practices initially conflicted with conservation regulations. The educational program successfully mediated this tension by identifying compatibility zones and

adaptation strategies—a process that Gunawan and Siregar (2025) identify as essential for integrating traditional practices with conservation frameworks.

Internal resistance from certain community segments also affected educational implementation. In all villages, some community members initially viewed conservation education as threatening traditional livelihoods or authority structures. Successful educational approaches directly addressed these concerns through what Maharani et al. (2025) call "transformative dialogue"—structured discussions that explore tensions between conservation and development goals. Kota Pari's "Community Values Mapping" exercise exemplifies this approach, explicitly addressing potential conflicts between conservation education and existing social arrangements.

Key success factors emerging from our comparison include: (1) educational adaptation to local knowledge systems and livelihood patterns; (2) balanced stakeholder involvement with clear community leadership; (3) diverse learning pathways accommodating different preferences and capacities; (4) mechanisms for knowledge validation and integration; and (5) incremental implementation allowing for experimentation and adaptation. These factors align with Albrecht and Raymond's (2023) framework for effective environmental education in community contexts, particularly their emphasis on knowledge co-production rather than transfer.

Methodological Reflections and Limitations

Reflecting on our research approach, the combination of quantitative metrics with qualitative insights proved essential for understanding the nuanced dynamics of educational processes in CBE contexts. The stories and perspectives shared by community members often revealed dimensions that wouldn't have been captured through quantitative measures alone. This mixed-methods approach aligns with Reed et al.'s (2010) recommendation for studying social learning processes through multiple epistemological lenses.

Nevertheless, our study faced several limitations. The cross-sectional nature of the research means we captured a snapshot of ongoing processes rather than their full developmental trajectory. Additionally, while our sample size was sufficient for the comparative analysis, broader generalization requires caution. The four villages, while sharing some common characteristics, also differ in ways that complicate direct comparison. Pantai Cermin's greater accessibility and resulting higher visitor numbers create different educational opportunities compared to more remote villages. Similarly, Perbaungan's predominantly agricultural character shapes its educational priorities in ways distinct from more diverse economies.

Our positionality as researchers likely influenced data collection and interpretation in ways requiring acknowledgment. As external researchers associated with academic institutions, community members may have emphasized certain aspects of their educational experiences while downplaying others. We attempted to mitigate this through prolonged engagement, diverse data sources, and participatory verification of preliminary findings with community members.

Theoretical Implications

Our findings contribute to several theoretical domains. First, they extend Ostrom's (2015) common-pool resource management framework by illuminating how educational processes contribute to institutional development for sustainable resource governance. The observed progression from basic conservation awareness to

sophisticated knowledge co-production systems provides empirical support for Pahl-Wostl's (2009) multi-level learning theory in resource governance contexts.

Second, our research advances understanding of social learning processes in conservation contexts. The alternative knowledge pathways identified in our study villages demonstrate how social learning emerges through diverse interactions beyond formal educational settings. This supports and extends Reed et al.'s (2010) conceptualization of social learning as necessarily social and contextual rather than merely individual and abstract.

Third, our findings contribute to emerging theoretical frameworks around knowledge co-production in conservation contexts. The ways communities selectively integrated external scientific knowledge with local ecological understanding supports Chai and Liu's (2024) concept of "knowledge hybridity" while adding nuanced understanding of how this process unfolds in CBE contexts specifically.

Fourth, our research adds empirical support to Folke et al.'s (2005) adaptive governance framework by demonstrating how educational processes contribute to socio-ecological system resilience. The observed correlation between educational maturity and community capacity to address external threats suggests that education functions as more than knowledge transfer—it fundamentally reshapes community adaptive capacity.

Future Research Directions

These findings point toward several promising directions for future research. Longitudinal studies tracking CBE educational outcomes over extended periods would provide deeper insights into developmental trajectories and long-term sustainability. More detailed analysis of knowledge flows between communities could illuminate how educational innovations diffuse across regional networks. Additionally, the emerging role of digital technologies in CBE education warrants further investigation. Several youth participants mentioned adapting social media platforms for conservation education purposes, suggesting untapped potential for technology-enhanced learning in rural contexts.

The relationship between educational approaches and community resilience to external shocks (environmental, economic, or social) represents an important area for future inquiry. Preliminary evidence suggests that villages with more robust educational systems may demonstrate greater adaptive capacity when facing challenges like market fluctuations or climate impacts. This aligns with Siahaan et al.'s (2025) recent findings on educational adaptations for climate resilience in coastal communities.

Future research should also investigate how educational innovations diffuse between communities within regional networks. Our current study revealed informal knowledge exchange occurring between the four villages, but the mechanisms and barriers affecting this diffusion remain incompletely understood. This relates to what Dewi and Suhardi (2025) identify as a critical research gap regarding "horizontal knowledge transfer" in community-based conservation initiatives.

Policy and Practical Implications

Our findings have several important policy implications for CBE development in Indonesia and potentially other contexts. First, funding cycles for CBE initiatives should reflect the time-dependent nature of educational outcomes, with longer implementation periods and graduated success metrics that acknowledge developmental stages. This aligns with Nasution and Arif's (2025) recommendation for "developmental evaluation

frameworks" that assess progress relative to implementation phase rather than against standardized benchmarks.

Second, educational program design should explicitly incorporate alternative knowledge pathways beyond formal training, creating space for spontaneous learning, intergenerational exchange, and visitor-community interactions. This may require rethinking conventional educational evaluation frameworks to capture these diverse learning processes, as Rahman et al. (2025) suggest in their climate resilience education model.

Third, youth engagement strategies should position young people as knowledge creators and disseminators rather than merely recipients, potentially through dedicated programs like Teluk Mengkudu's "Youth Environmental Educators." This approach may simultaneously address conservation education goals and rural youth retention challenges, supporting Sihombing and Raharjo's (2025) findings on youth engagement through digital storytelling approaches.

Fourth, economic development strategies should recognize the potential of knowledge valorization as a pathway to more equitable and sustainable rural livelihoods. Supporting knowledge-based enterprises through targeted capacity building and market access could strengthen the economic dimension of CBE initiatives, as demonstrated in Ibrahim and Amalia's (2025) entrepreneurial education framework for community-based ecotourism.

Finally, educational governance frameworks should balance structured progression with adaptation to local contexts. Rather than imposing standardized educational models, support programs should provide flexible frameworks that communities can adapt to their specific socio-ecological and economic conditions. This approach aligns with Wulandari et al.'s (2025) refined community empowerment model emphasizing knowledge co-production between scientific and indigenous systems.

CONCLUSION

Fundamental Findings: Looking back at our 8 months of field research across Kota Pari, Pantai Cermin, Perbaungan, and Teluk Mengkudu villages, several key findings stand out. First off, time matters a lot. Kota Pari's five-year program clearly outperformed the newer initiatives across pretty much every indicator we measured. You can't rush these things. I was particularly struck by how Mr. Sulaiman described their early struggles: "The first two years were mostly confusion and mistakes. Only in year three did we start seeing real educational traction." Second, the villages that somehow managed to create those bridges between traditional knowledge and scientific understanding got much better results both in education and conservation impact. This wasn't just about formal training either. Some of the most effective knowledge transfer happened through what Pantai Cermin locals call "belajar sambil jalan" (learning while walking) during tourist interactions. The youth factor really surprised us. Who would've thought that Teluk Mengkudu's youth program would hit 52% participation? That's huge, especially given they're the newest program. During my stay there, I watched teenagers confidently explaining mangrove restoration techniques to visitors twice their age. Quite different from the stereotypical narrative of disinterested rural youth. And then there's the economic stuff. The educational approaches weren't just nice to have add ons but actually transformed local economies through what locals started calling "knowledge businesses." I remember being skeptical about this at first, but the evidence was right there in the numbers more diverse income

streams and better distribution in the villages with mature programs. Something else that really jumped out at me was how these villages developed their own learning ecosystems outside formal structures. Pantai Cermin's market-based learning exchanges and Perbaungan's cross-generational knowledge systems weren't in anybody's original project plan but emerged organically and worked remarkably well! Finally, the successful villages didn't copy-paste some standardized educational model but created adaptive governance approaches tailored to their specific challenges.

Implications: so what does all this mean? For folks making policy, our research suggests they need to rethink those 1-2 year funding cycles that dominate development work in Indonesia. These educational outcomes take time to mature something our government partners acknowledged was problematic given budget cycles, but essential for sustainability. For practitioners on the ground, there's a clear implication: stop seeing community members (especially young people) as just passive recipients of knowledge. The most successful approaches positioned them as co creators and knowledge producers in their own right. As one young woman in Teluk Mengkudu told me: "We aren't just learning about our mangroves; we're teaching others and creating new knowledge about them." The economic implications are particularly interesting. These educational approaches aren't just nice extras but fundamental to creating what some academics call "regenerative economies" in rural areas. The emergence of knowledge based enterprises in the more established villages shows a promising path forward that balances conservation and livelihoods. This matters tremendously in North Sumatra where traditional extractive industries are declining. For local governance, Kota Pari's zoning system offers a practical blueprint for balancing conservation priorities with community needs. When I asked the village head about its development, he laughed and said, "We tried three different approaches before finding one that didn't cause fights at community meetings." This trial-and-error approach yielded context-sensitive arrangements that worked far better than the standardized models often imposed by outside agencies. And pedagogically? Our findings challenge the one way knowledge transfer model that still dominates environmental education. The successful villages created what I started thinking of as "knowledge ecosystems" where information flows in multiple directions - sometimes from expert to community, sometimes from elder to youth, but also from youth to elder, community to visitor, and visitor to community.

Limitations: i'd be dishonest if I didn't acknowledge our study's limitations. The biggest one is probably the cross sectional design. We essentially took a snapshot of ongoing processes rather than tracking them over time. This limits what we can say about how these educational approaches develop and mature. Our initial research plan included a longitudinal component, but budget constraints forced us to scale back. Sample size is another obvious issue. Four villages gave us enough for comparison, but makes broad generalization tricky. Villages even 20km away might have completely different dynamics based on their ecological, cultural, or economic characteristics. North Sumatra's diversity means our findings might not apply even within the same province. We also focused mainly on participation rates and tangible outcomes, but didn't dig as deep into the psychological aspects how knowledge gets internalized and changes attitudes. This was partly intentional (avoiding imposing Western psychological constructs) but does leave gaps in understanding the inner workings of educational impact. Our economic analysis centered on household income and benefit distribution important stuff, but we didn't fully investigate how these knowledge-based businesses actually operate and sustain themselves. During field visits, I saw intriguing

business models emerging that deserve deeper study. Another limitation: we mostly captured community perspectives, with less attention to what visitors learned and whether it changed their behavior after leaving. Several tourists I chatted with informally mentioned profound learning experiences, but we didn't systematically capture this important dimension. Finally, while we noted knowledge transfer between villages (especially Teluk Mengkudu learning from Kota Pari), our methods weren't designed to map these knowledge networks comprehensively. Given how important they seemed to accelerating success in newer programs, this is an unfortunate gap.

Future Research: looking ahead, several research directions seem promising. The obvious one is longitudinal studies tracking outcomes over 5-10 years. How do these knowledge systems evolve? Do they maintain momentum or peter out? What happens when original champions move on? These questions need time to answer properly. I'm particularly interested in explicitly mapping knowledge flows between CBE initiatives. During fieldwork, we kept hearing references to specific individuals who served as knowledge brokers between villages. Understanding these networks could help identify both catalysts and barriers to sharing innovations. The digital technology angle also deserves attention. I was struck by watching teenagers in Teluk Mengkudu documenting traditional mangrove knowledge using TikTok and Instagram. There's untapped potential here for bridging traditional ecological knowledge with contemporary communication channels that resonate with younger generations. Another critical question: how do these educational approaches affect community resilience? When floods hit Pantai Cermin in 2023, community members credited their CBE knowledge networks with facilitating faster recovery than neighboring non-CBE villages. This anecdotal evidence deserves systematic investigation. The visitor learning experience also warrants deeper study. Does participating in these educational CBE activities actually change subsequent conservation behaviors and attitudes? Several tourists I interviewed mentioned changing household practices after visits, but we need more systematic research on this dimension. Finally, comparing educational approaches across different ecosystems could yield valuable insights. Do coastal communities like Pantai Cermin require fundamentally different educational strategies than forest communities like parts of Kota Pari? Such comparative work could help develop more flexible, context-sensitive models for community-based natural resource management throughout Indonesia and similar regions globally.

ACKNOWLEDGEMENTS

The authors express their deepest gratitude to all individuals and institutions that contributed to the completion of this research. We extend special thanks to the communities of Kota Pari, Pantai Cermin, Perbaungan, and Teluk Mengkudu villages in Serdang Bedagai Regency for their warm welcome, active participation, and willingness to share their knowledge and experiences throughout our extended fieldwork. Their insights form the foundation of this study. We are grateful to Universitas Pembangunan Panca Budi and its Research and Community Service Institute (LPPM) for providing institutional support, research facilities, and administrative assistance that made this comparative study possible. Our appreciation goes to the Forestry Department and Tourism Office of Serdang Bedagai Regency for granting research permits, sharing valuable data, and facilitating access to the study locations. This research benefited tremendously from the dedication of our field research team, particularly Hendra Syahputra, Mira Damayanti, and Ridwan Nasution, who assisted with data collection

across multiple sites in challenging conditions. We acknowledge the valuable contributions of Dr. Ahmad Hidayat and Dr. Siti Nurhayati, whose expert feedback strengthened our methodological approach and analytical framework. Our sincere appreciation extends to the school administrators, teachers, village officials, CBE management committees, and community leaders who generously shared their time, knowledge, and insights during interviews and focus group discussions. The forest rangers and conservation officers who guided our field observations deserve special mention for their expertise and assistance. Portions of this research received funding through the Regional Innovation Research Grant program (Grant No. RIPD-2023-27) and the University Internal Research Scheme (Grant No. UPBM/INT/2023/42). The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and do not necessarily represent the views of the funding organizations. Finally, we thank our families for their unwavering support and understanding during the extended periods of fieldwork and analysis required to complete this study.

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