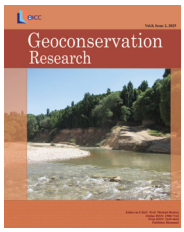

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# Bridging Generational and Educational Divides: Cognitive Uniformity Towards Ecosystem Services in Kenyir Geopark, Terengganu, Malaysia

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**Abstract**

The designation of Kenyir Lake as a National Geopark necessitates a dynamic balance between rapid tourism development and natural resource conservation, for which local community support is essential. However, empirical studies on the community's engagement with ecosystem service values remain limited, often overshadowing their role in sustainable governance. This study aims to assess the community's level of understanding regarding the sustainability of ecosystem services across three core dimensions (environmental, social, and heritage) and to analyze the influence of demographic factors on this awareness. Employing a quantitative cross-sectional survey design, data were collected from 510 heads of household in ten strategically selected villages surrounding Kenyir Geopark. Our analysis reveals that the community possesses a high overall level of understanding (mean = 3.49), with the environmental ecosystem dimension scoring the highest (mean = 3.53). Chi-squared tests show no statistically significant differences in the level of understanding based on age or educational attainment ($p > 0.05$). This cognitive uniformity demonstrates that environmental awareness in Kenyir Geopark is not contingent upon formal education but is driven by the assimilation of traditional knowledge and experience-based learning. We conclude that a robust form of environmental citizenship exists among the local resident population, and we recommend a policy shift towards a bottom-up management approach to ensure the long-term viability of the Geopark's aspirations.

**Keywords:** Kenyir Lake, National Geopark, Ecosystem Services, Community Perception, Environmental Citizenship

## Introduction

A paradigm shift in global natural resource management now demands a dynamic balance between economic development and environmental conservation, and we can analyze this around a Geopark in Malaysia. Kenyir Lake, located in the Hulu Terengganu district of the state of Terengganu, Malaysia, is the largest artificial lake in Southeast Asia, covering an area of 260,000 hectares. The lake borders the western part of Kelantan and the southern part of Pahang, making it a unique ecological treasure on the east coast

of peninsular Malaysia. Its construction began in 1978 as the country's main hydroelectric dam project, which was completed in 1985, with the aim of supporting the country's growing electricity needs in line with population and industry growth (Osnin & Rahman 2018).

From a historical perspective, before the construction of the dam, the area of Kenyir Lake was a natural forest rich in biodiversity, inhabited by indigenous communities who relied on traditional activities such as agriculture, fishing and hunting. The construction of the dam resulted in the displacement of the local population, creating a significant shift from a resource-based lifestyle to a new reality. The post-1985 phase saw Kenyir Lake develop as a sustainable ecotourism destination, with an emphasis on environmental conservation while promoting activities such as island tours, fishing, and flora-fauna observation. In 2017, the government gazetted this area as a tax-free zone under the Free Zones Act 1990, aiming to attract more tourists and stimulate the local economy through trade and tourism (East Coast Economic Region Development Council 2020).

In 2023, Kenyir Lake was recognized as a National Geopark, defined as an area officially recognized by the National Geopark Committee under the Ministry of Natural Resources and Environmental Sustainability (MNRE) to promote sustainable development through education, research, and geotourism (BERNAMA 2023; Majlis Daerah Hulu Terengganu 2023). This concept is in line with the UNESCO Global Geoparks framework which emphasizes the integration of geological elements with the socio-economic aspects of local communities. Malaysia, as a country rich in biodiversity and ancient geological formations, has recognized national geoparks since the early 2000s, with Langkawi being the first to be named as a UNESCO Global Geopark in 2007. This recognition aims to promote sustainable ecotourism while preserving the lake ecosystem, which also supports services such as flood control and fisheries resources. In the context of socio-economic development, Kenyir Geopark is integrated with the Free Zone initiative to stimulate investment and tourism to achieve UNESCO Global Geopark status by 2027.

Rapid infrastructure development and active tourism promotion, including the designation of Free-Tax Zone (FTZ) status, can trigger land use conflicts and put anthropogenic pressure on sensitive ecosystems (Ullah *et al.* 2023). This development dilemma places local communities at a crossroads; on the one hand, they are promised economic prosperity, but on the other hand, they face the risk of degradation of the natural resources that form the basis of their livelihood. The success of the geopark does not solely depend on its geological uniqueness but is highly dependent on the support and willingness of the local community (Sharina & Azizah 2017). The community is the main stakeholder that interacts directly with the environment. However, a critical question is the extent to which local communities understand the concept of "sustainability" in the context of ecosystem services (ES)? ES are defined as the benefits humans derive from nature, encompassing provisioning, regulating, cultural and supporting services (Millennium Ecosystem Assessment 2005). Are they aware that sustainability is not just about preserving forests but also encompasses the dimensions of social and cultural heritage that support their well-being? Without a clear cognitive understanding of the value of ES whether as resource providers, environmental regulators or carriers of cultural values, geopark management efforts risk becoming top-down initiatives that fail to gain grassroots support.

Our literature review revealed significant empirical gaps in existing research on Kenyir Lake. Most

previous studies focused on purely scientific and technical aspects, such as water quality, biodiversity inventory and lake hydrology, such as studies by Naser and Ahmad (2023) and Shafie *et al.* (2023). However, studies measuring the level of community understanding of the sustainability of ecosystem services remain limited.

Recognizing the importance of the role of the community in the geopark ecosystem, this study aims to fill this gap by analyzing the cognitive dimensions of perception and understanding by local residents. Specifically, this study is driven by two objectives: first, to assess the level of community understanding of the three main dimensions of ecosystem service sustainability, namely the environmental, social and heritage ecosystems and second, to analyze the relationship between key demographic factors (age and education level) and the level of understanding to determine the uniformity of understanding within the community. The findings of this study are critical as basic data for the management of Kenyir Geopark in formulating more inclusive and community-based development policies in line with the principles of sustainable development.

## Literature Review

### Conceptualization of Ecosystem Services

Ecosystem Services (ES) are defined as the benefits humans obtain from nature that support survival and well-being (Millennium Ecosystem Assessment, 2005). Broadly, ES are categorized into four interrelated functions: (i) provisioning services, including material outputs such as food, clean water and genetic resources; (ii) regulating services, which encompass benefits derived from ecosystem processes like flood control, climate stabilization and water purification; (iii) cultural services, which involve non-material benefits such as aesthetic value, recreation, and spiritual heritage and (iv) supporting services, which provide the foundation for other services such as nutrient cycling and soil formation (Millennium Ecosystem Assessment 2005; Costanza *et al.* 1997). Previous studies assert that the failure of communities or policymakers to understand the intrinsic value of these services, particularly the often-intangible regulating and supporting services, can lead to development decisions detrimental to the long-term health of the ecosystem (Fisher *et al.* 2009).

### Sustainable Development within the Geopark Framework

The Geopark concept has emerged as a holistic regional development model integrating geological heritage conservation with the sustainable development of local communities. According to UNESCO, a Geopark is not merely a protected area but a territory that utilizes its geological heritage (Rebmann 2020; Naydenov 2022) to foster awareness of key societal challenges, including the sustainable use of natural resources and the mitigation of natural disaster risks (Fleig *et al.* 2022). Within the context of sustainable tourism, a geopark functions as a platform to educate communities about the symbiotic relationship between geological heritage and biodiversity. Sharina and Azizah (2017) emphasize that the success of a geopark depends on community readiness, and this involves more than just providing infrastructure. At its core, it requires cognitive readiness from a community; without a clear comprehension of ecosystem sustainability, geopark initiatives risk failing to achieve their goals of inclusive socioeconomic development.

### Theoretical Framework: Social-Ecological Systems (SES)

To analyze the complex relationship between the Kenyir Lake community and its environment, this study adapts the Social-Ecological Systems (SES) framework pioneered by Berkes and Folke (1998) and further developed by Ostrom (2009).

The SES theory rejects a reductionist approach that separates human (social) systems from natural (ecological) systems, and views both as a single, integrated system characterized by high interaction and interdependence known as coupled human-environment systems (Dietz 2017; Juan & Gabriela 2019).

Within the context of this study, SES is used to clarify the two-way relationship between community perceptions, like local knowledge and cultural values, and ecosystem dynamics. Each continually shapes and is shaped by the other. Berkes *et al.* (2016) assert that a community's resilience in the face of environmental change depends on social memory and local ecological knowledge. For a social-ecological system to remain balanced, the community's understanding of how to sustain ecosystem services is essential, going far beyond just an attitude or belief in sensitive areas like Geoparks.

The SES framework adapted for the present study (Fig. 1) differs from conventional linear models in proposing that the ecosystem assets of Kenyir Lake (the ecological system) interact dynamically with local communities (the social system) through their perceptions of ecosystem services. In this model, traditional knowledge and lived experience are positioned as the primary mediating mechanisms that shape a consistent community understanding across three dimensions, namely environmental, social and heritage, thereby overriding the influence of external demographic factors such as age or formal education.

## Community Perception and Demographic Determinants

The model proposed by Kollmuss and Agyeman (2002) suggests that environmental knowledge is a prerequisite for action, yet it is influenced by various external and internal factors, including demographics. Many studies find that formal education level has a strong positive correlation with environmental awareness, where individuals with higher education tend to have a better understanding of complex issues like climate change and biodiversity (Helliwell *et al.* 2018). Similarly, younger generations are often associated with higher levels of environmental literacy compared to older generations. However, in the context of rural and resource-dependent communities like those around Kenyir Lake, this narrative may

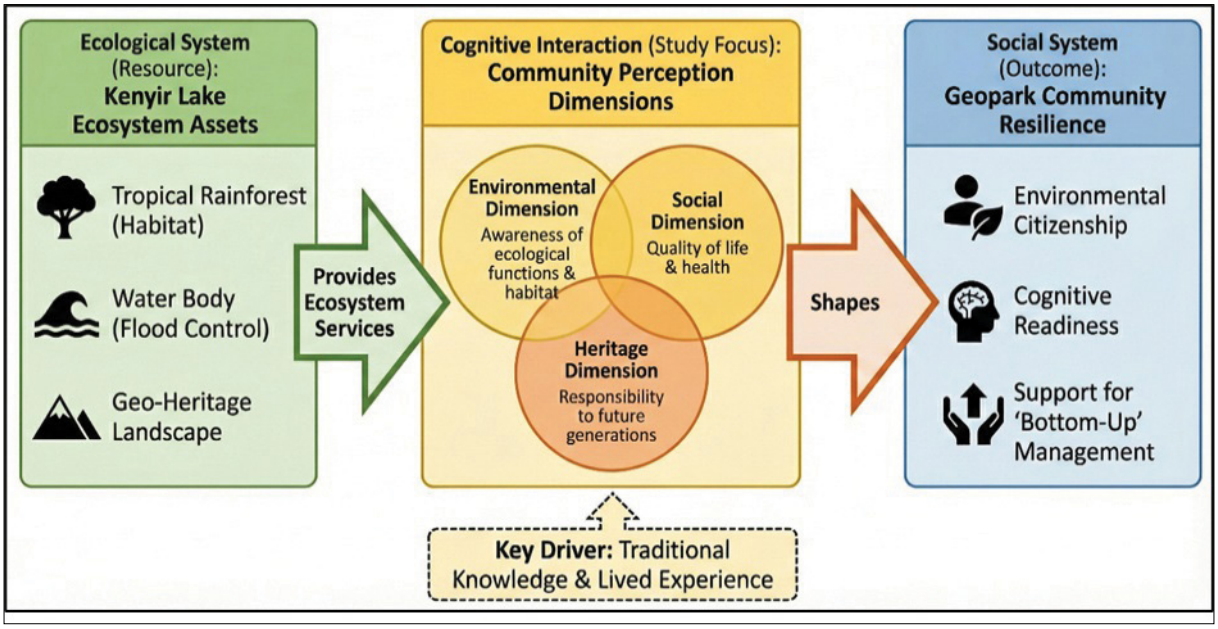


**Figure 1.** Kenyir Lake social-ecological interaction (Adapted from Ostrom 2009)

differ. Traditional knowledge (local knowledge) acquired through lived experience often becomes the primary determinant of understanding, transcending the boundaries of formal education (Hungerford & Volk 1990). This study seeks to examine this dynamic within the Kenyir Lake context to determine whether demographic factors remain the primary determinants of understanding within a community undergoing the transition to Geopark-led development.

## Methodology

### Study Area

This study was conducted in the Kenyir Lake region of Terengganu, which is the largest human-made lake in Southeast Asia and is now designated as a National Geopark. The study area covers villages surrounding Tasik Kenyir, Terengganu (Fig. 2), in the eastern region of Peninsular Malaysia. We include ten traditional villages situated within three primary sub-districts (mukim): Hulu Telemong, Jenagor and Kuala Berang (Figs 3, 4). The selection of these locations is strategic, as the communities in these areas are the primary stakeholders who interact directly with the lake ecosystem and are the most directly impacted by Geopark development policies and the designation of the FTZ.


**Figure 2.** Map of Peninsular Malaysia highlighting the sampling area located at Kenyir Lake, Terengganu (Source: Mazlan *et al.* 2015)

### Research Design and Sampling

Our research design is quantitative, using a cross-sectional survey approach. This aligns with similar quantitative surveys in geoparks such as those by Sharina and Azizah (2017) and Pour *et al.* (2023). We adopted the cross-sectional survey design to focus on a single point in time because the objective of the study was to assess existing understanding of ecosystem services, not change over time, as in other studies. We do not use longitudinal or mixed-method approaches, and we aim to provide a snapshot for subsequent research.

Our focus was the Head of Household (HoH), selected as the unit of analysis through their role

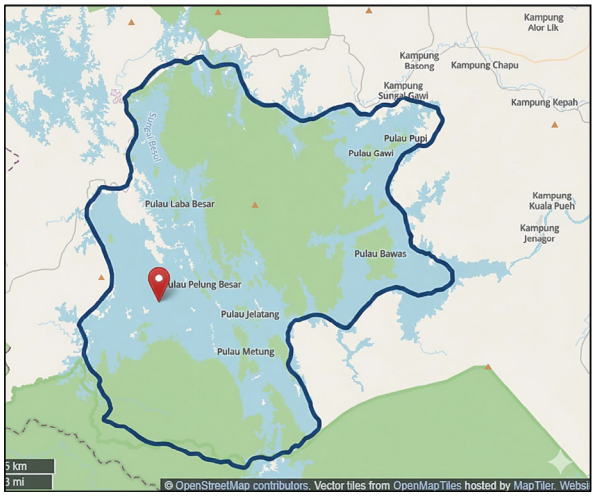


**Figure 3.** Map of the Kenyir Lake Study Area. (Source: MapTiler | © OpenStreetMap contributors)

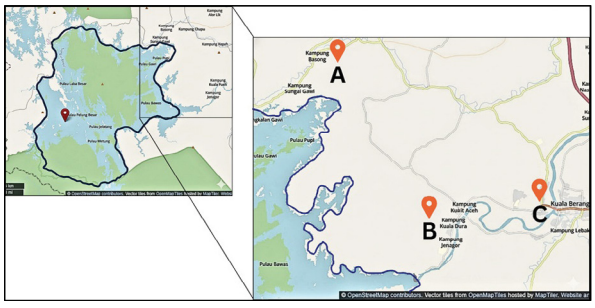


**Figure 4.** Location map of the study area showing the distribution of observation points (A = Hulu Telemong; B = Jenagor; C = Kuala Berang) on the periphery of Kenyir Lake, Terengganu. The left panel displays the boundaries of the main study area, while the right panel details the relative positions of those points with nearby settlements. (Source: MapTiler | © OpenStreetMap contributors)

as the primary decision-maker within the family unit and their influence on patterns of natural resource use. A sample size of 510 respondents was determined using a simple random sampling technique. This sample size is sufficient to represent the population with a 95% confidence level, minimize sampling error and meet the statistical power requirements for inferential analysis.

### Research Instrument

Primary data were collected using a structured questionnaire developed for the local socio-ecological context, based on the key dimensions of the SES framework and adapted from existing literature. A pilot test was conducted with 30 individuals to ensure clarity and relevance, and was reviewed by experts. Our questions focused on three main constructs:

1.Environmental Ecosystem: Items assessing respondents' knowledge of forest ecological functions, flood control and biodiversity balance.

2.Social: Items measuring understanding of quality of life, community health and the need for public involvement in the development process.

3.Heritage: Items evaluating the perception of the importance of preserving natural landscapes as a heritage for future generations.

Each item was measured using a 4-point Likert scale (1 = Strongly disagree to 4 = Strongly agree). The selection of this even-point (forced-choice) scale is intended to prevent respondents' tendency to choose a neutral option (central tendency bias), thereby compelling them to take a clear stance. The interpretation of mean scores was based on the following scale for the 4-point Likert scale used: Low (1.00 – 2.33), Moderate (2.34 – 3.67), and High (3.68 – 4.00).

### Data Analysis

Data analysis was performed using SPSS Statistics Version 23 software. Our descriptive analysis used Mean (M) and Standard Deviation (SD) values, and these were classified into low, moderate and high levels.

Inferential analysis, specifically the Chi-Square Test of Independence, was applied to analyze the relationship between demographic variables (age and education level) and the level of sustainability understanding. This non-parametric test was chosen because it is suitable for determining whether the frequency distribution of perceptions is dependent or independent of demographic factors, thereby testing the hypothesis of uniformity of understanding across the community.

## Results

The 510 Heads of Household are dominated by males (77.6%), aligning with the traditional social structure in rural areas where men typically hold the role of primary family decision-makers (Table 1). Most respondents belong to the middle-aged group of 41 to 60 years (48.6%), followed by seniors aged 61 and above (31.5%). A significant portion of the community has a basic education, with the majority completing schooling at the secondary level (46.1%) and primary level (34.9%), while only a small proportion have tertiary education.

We find that the Kenyir Lake communities possess a high level of understanding (M = 3.49) of the sustainability concept (Table 2). The Environmental ecosystem dimension recorded the highest mean score (M = 3.53, SD = 0.445), followed closely by the Social dimension (M = 3.52) and the Heritage sustainability dimension (M = 3.43).

The statistical analysis shows (Table 3), unexpectedly, that there is no significant difference in the level of

**Table 1.** Demographic profile of Heads of Household

| Demography | Criteria | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Men | 396 | 77.6 |
| | Female | 114 | 22.4 |
| | Total | 510 | 100 |
| Age Group | 40 years and below | 100 | 19.8 |
| | 41 to 60 years | 248 | 48.6 |
| | 61 years and above | 162 | 31.5 |
| | Total | 510 | 100 |
| Education Level | No Formal Schooling | 39 | 7.6 |
| | Adult Education / Pondok School | 2 | 0.4 |
| | Primary School | 178 | 34.9 |
| | Secondary School | 235 | 46.1 |
| | College / University (Tertiary Education) | 54 | 10.6 |
| | Total | 510 | 100 |

**Table 2.** Level of perception regarding ecosystem service sustainability by dimension

| Dimension | Mean (M) | Standard Deviation (SD) | Mean Interpretation |
|---|---|---|---|
| Environmental Ecosystem | 3.53 | 0.445 | High |
| Social | 3.52 | 0.472 | High |
| Heritage Sustainability | 3.43 | 0.473 | High |
| Overall Mean | 3.49 | | High |

**Table 3.** Chi-Square test assessing community understanding of ecosystem service sustainability

| Hypothesis | Degrees of Freedom (df) | Significance Value (p=0.05) | Chi-Square ($\chi^2$) | Hypothesis Decision |
|---|---|---|---|---|
| Hypothesis 1 | 4 | 0.473 | 3.534 | Accept $H_o$ |
| Hypothesis 2 | 12 | 0.808 | 7.696 | Accept $H_o$ |

understanding among the younger, middle-aged and senior citizen groups (the statistical value, with p = 0.473, is far greater than the significance level of 0.05). The same was observed for the education factor where the statistical value (p = 0.808) also exceeds 0.05. This demonstrates that the level of formal education, whether no schooling, primary or tertiary education, does not influence the level of understanding of ecosystem service sustainability.

We have identified cognitive uniformity or consensus within the Kenyir Lake community. Understanding the importance of environmental stewardship and ecosystem functions is transcends generational boundaries and educational status. This suggests that knowledge of sustainability is not a product of formal schooling but is likely inherited through local knowledge, lived experience and daily interaction with the lake environment.

## Discussion

### Drivers of High Ecosystem Awareness

We find high mean scores (M > 3.40) across all three sustainability dimensions, with particular

emphasis on the environmental ecosystem dimension. This reflects the community's profound understanding of the physical and biological functions of the tropical rainforest, particularly the role of forests as wildlife habitats and the critical function of the lake in flood control and hydrological balance. The low standard deviation values (SD < 0.5) across all dimensions indicate a high degree of consensus among respondents, suggesting they share a similar view on the importance of conserving the Kenyir Lake ecosystem.

This phenomenon of high understanding is rooted in the community's existential dependence on natural resources. The majority of Kenyir Lake residents are involved in the fisheries, agriculture and ecotourism sectors, and so interact with the lake not as external observers but as an integral part of the ecosystem. As emphasized by SES theory, this daily interaction fosters a deep ecological knowledge where the community is directly aware that any environmental degradation, such as water pollution or deforestation, will have an immediate impact on their livelihoods (Sterling *et al.* 2017).

Beyond experiential factors, the role of institutional interventions cannot be overlooked. Consistent understanding programs by agencies such as KETENGAH and PERHILITAN have successfully translated scientific concepts like biodiversity and flood control into publicly accessible language. More interestingly, interactions with tourists also serve as an informal educational mechanism. When tourists appreciate the natural beauty, they indirectly validate and formalize the community's traditional knowledge regarding the value of their natural assets, simultaneously enhancing their sense of pride and responsibility for preservation (De Frias Barreto *et al.* 2025).

**Interpreting Cognitive Uniformity: Beyond Age and Education**

One of our key findings is the lack of a statistically significant relationship between demographic factors (age and education) and the level of sustainability understanding. This challenges the conventional narrative that often associates higher education and younger generations with greater environmental literacy (Kollmuss & Agyeman 2002). In the context of Kenyir Lake, this cognitive uniformity can be explained through traditional knowledge and experiential learning. Older generations and those with less formal education gain ecological understanding through decades of life experience, where it is a form of tacit knowledge between generations (Pour *et al.* 2023). Conversely, younger, formally educated residents gain awareness through school curricula and media. Despite differing knowledge sources, both groups converge on the recognition that the Kenyir ecosystem is vital for survival. This suggests that in resource-dependent communities, environmental awareness is a lived necessity rather than an intellectual privilege.

This finding provides a critical counterpoint to literature that prioritizes formal education and youth as key drivers of environmental literacy. It aligns strongly with the Social-Ecological Systems (SES) framework, which posits that tightly coupled human-environment systems foster shared ecological knowledge that transcends demographic divides (Berkes *et al.* 2016). For geoeducation, this implies a shift from a 'knowledge deficit' model to an 'asset-based' approach that integrates traditional wisdom with scientific understanding. For geopark management, it supports a move away from generic awareness campaigns toward co-management strategies that empower local communities as active conservation partners in line with UNESCO Global Geopark principles (UNESCO 2025)

## Strategic Implications for Geopark Management

These findings carry significant implications for the management of Kenyir Geopark. The local community has reached a mature level of cognitive understanding, meaning that Geopark management does not need to start from scratch to educate the community about the fundamental value of the environment. The absence of a generational gap in understanding also means that Geopark communication and education strategies can be implemented inclusively without the need for segmentation by age. This opens opportunities for a collaborative management model in which the traditional knowledge of elders can be integrated with the technological literacy of youth (Hermawan *et al.* 2025). This places Kenyir Lake on a solid footing to meet UNESCO criteria, which demand the active involvement of the community in site management (UNESCO 2025).

Our key finding of 'cognitive uniformity' across the community confirms a high level of understanding that transcends demographic factors. This should be a catalyst for educational innovation in the Kenyir Geopark context. Instead of continuing with conventional top-down educational programs that assume a knowledge deficit, Geopark management can now pioneer a more sophisticated collaborative model, shifting the focus from basic awareness-building 'what to know' to participatory capacity-building 'how to act' (Occhipinti 2025). For example, educational initiatives can be designed to merge the elders' traditional ecological knowledge with the youth's technological literacy to co-create new methods for geo-heritage monitoring and interpretation. This transforms the community from passive recipients of information into active partners in knowledge generation and conservation, fulfilling a core principle of the UNESCO Geopark philosophy.

## Conclusion

Our finding that the communities around Lake Kenyir have a high and uniform level of understanding of the sustainability of ecosystem services is significant because it reflects the existence of a strong environmental citizenship in the local social fabric. The absence of significant differences based on age and education factors proves that the sustainability values in this region are not the exclusive result of formal education but rather stem from cultural assimilation, life experiences and long-standing symbiotic interactions between humans and nature. This confirms that the community of Kenyir Lake is not just a passive recipient of development but is a knowledgeable and cognitively prepared custodian to carry out the aspirations of the National Geopark.

We propose a paradigm shift in the governance of the Kenyir Geopark. The conventional top-down management model where government agencies dominate the conservation narrative, should be replaced with a bottom-up or co-management approach. This strategic shift is directly aligned with the core philosophy of the UNESCO Global Geopark framework which mandates a bottom-up approach and champions the active involvement of local communities in the care of their heritage. As communities understand the intrinsic value of their ecosystems, the focus should shift to empowering communities to be directly involved in decision-making, environmental monitoring and geo-heritage interpretation. Future policies for the development of the FTZ and tourism infrastructure need to integrate this local knowledge to reduce land-use conflicts and ensure truly sustainable development.

Future research is recommended to examine variables such as household income, length of residence and distance from tourist centers to understand their influence on perceptions of

sustainability. Furthermore, it is important to investigate the gap between knowledge and behavior. While community understanding is high, does it fully translate into pro-environmental behavior in everyday life? Understanding the dynamics of the transition from 'knowing' to 'doing' is an important next step to ensure the enduring legacy of Kenyir Lake as a global geological and biological heritage site.

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**Conflict of Interest Statement**

The authors declare no competing interests.

**Authors' Contributions**

Ihsan Alwi: conceptualization, methodology, investigation, data management and formal analysis, as well as drafting the original manuscript and contributing to its review and editing. Jamilah Mohd Salim and Hazman Samsudin: funding acquisition, validation and manuscript review. Nor Hayati Sa'at: conceptualization, methodology and formal analysis while also providing supervision and reviewing and editing the manuscript.

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