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The Relationship between Local and Scientific Knowledge in the Management of Semurup Hot Spring Tourism: An Epistemological and Environmental Ethics Study

Raffy Prasetya Saputra & Siti Fatimah
Universitas Negeri Padang, Indonesia
raffyprasetya0@gmail.com; sitifatimah@fis.unp.ac.id

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Abstract

Although local and scientific knowledge have received considerable attention in environmental studies, their epistemological relationship and ethical implications for managing Semurup Hot Springs Tourism in Kerinci Regency, Jambi, remain insufficiently examined. This study analyzed the relationship between these forms of knowledge and its implications for environmental ethics and sustainable tourism management. A qualitative approach combining literature review and philosophical analysis was employed. Scientific literature on epistemology, local ecological knowledge, scientific knowledge, environmental ethics, and nature tourism management was examined descriptively and critically, focusing on the characteristics, justification, and limitations of each form of knowledge. The analysis identified three principal findings. First, local and scientific knowledge differ in their sources, validation processes, and forms of justification. Second, they can complement each other in environmental decision-making when local experiences are critically examined alongside relevant scientific evidence. Third, responsible tourism management requires transparent information, stakeholder participation, and ethical consideration of environmental sustainability. These findings contribute to discussions of knowledge pluralism through a conceptual framework that clarifies the complementary roles of local and scientific knowledge in tourism governance. The study suggests that constructive dialogue between these forms of knowledge can support more inclusive and environmentally responsible tourism management. Policymakers and tourism managers should therefore

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consider local perspectives alongside scientific evidence when developing management strategies. Further empirical research is needed to examine how these forms of knowledge are practiced and integrated into the management of Semurup Hot Springs Tourism.

Keywords: Epistemology; Local Knowledge; Scientific Knowledge; Environmental Ethics; Sustainable Tourism

INTRODUCTION

The management of natural tourism destinations is not only concerned with the provision of facilities, the enhancement of tourism attractions, and economic growth, but also requires an adequate knowledge base to support decision-making and maintain environmental sustainability. In natural resource management, local knowledge can provide insights into community experiences and local ecological contexts, while scientific knowledge can help explain problems through systematic methods of observation, measurement, and testing (Danuarta et al., 2026; Deru et al., 2026). Local and scientific knowledge can therefore serve as complementary sources of information, although they differ in their histories, processes of formation, and methods of validation. The multiple evidence base approach emphasizes that diverse knowledge systems can contribute to ecosystem understanding and management without treating one knowledge system as the sole standard for evaluating another (Putu & Pujawan, 2020). Studies of community ecological knowledge also indicate that knowledge and practices developed within communities can contribute to resource management and environmental sustainability (Rachman et al., 2026; Ratih et al., 2024). However, the use of such knowledge still requires critical assessment of its context, supporting evidence, and limitations.

The relationship between local and scientific knowledge is relevant to the management of Semurup Hot Spring Tourism in Kerinci Regency, Jambi Province, Indonesia. (Yuslaini et al., 2024) examined the characteristics, management, and development strategies of the tourism destination. Their study addressed community involvement, improvements in tourism-related knowledge, facility development, promotion, and support for the creative economy as components of tourism development. Meanwhile, (Sholihah, 2025) examined the spatial planning of the Semurup Hot Spring area, highlighting the need for facilities and circulation routes to improve visitor comfort and safety. These studies provide important context for understanding the development and spatial planning

of the Semurup tourism destination. Nevertheless, discussions of facilities and development strategies do not, in themselves, explain how local knowledge and scientific evidence are considered in environmental management decisions. Accordingly, the relationship between knowledge foundations, community involvement, and environmental responsibility remains relevant for examination from a philosophical perspective.

Research on local ecological knowledge in various contexts highlights the importance of understanding how communities perceive and interact with their environments. For example, (Sarjan, 2026) examined the knowledge of the Baduy community and its relevance to science education and sustainability. (Pasundan et al., 2025) discussed the potential use of Indigenous ways of knowing and traditional ecological knowledge in environmental education. Meanwhile, (Siburian, 2018) reviewed the role of traditional ecological knowledge in natural resource management. A systematic review by (Renaldi et al., 2024) also indicated that traditional ecological knowledge may encompass customary rules, practices, prohibitions, and knowledge of plants, animals, and landscapes that can potentially support biodiversity conservation. (Darusman, 2014) explained that Indigenous peoples and local communities contribute to territorial management, conservation, environmental monitoring, and natural resource governance. This literature demonstrates that local knowledge can be an important resource for understanding environmental issues; however, it cannot automatically be treated as evidence of community practices in every location. (Jasmine & Abdulkadir, 2023) also highlighted the need to critically examine the application of traditional ecological knowledge in environmental science. Therefore, an analysis of Semurup must distinguish between concepts developed in previous studies, findings derived directly from the site, and arguments formulated through a literature-based analysis.

From an epistemological perspective, the relationship between local and scientific knowledge needs to be analyzed by asking who produces knowledge, what evidence is used to justify it, and how that knowledge gains recognition in decision-making processes. (Wibowo & Belia, 2023) discussed the relationship between local epistemology and modern science in the context of ecological knowledge based on Tambora's local wisdom. (Anggia, 2017) highlighted the importance of epistemic justice in integrating local ecological knowledge into marine conservation governance. Similarly, (Amdah, 2024) explained that the neglect or underrepresentation of community knowledge can raise issues of justice in the formulation of environmental adaptation policies. (R. V. Masri et al., 2023) also emphasized the importance of epistemic justice when different forms of knowledge are brought together

to support environmental governance. (Khikmah & Fintani, 2026) further argued that the integration of local and scientific knowledge in conservation and natural resource management needs to account for power imbalances that may lead to the underrecognition of certain groups' knowledge. These perspectives provide a basis for evaluating the relationship between local and scientific knowledge without overlooking social context, the quality of evidence, or the distinct functions of different knowledge sources.

In tourism management, the relationship between knowledge and decision-making is also connected to community participation and destination sustainability. Participatory research offers opportunities to involve communities affected by tourism activities in decision-making processes. (Tanjung et al., 2017) examined community participation in sustainable tourism development, taking into account community perceptions and opportunities for involvement. Meanwhile, (Widanti, 2025) explored the relationship between sustainable tourism and community-based tourism, including the importance of treating environmental sustainability as a guiding principle in tourism development. (N. R. Masri & Handayani, 2026) indicated that local knowledge-based adaptation strategies should be assessed across social, economic, and environmental dimensions to provide a more comprehensive understanding of their contributions to sustainability. Research on knowledge co-production also suggests that bringing together diverse sources of knowledge can support environmental decision-making, although such processes require collaboration and attention to differing interests (Junaid et al., 2022). This literature strengthens the argument that tourism management should consider not only technical aspects but also the informational foundations of decisions, stakeholder involvement, and the environmental consequences of those decisions.

Based on the previous studies, this article addresses a research gap by bringing the development of Semurup Hot Spring Tourism into dialogue with epistemological analysis and environmental ethics within a single philosophical framework. (Rifdah & Kusdiwanggo, 2024) emphasized strategies for tourism area development, particularly the arrangement of facilities and circulation within the area. Meanwhile, studies of local and scientific knowledge provide a foundation for examining how knowledge is formed, evaluated, and used in decision-making (Wulandari et al., 2026). Accordingly, this article does not claim that previous research on the management of Semurup Hot Spring does not exist; rather, it offers a different analytical perspective on the issue. Its proposed contribution is a conceptual framework connecting three aspects: the validity of knowledge, openness to relevant

knowledge sources, and ethical responsibility toward the environment. This framework is developed through a literature review and philosophical analysis, rather than through empirical measurement of management practices currently being implemented at the site.

Based on this discussion, this study aims to analyze the relationship between local and scientific knowledge in the management of Semurup Hot Spring Tourism, Kerinci Regency, Jambi Province, Indonesia, from the perspectives of epistemology and environmental ethics. Specifically, the study seeks to explain the characteristics, grounds for justification, and limitations of both forms of knowledge; examine their potential contributions to decision-making in natural tourism management; and formulate a conceptual framework that takes environmental responsibility and sustainability into account. The findings are expected to enrich discussions in the philosophy of science concerning knowledge pluralism while providing a conceptual foundation for future field research on community experiences, management policies, and the implementation of sustainability principles at Semurup Hot Spring.

METHODS

Research Type

This study employs a descriptive quantitative approach combined with philosophical analysis. The quantitative approach is used to describe the hydrochemical characteristics of Semurup Hot Spring, estimate the temperature of the geothermal reservoir, calculate the carrying capacity of the tourism area, and analyze respondents' perceptions of epistemological and environmental ethics issues. Meanwhile, the philosophical analysis examines the relationship between local and scientific knowledge in natural tourism management, particularly in relation to the justification of knowledge, the use of evidence, and environmental responsibility.

The study focuses on the Semurup Hot Spring tourism area in Kerinci Regency, Jambi Province, Indonesia. A literature review serves as the conceptual foundation for interpreting the measurement and survey results from the perspectives of epistemology and environmental ethics. Thus, quantitative analysis and philosophical inquiry are used complementarily to explain issues related to tourism area management.

Research Design

The research was conducted in several stages. The first stage involved collecting hydrochemical data from five observation points in the Semurup Hot Spring area. The parameters examined included temperature, pH, silica (SiO_2), chloride (Cl), sulfate (SO_4), bicarbonate (HCO_3), and hydrogen sulfide (H_2S). The second stage involved estimating the geothermal reservoir temperature using geothermometers based on the available water chemistry data. The third stage involved calculating the carrying capacity of the tourism area using the Physical Carrying Capacity (PCC) and Real Carrying Capacity (RCC) approaches.

The next stage involved collecting data on respondents' perceptions of epistemological and environmental ethics issues. The data were then analyzed descriptively and, where appropriate to the research objectives, using Spearman's rank correlation. The final stage involved interpreting the measurement results and statistical analyses with reference to the literature on local knowledge, scientific knowledge, and environmental ethics.

Data Sources and Research Participants

The perception survey involved 120 respondents, consisting of 30 members of Indigenous communities, 30 tourism area managers, and 60 tourists. The survey data were used to identify respondents' perceptions of the relationship between local and scientific knowledge and the application of environmental ethics principles in the management of Semurup Hot Spring. Relevant journal articles, academic books, and scientific publications were used as literature sources to support the epistemological and environmental ethics analysis.

Research Instruments and Data Collection Techniques

Data were collected through hydrochemical measurements, documentation of tourism area parameters, and a questionnaire-based survey. Hydrochemical measurements were conducted at five observation points labeled ST-01 to ST-05. The recorded parameters included water temperature, pH, SiO_2, Cl, SO_4, HCO_3, and H_2S. Measurement procedures, instruments, and analytical methods for each parameter followed the procedures actually applied during sample collection and testing.

Data for calculating the tourism area's carrying capacity were obtained from parameters relating to usable area, space requirements per visitor, visitor rotation factors, and

three correction factors. The value of each parameter was recorded based on the sources or measurements used in the study. Perception data were collected using a questionnaire comprising six indicators: customary prohibitions, scientific rationalization, convergence of customary knowledge and science, anthropocentrism, biocentrism, and ecocentrism.

Data Analysis Techniques

Data analysis was conducted quantitatively and philosophically. Hydrochemical data were analyzed descriptively by comparing the values of each parameter across the five observation points. Reservoir temperature was estimated using a silica geothermometer based on the available SiO_2 concentrations. If additional geothermometers were used, their equations and the basis for the concentration units must be explained and verified before the results are interpreted.

The carrying capacity of the tourism area was calculated in two stages. Physical Carrying Capacity (PCC) was calculated based on the usable area, space requirements per visitor, and visitor rotation factors. Subsequently, Real Carrying Capacity (RCC) was calculated by applying correction factors to the PCC value. The correction factor values and the rationale for their determination were based on the data and methods applied in the study.

Survey data were analyzed descriptively by calculating the mean respondent ratings for each indicator and respondent group. The Percentage of Score Achievement (PCS) was calculated by dividing the mean score by the maximum possible score on the rating scale and multiplying the result by 100%. The overall mean was calculated by taking into account the number of respondents in each group.

The correlation coefficient was calculated based on paired rankings for each respondent. Statistical significance was tested at a significance level of 0.05 using a procedure appropriate to the characteristics of the data. The correlated variables, scoring procedures, treatment of tied ranks, and test results must be reported to ensure that the analysis can be independently assessed.

The quantitative results were subsequently interpreted through philosophical analysis based on relevant literature. Epistemological analysis was used to examine the sources, grounds for justification, and limitations of both local and scientific knowledge. Environmental ethics analysis was used to discuss human responsibility toward the

environment and ethical considerations in tourism area management. Interpretations were limited to findings supported by the research data and the literature used.

Data Validity and Ethical Considerations

Data verification involved examining the consistency of measurement records, the appropriateness of units, the accuracy of calculations, and the consistency of survey data. Survey data were reviewed to ensure that the number of respondents, indicator scores, group means, overall mean, and statistical analysis results were consistent with one another. Literature sources were assessed based on their relevance, the clarity of their publication details, and the traceability of the information provided.

The survey was required to observe informed consent, respondent confidentiality, and the use of data for the stated research purposes. Information regarding the data collection period, respondent consent procedures, measurement instruments, and sample testing procedures should be reported according to the actual implementation of the study.

RESULTS

Hydrochemical Measurement Results

Hydrochemical measurements were conducted at five sampling points within the Semurup Hot Spring area. The parameters measured included water temperature, pH, silica (SiO_2), chloride (Cl), sulfate (SO_4), bicarbonate (HCO_3), and hydrogen sulfide (H_2S). The measurement results for each parameter are presented in Table 1.

Table 1. Hydrochemical Parameters of Semurup Hot Spring

Code	Sampling Location	Temperature (°C)	pH	SiO_2 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	H_2S (ppm)
ST-01	Main crater/boiling source	85.2	7.8	215.4	318.5	145.2	84.0	3.15
ST-02	Traditional egg-boiling pool	79.6	7.9	208.1	310.0	142.0	88.5	2.40
ST-03	Downstream tourist distribution channel	54.3	8.1	182.7	295.4	134.8	96.2	0.85
ST-04	Public therapeutic soaking pool	42.1	8.2	165.0	280.2	128.6	102.4	0.20

ST-05	Overflow stream into the Siulak River	31.5	7.4	94.5	142.1	78.5	118.0	0.02

Source: Field measurements and water sample analysis conducted by the researcher (2026).

Based on Table 1, water temperatures in the Semurup Hot Spring area ranged from 31.5 to 85.2 °C, while pH values ranged from 7.4 to 8.2. The highest concentrations of silica (SiO_2), chloride (Cl), sulfate (SO_4), and hydrogen sulfide (H_2S) were recorded at sampling point ST-01. In contrast, the highest bicarbonate (HCO_3) concentration was found at ST-05, reaching 118.0 mg/L.

Estimated Geothermal Reservoir Temperature

The geothermal reservoir temperature was estimated using a silica geothermometer. The equation used to estimate the reservoir temperature is presented in Equation (1).

$$T_{SiO_2} = \frac{1309}{5.19 - \log_{10}(C_{SiO_2})} - 273.15 \quad (1)$$

Using a SiO_2 concentration of 215.4 mg/L, the calculation was performed as follows:

$$T_{SiO_2} = \frac{1309}{5.19 - \log_{10}(215.4)} - 273.15 \approx 185.1°C$$

The calculation yielded an estimated reservoir temperature of approximately 185.1 °C based on the silica geothermometer. A summary of the input data and estimated geothermal temperatures is presented in Table 2.

Table 2. Summary of Estimated Geothermal Reservoir Temperatures

Parameter	Input Data	Result	Unit
Silica geothermometer	SiO_2 = 215.4 mg/L	185.1	°C
Na-K geothermometer	Na = 382.0 mg/L; K = 48.6 mg/L	Not yet determined	°C

Source: Processing of hydrochemical data and geothermometer calculations by the researcher (2026).

As shown in Table 2, the silica geothermometer produced an estimated reservoir temperature of 185.1 °C. Meanwhile, the estimate based on the Na-K geothermometer has not yet been determined because the equation and concentration-unit basis used in the initial calculation still require verification.

Tourism Area Carrying Capacity Calculation Results

The carrying capacity of the tourism area was calculated in two stages: Physical Carrying Capacity (PCC) and Real Carrying Capacity (RCC). The PCC calculation was based

on the usable area, the space requirement per visitor, and the visitor rotation factor. The equation used is presented in Equation (2).

$$PCC = \frac{A}{B} \times R_f \qquad (2)$$

Substituting the available values gives:

$$PCC = \frac{1850}{4} \times 6 = 2775 \text{ visitors/day}$$

The RCC value was calculated by applying three correction factors to the PCC, as shown in Equation (3).

$$RCC = PCC \times Cf_1 \times Cf_2 \times Cf_3 \qquad (3)$$

$$RCC = 2775 \times 0.65 \times 0.82 \times 0.85 = 1257.21 \text{ visitors/day}$$

A summary of the parameters and carrying capacity calculations is presented in Table 3.

Table 3. Summary of Tourism Area Carrying Capacity Calculations

Parameter	Input Value	Result
Usable area (A)	1,850 m^2	-
Space requirement per visitor (B)	4 m^2/person	-
Visitor rotation factor (Rf)	6 times/day	-
Physical Carrying Capacity (PCC)	A/B × Rf	2,775 visitors/day
First correction factor (Cf_1)	0.65	-
Second correction factor (Cf_2)	0.82	-
Third correction factor (Cf_3)	0.85	-
Real Carrying Capacity (RCC)	PCC × Cf_1 × Cf_2 × Cf_3	1,257.21 visitors/day

Source: Site observations and carrying capacity calculations based on the research parameters (2026).

Based on Table 3, the calculated Physical Carrying Capacity (PCC) of the Semurup Hot Spring tourism area was 2,775 visitors per day. After accounting for the three correction factors, the Real Carrying Capacity (RCC) was estimated at 1,257.21 visitors per day. These results indicate a difference between the area's physical capacity and its adjusted visitor capacity after the specified correction factors have been applied.

Survey Results on Respondents' Perceptions of Epistemology and Environmental Ethics

The perception survey involved 120 respondents, consisting of 30 members of Indigenous communities, 30 tourism area managers, and 60 tourists. Six indicators were

assessed, covering three epistemological dimensions and three environmental ethics dimensions. The mean ratings for each respondent group are presented in Table 4.

Table 4. Mean Respondent Perceptions of Epistemological and Environmental Ethics Indicators

Code	Indicator	Indigenous Community (n=30)	Managers (n=30)	Tourists (n=60)	Overall Mean	PCS (%)
E-01	Customary prohibitions and taboos	4.73	3.10	3.45	3.76	75.2
E-02	Scientific rationalization	4.20	4.85	4.60	4.55	91.0
E-03	Convergence of customary and scientific knowledge	4.80	4.40	4.30	4.50	90.0
ET-01	Anthropocentrism	1.80	3.90	3.25	2.98	59.6
ET-02	Biocentrism	4.40	3.65	4.10	4.05	81.0
ET-03	Ecocentrism	4.65	3.20	3.80	3.88	77.6

Source: Processing of questionnaire data collected from 120 respondents (2026).

The Percentage of Score Achievement (PCS) was calculated by dividing the mean score by the maximum possible rating-scale score. The equation used is presented in Equation (4).

$$PCS = \frac{\bar{x}}{5} \times 100\% \qquad (4)$$

For indicator E-02, the PCS was calculated using the overall mean of 4.55, as follows:

$$PCS = \frac{4.55}{5} \times 100\% = 91.0\%$$

Based on Table 4, the reported PCS values ranged from 59.6% to 91.0%. The highest value was recorded for scientific rationalization, at 91.0%, whereas the lowest was recorded for anthropocentrism, at 59.6%. These results indicate differences in respondents' perceptions of epistemological and environmental ethics dimensions. Nevertheless, the overall mean values and PCS figures require verification against the raw data because some overall means do not fully correspond to calculations weighted by the number of respondents in each group.

Results of Spearman's Rank Correlation Analysis

Spearman's rank correlation analysis was used to examine the strength of the relationship between two variables based on ranked data. The initial calculation used data from 120 respondents, with a reported sum of squared rank differences of 72,840. Spearman's rank correlation coefficient was calculated using Equation (5).

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \qquad (5)$$

Substituting the reported values gives:

$$r_s = 1 - \frac{6(72840)}{120(120^2 - 1)} \approx 0.7471$$

A summary of the initial Spearman's rank correlation analysis is presented in Table 5.

Table 5. Summary of Spearman's Rank Correlation Analysis

Statistical Parameter	Reported Value
Number of respondents (n)	120
Sum of squared rank differences (Σd_i^2)	72,840
Spearman's rank correlation coefficient (r_s)	0.7471
Degrees of freedom (df)	118
Reported calculated t-value	12.21
Reported critical t-value	1.980
Significance level (α)	0.05

Source: Statistical analysis of the research data using Spearman's rank correlation (2026).

Based on Table 5, the initial calculation yielded a Spearman's rank correlation coefficient of 0.7471. This value indicates a relatively strong positive relationship between the variables analyzed. In other words, a higher rank for one variable tends to be associated with a higher rank for the other variable.

The calculated t-value of 12.21 and critical t-value of 1.980 are those reported in the initial calculation summary. Neither value has been independently verified. Therefore, further examination using the paired data for each respondent is necessary to confirm the accuracy of the correlation coefficient and the statistical significance of the observed relationship.

DISCUSSION

Analysis and Interpretation of Findings

The hydrochemical characteristics of Semurup Hot Spring varied across the five observation points. Water temperature decreased from 85.2 °C at the main crater to 31.5 °C at the overflow stream, accompanied by decreasing concentrations of silica, chloride, sulfate, and hydrogen sulfide. These variations may reflect cooling, dilution, and interactions with surrounding surface water. The findings demonstrate how scientific measurements provide systematic information for understanding environmental conditions and supporting evidence-based tourism management.

The silica geothermometer estimated a reservoir temperature of 185.1 °C. However, this value is an indirect estimation rather than a direct measurement and therefore requires further verification. Similarly, the carrying capacity analysis produced a Physical Carrying Capacity (PCC) of 2,775 visitors per day and a Real Carrying Capacity (RCC) of 1,257.21 visitors per day. This difference highlights the importance of considering environmental conditions and visitor safety when determining sustainable tourism capacity.

The perception survey showed that scientific rationalization had the highest reported PCS (91.0%), followed by the convergence of customary and scientific knowledge (90.0%). These results indicate respondents' recognition of the importance of scientific explanations and knowledge integration. Nevertheless, perceptions do not necessarily demonstrate that both knowledge systems have been integrated into actual tourism management practices.

Comparison with Theories and Previous Literature

The findings are relevant to the multiple evidence base perspective, which recognizes the contribution of different knowledge systems to environmental understanding and resource management. (Hs et al., 2020) emphasized community participation in development, while (Raraga & Korengkeng, 2021) discussed the contribution of traditional ecological knowledge to understanding natural resources. In the context of Semurup Hot Spring, scientific measurements can explain geothermal characteristics, whereas local knowledge may provide contextual insights based on community experiences and environmental interactions.

This relationship also relates to epistemic justice, which emphasizes the recognition of different sources of knowledge. (Hasibuan & Muhtaj, 2025) highlighted the relevance of

local knowledge in sustainable resource management. Accordingly, scientific and local knowledge should be considered critically and contextually rather than allowing one to automatically replace the other.

The carrying capacity findings support the principles of sustainable tourism, which require attention to environmental conditions and community participation. (Raudhatul & Sarjan, 2025) emphasized the importance of local communities in tourism development. Furthermore, the reported PCS values for anthropocentrism (59.6%), biocentrism (81.0%), and ecocentrism (77.6%) indicate differences in respondents' environmental perspectives. These findings reinforce the importance of environmental responsibility in tourism management, as also emphasized by (Kasta & Wijaya, 2024).

Research Implications

This study highlights the potential complementary roles of local and scientific knowledge in managing natural tourism destinations. Scientific measurements provide information about geothermal characteristics and tourism carrying capacity, while local knowledge may contribute contextual understanding based on community experiences. Their integration can strengthen tourism decision-making when supported by critical evaluation, transparency, and environmental responsibility.

Practically, the hydrochemical measurements and carrying capacity calculations may serve as preliminary references for tourism managers and local policymakers in managing visitors, utilizing geothermal resources, and monitoring environmental conditions. Community participation is also important to ensure that local perspectives are considered alongside scientific evidence in tourism development and environmental protection.

Research Limitations and Directions for Future Research

This study has several limitations. Hydrochemical measurements covered only five observation points, limiting their representation of seasonal variations and the entire geothermal system. The silica geothermometer estimation also requires verification using additional methods, while carrying capacity parameters need validation through field observations.

The survey involved 120 respondents, including Indigenous community members, tourism managers, and tourists. However, overall mean scores require recalculation using respondent-level data and appropriate weighting. The Spearman correlation coefficient of

0.7471 also requires verification because the paired variables and statistical procedures have not been fully established. Thus, these statistical findings should be considered preliminary.

Future research should expand hydrochemical sampling across seasons and locations, verify geothermometric estimates, and validate carrying capacity parameters through field observations. Interviews and participatory approaches are also necessary to examine the integration of local knowledge into tourism management, supporting more sustainable and environmentally responsible management of Semurup Hot Spring.

CONCLUSION

This study indicates variations in the hydrochemical characteristics of Semurup Hot Spring across the five observation points, with temperatures ranging from 31.5 to 85.2 °C and pH values ranging from 7.4 to 8.2. The silica geothermometer produced an estimated reservoir temperature of 185.1 °C, while the carrying capacity calculations yielded a PCC of 2,775 visitors per day and an RCC of 1,257.21 visitors per day. The preliminary survey results showed the highest PCS value for the scientific rationalization indicator, while the Spearman correlation coefficient was reported as 0.7471.

These findings provide an initial overview of the relationships among geothermal characteristics, tourism capacity, and epistemological and environmental ethics considerations in the management of Semurup Hot Spring. However, several results require further verification, particularly the combined survey means, the reservoir temperature estimate, and the correlation analysis. Future research should expand the sampling coverage, validate the correction factors used in the carrying capacity calculations, and use complete respondent-level data to ensure that the findings are more accurate and scientifically defensible.

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