Jurnal DIDAKTIKA
https://didaktika.lombokinstitute.com/index.php/JPTK

Vol.4, No.2 (October – 2026)
E-ISSN: 2987-4343
pp. 138-162

Ecotourism as a Natural Laboratory for Science Learning: A Narrative Literature Review

Baiq Muli Harisanti[1,2], Siti Nurhidayati[1,2*], Baiq Asma Nufida[1,3], Ratna Azizah Mashami[1,3], Agil Al Idrus[1]

[1]Doctoral Program in Science Education, Universitas Mataram, Mataram, Indonesia.
[2]Biology Education Study Program, Universitas Pendidikan Mandalika, Mataram, Indonesia.
[3]Chemistry Education Study Program, Universitas Pendidikan Mandalika, Mataram, Indonesia.
*Corresponding Author: sitinurhidayati@undikma.ac.id

Abstract

This study aims to analyze and synthesize ecotourism as a natural laboratory for science learning in terms of the available science phenomena, pedagogical design, learning outcomes, implementation conditions, and its relevance to science education in Indonesia. The study employed a narrative literature review approach by synthesizing 14 relevant journal articles published between 2023 and 2026 and identified through a primary Google Scholar search supplemented by Google Search. Information from each article was organized using a data-extraction matrix covering study design or method, participants or context, location and science phenomena, learning outcomes, main findings, and interpretive limitations. The data were analyzed through thematic synthesis and narrative interpretation. The synthesis shows that the strength of evidence for the educational use of each destination varies according to study design. Sade Village and Pemepek show potential for contextual science learning through cultural, ecological, hydrological, energy, biodiversity, and biotechnology phenomena. Gili Sulat, Olaya, and Bagek Kembar provide contexts for mangrove ecology, coastal protection, and conservation, while Gunung Tunak and Kerandangan have been used in learning related to wildlife ecology and conservation. Iboih in Sabang, Ngawonggo Partitraan, Depati VII Coffee & Resort, and Jonggol Teaching and Research Farm also demonstrate pedagogical potential through marine ecosystems, biodiversity, ethnobotany, agroforestry, agriculture, livestock, and local technologies. Environments associated with Papuan local wisdom and the implementation of ecotourism-based teaching materials in East Lombok further broaden the range of learning contexts. Overall, ecotourism can complement school laboratories when authentic phenomena are connected to a structured learning sequence involving preparation, field investigation, evidence processing, reflection, and assessment. However, claims of effectiveness should be limited to the contexts, participants, and interventions that were directly tested, since part of the available evidence still consists of potential mapping, teaching-material development, and implementation studies.

Article History
Received: 10-08-2026
Reviewed: 22-09-2026
Accepted: 20-10-2026
Published: 30-10-2026

Key Words
Ecotourism, natural laboratories, science learning, scientific literacy, conservation education.

How to Cite: Harisanti, B. M., Nurhidayati, S., Nufida, B. A., Mashami, R. A., & Al Idrus, A. Ecotourism as a Natural Laboratory for Science Learning: A Narrative Literature Review. *Jurnal DIDAKTIKA,* 4(2). 138-162.

This is an open-access article under the CC-BY-SA License.

Introduction

Science learning is not merely intended to promote conceptual understanding; it also aims to develop students' ability to connect scientific concepts with real-world phenomena through processes of inquiry. Learning that relies solely on textbooks or closed laboratory settings may create a gap between scientific concepts and the contexts of everyday life (Suryaningsih, 2018). Ecotourism areas can therefore be utilized as natural laboratories

Copyright © the Author(s)

because they provide authentic phenomena in the form of organisms, landscapes, local technologies, resource-management practices, and environmental issues that can be investigated scientifically. A study conducted in Sade Village, Lombok, identified 13 scientific phenomena associated with architecture, dyeing processes and fibers in traditional weaving, as well as the decomposition of organic materials. These findings indicate that learning objects are not limited to forests or wildlife, but may also include cultural artifacts and everyday practices (Yuliani et al., 2026).

This perspective can be further strengthened through the concept of synecology, or community ecology. Barbour et al. (1999) explain that an ecological community should not be understood merely as a collection of species inhabiting a particular place, but rather as a system formed through interactions among organism populations and their relationships with environmental factors. In the context of science learning, a synecological approach enables students to understand that biodiversity, adaptation, competition, symbiosis, and environmental change are components of complex relationships within living systems. Accordingly, ecotourism areas have pedagogical value as natural laboratories because they provide real ecological phenomena that can be analyzed through the concepts of communities and ecosystems.

A natural laboratory can be understood as a real-world environment that provides objects, variables, evidence, and problems to be observed and analyzed through scientific procedures. This understanding distinguishes a natural laboratory from educational tourism that merely transfers classroom lectures to an outdoor setting. A destination should contain phenomena that can be aligned with science competencies, worksheets that guide observation, safety procedures, and forms of assessment that evaluate evidence-based reasoning. The bio-edutourism framework of Depati VII Coffee & Resort positions ecology, ethnopedagogy, and pedagogy as interconnected subsystems; without the pedagogical subsystem, natural and cultural diversity does not automatically become a meaningful learning experience (Nengsih et al., 2026; Muliadi et al., 2026; Siregar et al., 2025).

Previous studies have examined the use of ecotourism in education from relatively separate perspectives, including mapping the potential of destinations as learning resources, developing teaching materials based on local environments, implementing field-based learning, and examining its effects on scientific literacy, science process skills, and critical thinking. At a broader level, Mann et al. (2022), through a systematic review of 147 studies, showed that learning in natural environments provides benefits in academic, social-emotional, learning-engagement, and student well-being domains. However, their review encompassed a wide range of *nature-specific outdoor learning* approaches and did not specifically explain how the characteristics of scientific phenomena at particular destinations are connected to pedagogical design and science learning outcomes. In the Indonesian context, Annam (2026) specifically reviewed ecotourism as a science learning resource and demonstrated its contributions to contextual learning, scientific literacy, critical thinking, environmental attitudes, and Education for Sustainable Development. That review also identified learning models and various implementation challenges, but it did not explicitly integrate the characteristics of science phenomena at each destination, pedagogical design, scientific learning processes, learning outcomes, and implementation conditions into a single conceptual relationship.

In contrast to these two reviews, the present study synthesizes the relationships among the potential science phenomena found in ecotourism areas, the pedagogical designs that mediate their educational use, scientific learning processes, reported learning outcomes, and implementation conditions that influence learning success. This review also differentiates the

Copyright © the Author(s)

strength of interpretation according to the type of evidence, so that studies on potential mapping, teaching-material development, implementation, and learning-outcome testing are not treated as equivalent forms of evidence. The novelty of this review therefore lies in its integrated synthesis of these components, positioning ecotourism not merely as a place or learning resource, but as a natural laboratory that requires deliberate pedagogical design.

This review focuses on five questions: what science phenomena are available at ecotourism destinations; what learning models transform these phenomena into inquiry; what learning outcomes have been reported; what conditions facilitate or hinder implementation; and to what extent the available evidence supports application in Indonesian schools. Empirical evidence is prioritized where available, whereas exploratory and development studies are used to map potential and instructional design. Differences in the types of evidence are maintained so that pedagogical recommendations are not equated with causal evidence. Based on this focus, the study aims to analyze and synthesize the potential of ecotourism areas as natural laboratories for science learning in terms of the available scientific phenomena, pedagogical design, evidence of learning outcomes, implementation conditions, and their relevance to the implementation of science learning in Indonesia.

Research Method

This article employed a narrative literature review to examine the use of ecotourism areas as natural laboratories for science learning. Literature reviews are used to integrate and synthesize previous studies in order to provide a comprehensive overview of a particular field of inquiry (Green et al., 2006; Snyder, 2019). The review integrated studies on destination potential mapping, teaching-material development, implementation, and learning outcomes included in the reference list. This review was not designed as a systematic review or meta-analysis; therefore, the number of studies discussed should not be interpreted as the result of an exhaustive search of all available publications. A narrative review approach was selected because the evidence included in the review varied in terms of objectives, research designs, participants, and outcomes (Snyder, 2019).

The literature search was conducted on September 23, 2026, using Google Scholar as the primary source with the Boolean combination ("ecotourism" OR "edu-ecotourism" OR "bio-edutourism") AND ("science education" OR "biology learning"). Additional searches were conducted using more specific keywords, including "edu-ecotourism" AND "TWA Kerandangan". For relevant articles that were not identified through Google Scholar, supplementary searches were conducted using Google Search with the combinations ("mangrove ecotourism" OR "edu-ecotourism") AND ("education and learning" OR "community empowerment"), as well as "outdoor learning" AND ("guided inquiry" OR "discovery learning" OR "science process skills" OR "Papuan local wisdom"). The initial search yielded approximately 8,190 documents. After limiting the publication period to 2023–2026, approximately 3,500 documents remained. Restricting the search results to articles published in English or Indonesian resulted in approximately 2,970 documents. Results from all search routes were then combined and checked for duplicates. Screening was conducted based on the relevance of titles and abstracts, followed by full-text assessment using the predefined inclusion and exclusion criteria.

A total of 14 articles published in English or Indonesian between 2023 and 2026 were included as the units of synthesis. Sources published before this period, such as Barbour et al. (1999), Green et al. (2006), Kurnia and Suryadharma (2016), Suryaningsih (2018), and

Copyright © the Author(s)

Snyder (2019), were used only as conceptual or methodological foundations and were not included in the synthesis. Articles were excluded if they discussed ecotourism solely as a tourism activity without an educational connection, were unrelated to science or biology learning, or did not provide relevant information concerning the potential of learning resources, instructional design or implementation, or learning outcomes. The complete list of the 14 articles included in the synthesis is explicitly presented in the synthesis table so that the studies can be clearly identified and traced by readers.

The literature review process in this study involved defining the focus of the review, conducting the literature search, selecting articles according to the established criteria, determining the articles to be included as units of analysis, extracting data, comparing study characteristics, conducting thematic synthesis, and drawing conclusions. The overall procedure of the narrative literature review is presented in Figure 1.

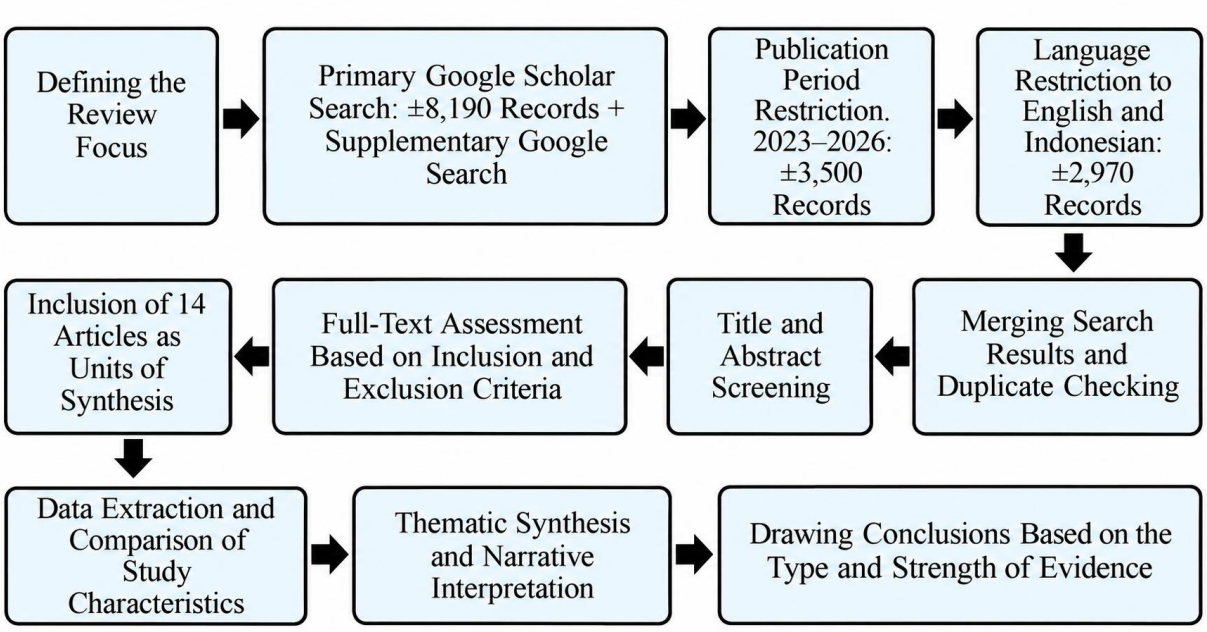


Figure 1. Flow of the Narrative Literature Review Process

Information from each study was organized using a data-extraction matrix covering the study design or method, participants or context, location and science phenomena, learning outcomes, main findings, and interpretive limitations. Each article was reviewed consistently according to these categories (Snyder, 2019) and then compared across publications by considering differences in research design, participants, and types of evidence (Green et al., 2006). All 14 articles included as units of synthesis were comparatively summarized in Table 1, allowing the design or method, context, main findings, interpretive limitations, and location characteristics of each study to be directly traced. Presenting all articles in this table was intended to enhance the traceability and auditability of the synthesis process. Numerical findings and descriptions of study locations were reported as presented in the original articles; this review did not recalculate effect sizes or pool raw data across studies.

The synthesis was conducted thematically by grouping the evidence into science content, pedagogical models, learning outcomes, and implementation conditions. These categories were used to identify recurring patterns and themes in the literature as the basis for

Copyright © the Author(s)

Vol.4, No.2 (October – 2026)
E-ISSN: 2987-4343
pp. 138-162

the narrative synthesis (Snyder, 2019). Conclusions were bounded according to the type of evidence: exploratory studies were used to describe potential and design needs, whereas studies with comparison groups were used to discuss differences in learning outcomes. Accordingly, findings concerning destination potential, the feasibility of teaching materials, or participants' perceptions were not treated as evidence of instructional effectiveness. Limitations related to sample size, long-term measurement, and differences in research design across studies were taken into account when interpreting the findings.

Research Findings and Discussion

Ecotourism as a Contextual Natural Laboratory

Ecotourism can be understood as a contextual natural laboratory because it brings together authentic phenomena, field experiences, local knowledge, and conservation issues within a single learning environment. This potential becomes a science learning resource when observed objects are connected to scientific concepts through data recording, the construction of representations, and evidence-based explanations. The following synthesis discusses four interrelated aspects: authentic phenomena as starting points for conceptual learning, transforming experience into scientific representations, local knowledge as a source of evidence, and conservation as both a learning objective and context (Muliadi et al., 2026; Yuliani et al., 2026; Nengsih et al., 2026; Verawati & Idrus, 2023).

Authentic Phenomena as Starting Points for Conceptual Learning

The principal strength of ecotourism lies in the visibility and measurability of its phenomena. In Pemepek, three destinations were mapped onto different themes: Lembah Datu for riparian ecosystems and simple machines, Pindah Alam for the hydrological cycle, hydrostatic pressure, and renewable energy, and KHDTK Rarung for biodiversity, symbiosis, and biotechnology (Muliadi et al., 2026). Such mapping provides teachers with a starting point for formulating learning objectives, rather than merely compiling a list of attractive places to visit.

Authentic contexts also allow a single location to be used across different branches of science. Thatched roofs can be used to discuss thermal insulation, stone stairs to examine mechanical advantage, cellulose fibers to connect biology and materials science, and floors made from fermented buffalo dung to explore decomposition and microbial activity (Yuliani et al., 2026). Thus, natural laboratories can support integrated science learning when learning questions are structured around relationships among factors rather than around separate disciplinary divisions.

Connecting Experience with Scientific Representations

Field observations acquire scientific value only when students transform their experiences into data, representations, and explanations. In the Iboih area, local natural potential was reconstructed into a concept map linking ecology, biodiversity, ecosystems, and pollution with biology teaching materials (Noviyanti et al., 2025). This reconstruction process is important because clearly observable objects do not automatically lead to understanding; students need to distinguish among observation, interpretation, causal inference, and conclusion.

The relationship between experience and concepts also depends on the quality of the questions posed. A question such as "What do you see?" may lead only to inventory-making, whereas questions such as "What patterns differ across habitats, what evidence supports those differences, and what variables might explain them?" encourage reasoning. A guided-inquiry study on biodiversity showed that gardens and plantations can provide contexts for direct

Copyright © the Author(s)

interaction with phenomena, but improvements in science process skills occurred because the intervention used guided inquiry rather than simply because students were learning outdoors (Siregar et al., 2025).

Local Knowledge as a Source of Evidence

Ecotourism in Indonesia often brings community-based ecological knowledge into contact with formal science concepts. The Depati VII study integrated coffee agroforestry, Rumah Basilo architecture, local technologies such as *jangki* and *lukah*, and Kerinci proverbs within ecological, ethnopedagogical, and pedagogical frameworks (Nengsih et al., 2026). In this context, local knowledge is not merely a form of cultural decoration, but a source of hypotheses concerning materials, functions, adaptation, and human–environment relationships that can be tested or compared with scientific concepts.

This approach may also reduce the distance between schools and communities. An outdoor learning model integrating Papuan local wisdom used forest conservation practices and traditional medicine to foster emotional connectedness and understanding of biodiversity (Linda et al., 2025). However, teachers need to distinguish respectfully among empirical claims, cultural values, and normative beliefs. The aim is not to replace local knowledge with school-based terminology, but to bring the two into dialogue through evidence-based inquiry.

Conservation as Both a Learning Objective and Context

Ecotourism areas provide real-world problems that can guide learning, such as changes in water quality, waste, habitat fragmentation, visitor pressure, and the sustainability of resource use. The Gili Sulat mangrove study reported that ten biology education students understood the role of mangroves in coastal protection and expressed greater inspiration to protect the environment after participating in the field practicum; they also proposed species name boards as an improvement to educational facilities (Verawati & Idrus, 2023).

Participants' reported concern should not be equated with measurable changes in conservation behavior. Natural laboratories need to connect concepts with observable actions, for example through pre- and post-activity waste surveys, water-quality monitoring, records of habitat disturbance, or management plans discussed with site managers. In this way, conservation becomes both an object of inquiry and an ethical boundary for learning activities, rather than merely a moral message delivered at the end of a visit (Suryaningsih, 2018; Verawati & Idrus, 2023).

The Spectrum of Science Content in Ecotourism Destinations

The science content identified in the reviewed ecotourism literature is dominated by biological objects and ecological processes, particularly biodiversity, ecosystems, conservation, and interactions between organisms and their environment (Rachmawati et al., 2025; Noviyanti et al., 2025; Nengsih et al., 2026; Verawati & Idrus, 2023). Several studies also identified physical and chemical phenomena, although these were less well represented. Physical phenomena included water flow, energy, temperature, light, and simple mechanical systems, whereas chemical phenomena appeared in material properties, pH, fermentation, processing activities, and matter cycles (Muliadi et al., 2026; Hikmah et al., 2025; Hidayat et al., 2024). Therefore, "integrated science" in this review refers to the potential interconnectedness of science concepts within particular contexts, rather than to an equal representation of biology, physics, and chemistry.

Based on the phenomena discussed in the literature, the science content was grouped into biodiversity and ecology; coastal and mangrove ecosystems; water, energy, and physical

Copyright © the Author(s)

phenomena; and agroecosystems, technology, and socioscientific issues. However, the strongest body of evidence remains within the domains of biology and ecology (Muliadi et al., 2026; Noviyanti et al., 2025; Rachmawati et al., 2025; Nengsih et al., 2026).

Biodiversity and Ecology

Biodiversity is the most direct theme because students can identify organisms, compare habitats, develop classifications, and examine relationships among populations. Ngawonggo Partitraan, for example, contains medicinal plants, various bamboo species, and higher plants that can be used to study plant taxonomy, ethnobotany, and sustainable resource use (Rachmawati et al., 2025). The butterfly edu-ecotourism program at Kerandangan Nature Tourism Park demonstrates the potential use of local fauna for interpretation and environmental education; however, the community-service report did not comparatively test student learning outcomes (Insani et al., 2025).

The selection of learning objects should consider their conceptual representativeness rather than merely species abundance. Students may compare different transects, measure occurrence frequencies, or analyze simple indices where their abilities and available time allow. At the elementary level, activities may focus on grouping organisms according to observable characteristics; at the secondary level, activities can progress toward interactions, adaptation, population dynamics, and anthropogenic pressures. Conceptual reinforcement depends on an observation design that prevents activities from ending merely with the collection of photographs (Kurnia & Suryadharma, 2016; Siregar et al., 2025).

Coastal and Mangrove Ecosystems

Mangrove ecosystems provide an integrated context for examining zonation, adaptation, food webs, matter cycles, coastal protection, pollution, and conflicts over spatial use. A study on the development of a natural laboratory in Olaya selected a mangrove area by considering forest extent, distance from settlements, natural conditions, accessibility, and community support; the resulting design explicitly integrated educational and tourism functions (Verawati & Idrus, 2023). These criteria indicate that pedagogical feasibility cannot be separated from ecological and social feasibility.

Bagek Kembar extends the mangrove theme into biopreneurship-based projects. The developed module integrates Grade 10 ecosystem content with project activities that utilize the potential of the local area, while content validation yielded an Aiken's index of 0.93 (Hidayat et al., 2024). This value indicates content feasibility and material clarity based on the reported validation process, rather than evidence that the module has improved students' learning outcomes. This distinction is important when teaching materials are promoted as instructional solutions.

Water, Energy, and Physical Phenomena

Ecotourism destinations often display physical phenomena that can be measured without complex laboratory equipment. Pindah Alam was mapped to the hydrological cycle, hydrostatic pressure, and renewable energy, whereas Lembah Datu provides examples of simple machines (Muliadi et al., 2026). Students can relate height, depth, flow, slope, force, or energy transformations to simple field measurements.

This potential requires careful attention to measurement validity. Field conditions vary according to weather, season, visitor density, and observation time. Therefore, learning activities should emphasize repeated measurements, unit recording, identification of sources of error, and comparisons across observation points, rather than requiring students to obtain a

Copyright © the Author(s)

single "correct value" from one measurement. Architectural phenomena in Sade, such as the insulating function of thatched roofs and the use of stone stairs as levers, also demonstrate how physics content can be connected to cultural objects embedded in community life (Yuliani et al., 2026).

Agroecosystems, Technology, and Socioscientific Issues

Agricultural land, plantations, livestock areas, and processing facilities provide opportunities to discuss energy flow, productivity, nutrient cycles, microclimates, fermentation, waste, and processing technologies. The edu-ecotourism plan at Jonggol Teaching and Research Farm inventoried plantations, livestock, processing industries, field laboratories, soil and geological variations, and dozens of plant and animal species; the final design incorporated spatial organization, circulation, green zones, and interpretive activities (Hikmah et al., 2025).

Such areas are also suitable for addressing socioscientific issues. Students can compare productivity with water use, discuss the benefits and risks of processing activities, or evaluate trade-offs between tourism income and environmental carrying capacity. The mangrove-based biopreneurship project model illustrates the potential to connect scientific literacy, the local economy, and conservation (Hidayat et al., 2024). However, learning activities should ensure that an entrepreneurial orientation does not obscure questions of equitable access, ecological impacts, and the distribution of benefits.

A Pedagogical Model for Transforming Visits into Learning

The use of ecotourism as a natural laboratory requires a pedagogical design that connects pre-visit activities, on-site investigation, and post-fieldwork processing of findings. Previous studies have identified learning components such as preparation and initial assessment, direct observation, data collection and analysis, guided inquiry, communication of findings, and final assessment (Yamin et al., 2025; Siregar et al., 2025). Experiential learning and inquiry worksheets have also been used to structure field activities so that they do not remain merely recreational experiences (Nengsih et al., 2026). Based on this synthesis, the present study proposes a three-stage sequence—before the visit, during the investigation, and after the visit—as a practical framework for teachers. This sequence represents the authors' synthesis rather than a single model that has been comprehensively tested as an integrated whole.

Before the visit, teachers establish learning objectives, introduce the site context, identify students' prior knowledge, and help students formulate questions and observation plans. An example question is: "How do differences in habitat conditions influence the diversity of organisms at the observed site?" Initial data may include students' predictions, the variables to be observed, and a planned observation table, while assessment may involve a pretest or a rubric for evaluating the observation plan. Preparation, pretesting, and field guides were implemented by Yamin et al. (2025), whereas question formulation, hypothesis development, and investigation planning were supported by Siregar et al. (2025).

During the investigation, students conduct observations, record and classify data, compare conditions across observation points, and relate their findings to science concepts. Data may include the types and numbers of organisms, habitat characteristics, measurement results, visual documentation, and ecological interactions. Process assessment may evaluate observation, classification, data interpretation, and scientific communication. After the visit, students organize data into tables or graphs, construct evidence-based explanations, present their findings, and engage in reflection. An example of a final task is: "Explain the relationship

Copyright © the Author(s)

between environmental conditions and the biodiversity patterns observed, and formulate one evidence-based conservation recommendation." Assessment may include reports, presentations, reflections, and posttests. Elements of observation, data collection, ecological analysis, and posttesting were reported by Yamin et al. (2025), whereas interpretation, communication, and concept application skills were assessed by Siregar et al. (2025).

This three-stage framework brings together elements that are distributed across previous studies. The effectiveness of the entire sequence as an integrated pedagogical model still requires empirical testing. Other studies, such as Hidayat et al. (2024), support the feasibility of biopreneurship-based project modules, while edu-ecotourism activities in Kerandangan provide examples of field-based educational implementation; however, neither study tested the complete three-stage sequence.

Experiential Learning and Reflection Cycle

Field visits are most effective when direct experience is followed by reflection and conceptualization. The Depati VII framework explicitly employs Kolb's experiential learning model to organize field-based strategies, with the ecological subsystem serving as the object of study and the pedagogical subsystem guiding the learning activities (Nengsih et al., 2026). In practice, the cycle may involve concrete experience, evidence recording, concept construction, testing of explanations, and reflection on conservation implications.

This cycle distinguishes learning from recreation. Before departure, teachers can introduce the phenomenon and guiding questions; at the site, students conduct focused observations; after returning, they process the data, test their explanations, and present their findings. In ecotourism-based biology learning materials, Kurnia and Suryadharma (2016) highlight the importance of designing teaching materials and activities that are aligned with field-based objects. The sequence of observation, data processing, and reflection presented here is a design proposal derived from the synthesis of the reviewed studies, rather than a sequence that has been independently tested as a complete model.

Guided Inquiry and Science Process Skills

Guided inquiry is well suited to natural laboratories because the phenomena are open-ended, while students' capacities to formulate problems, select variables, and evaluate evidence are not always equally developed. A study involving 19 Grade 10 students used garden and plantation environments for guided inquiry on biodiversity; the mean science process skills score increased from 43.79 to 90.11, with an N-Gain of 0.82 and a statistically significant Wilcoxon result ($Z = -3.826$; $p < 0.001$) (Siregar et al., 2025).

These findings support the potential benefits of the intervention, but the one-group pretest–posttest design does not isolate the effects of inquiry from repeated testing, teacher attention, or the novelty of the experience. From a pedagogical perspective, however, the findings remain useful for identifying skills that can be targeted, including classification, observation, interpretation, prediction, communication, and hypothesis formulation. Because hypothesis formulation was reported as the indicator with the smallest improvement, worksheets should provide specific practice in transforming observations into testable hypotheses (Siregar et al., 2025).

Ecotourism-Based Field Practicum

The *Ecotourism-Based Field Practicum* model engages university students in the study of the ecology and conservation of *M. reinwardt* at Gunung Tunak and Kerandangan Nature Tourism Parks, while the control group participates in conventional laboratory practicums

Copyright © the Author(s)

(Yamin et al., 2025). This structure more closely reflects authentic scientific inquiry because the organism is studied in its natural habitat, requiring students to observe, analyze data, and make evidence-based decisions.

In the quantitative results, the scientific literacy N-Gain reached 57% in the experimental group and 51% in the control group; the Mann–Whitney test yielded $p = 0.038$. A total of 69.23% of students met the scientific literacy standard, while 93.7% reported that the model was beneficial and expressed an intention to use it again (Yamin et al., 2025). In this study, N-Gain was reported as a percentage and was not directly compared with findings from other studies that used different reporting formats, instruments, participants, or research designs. N-Gain was also not treated as a standardized effect size. These findings indicate relatively higher achievement in the experimental group within the context of the study; however, effect size, consistency in the number of analyzed participants, and the duration of follow-up should be considered before broader generalization.

Projects, Interpretation, and Learning Products

Project-based activities enable students to produce assessable outputs, such as biodiversity maps, species catalogs, waste-processing prototypes, water-quality reports, or management recommendations. The Bagek Kembar biopreneurship module illustrates how project activities can connect mangrove ecosystems with curriculum learning objectives and the development of local potential (Hidayat et al., 2024). Such products make evidence of learning more visible than merely reporting that participants "enjoyed the visit."

Destination interpretation also constitutes an important pedagogical component. The Jonggol plan incorporated attraction maps and interpretive services into zoning and activity design (Hikmah et al., 2025). The species information boards proposed by Gili Sulat participants suggest that interpretive infrastructure can strengthen visitors' independence in connecting observed objects with scientific concepts (Verawati & Idrus, 2023). However, interpretation should go beyond naming labels; information should guide questioning, causal reasoning, and conservation-oriented action.

Reported Learning Outcomes

The learning outcomes reported in the literature include scientific literacy, critical thinking and decision making, science process skills and conceptual understanding, as well as environmental awareness and place identity. These findings were derived from different research designs and measurement approaches and therefore need to be interpreted according to the strength of evidence provided by each study. Score changes in studies with comparison groups, improvements within single-group designs, and participants' affective responses provide different types of information about learning outcomes. The following discussion presents the reported outcomes while distinguishing evidence of skill improvement, perceived usefulness, and the potential for changes in conservation behavior (Yamin et al., 2025; Yamin et al., 2026; Siregar et al., 2025; Linda et al., 2025; Verawati & Idrus, 2023).

Scientific Literacy

The strongest evidence in this body of literature comes from a quasi-experimental study involving preservice biology teachers. The ecotourism-based practicum produced an N-Gain of 57% compared with 51% in the conventional practicum, with a statistically significant difference (Yamin et al., 2025). Theoretically, this advantage is plausible because students engage directly with habitats, organismal variation, and conservation problems that require

Copyright © the Author(s)

the application of scientific concepts rather than merely the manipulation of materials on a laboratory bench.

Scientific literacy encompasses more than test scores. The study also reported high levels of agreement regarding the usefulness of the model, but perceived usefulness should not be treated as evidence of improved scientific literacy. More robust evaluation should combine transfer tests, argument analysis, interpretation of unfamiliar data, and conservation-related decision making assessed using appropriate rubrics. In this way, learning outcomes can be distinguished from participants' satisfaction with the field-based learning environment (Yamin et al., 2025).

Critical Thinking and Decision Making

Another study employed a quasi-experimental design to compare *Ecotourism-Based Field Learning* focused on the ecology and conservation of *M. reinwardt* with conventional laboratory practicum activities. N-Gain and Mann–Whitney analyses indicated a significant difference in the improvement of critical thinking and a substantive effect on higher-order cognitive achievement (Yamin et al., 2026). These findings strengthen the proposition that authentic ecological problems can promote evidence evaluation and argumentation.

The available abstract does not provide detailed information on sample size, N-Gain values, or effect size. Therefore, the most defensible conclusion is that the study found a difference in improvement according to its analysis, rather than that all ecotourism visits enhance critical thinking. The quality of questions, opportunities to compare conflicting evidence, and requirements to justify conclusions may be more influential than the tourism setting itself (Yamin et al., 2026).

Process Skills and Conceptual Understanding

An environment-based guided inquiry intervention involving 19 students resulted in an increase in science process skills from a mean score of 43.79 to 90.11, with an N-Gain of 0.82. All indicators improved, with classification showing the highest gain and hypothesis formulation the lowest (Siregar et al., 2025). These findings suggest that outdoor environments can support operational and reasoning skills, although teacher support needs to be directed toward the most challenging components of the inquiry process.

A discovery-based outdoor learning model integrated with Papuan local wisdom also reported improved understanding of biodiversity. The overall mean increased from 62.40 to 84.80; understanding of Papuan flora and fauna increased from 61.20 to 84.10, understanding of ecosystem roles from 63.00 to 86.30, and understanding of conservation and local wisdom from 63.00 to 84.00, with all differences reported as significant at $p = 0.000$ (Linda et al., 2025). Because the model was developed and tested within a specific context, replication in other regions should examine whether similar gains occur when the learning objects, teachers, and cultural settings differ.

Environmental Awareness and Place Identity

The mangrove practicum at Gili Sulat demonstrated relevant affective outcomes: participants reported a better understanding of the role of mangroves in coastal protection, felt more inspired to protect the environment, and expressed a willingness to participate again in educational activities (Verawati & Idrus, 2023). These findings are more appropriately interpreted as self-reported awareness, attitudes, and intentions because the study employed questionnaires and interviews rather than direct measures of actual conservation behavior.

Copyright © the Author(s)

Vol.4, No.2 (October – 2026)
E-ISSN: 2987-4343
pp. 138-162

In this review, awareness refers to understanding or recognition of environmental issues; attitude refers to evaluative or affective tendencies toward environmental protection; intention refers to a stated willingness to undertake a particular action; and conservation behavior is used only when there is evidence of actions that were directly observed or measured. Based on these criteria, most of the available evidence remains at the level of perceptions, attitudes, or immediate post-activity intentions. Therefore, there is currently insufficient evidence to conclude that these experiences result in sustained long-term changes in conservation behavior.

Implementation Requirements and Pedagogical Risks

The implementation of ecotourism-based science learning is influenced by pedagogical readiness, the feasibility of field activities, and relationships with the local environment and community. The educational potential of a destination needs to be supported by teachers and ready-to-use teaching materials, adequate time allocation, safety protocols, and appropriate assessment. Access, cost, and students' needs also determine the accessibility of the learning experience, while ecological integrity and community partnerships influence the sustainability of site use. The following synthesis discusses these conditions together with the pedagogical risks that may arise when visits are not purposefully designed (Andayani et al., 2026; Nengsih et al., 2026; Siregar et al., 2025; Verawati & Idrus, 2023).

Teacher Readiness and Teaching Materials

Ecotourism cannot be incorporated into the curriculum by relying solely on teachers' spontaneous creativity. In East Lombok, teaching materials integrating mangrove environments, Bajo-Mbojo culture, local wisdom, and socioscientific issues were implemented with teachers; 85% of respondents stated that the materials helped them achieve learning objectives more effectively, while approximately 40% reported time constraints in developing projects and technical difficulties in visiting the sites (Andayani et al., 2026).

These findings highlight the importance of institutional support, including repositories of worksheets, site-based concept maps, assessment rubrics, observation training, transportation coordination, and collaboration with site managers. The Pemepek design employed field observations and science-concept rubrics to map the content available at each destination (Muliadi et al., 2026). Such rubrics can help teachers transform site potential into assessable learning objectives.

Time Structure, Safety, and Assessment

The experience at Depati VII revealed three immediate risks: students' attention may be divided between recreation and learning, field time is limited, and structured observation guides are needed to prevent activities from becoming ordinary tourism experiences (Nengsih et al., 2026). These findings support the need for a clear activity structure before and during the visit. Based on the authors' synthesis, minimum mitigation measures may include safety briefings, role allocation, predefined routes and observation boundaries, time management for data collection, and post-activity reflection sessions. At sites where terrain or weather conditions may change, activities should also include checks of weather forecasts, assessment of terrain conditions, designated meeting points, emergency communication procedures, and alternative activities when field conditions are unsuitable.

Interaction with organisms and the environment should also be limited to avoid disturbing habitats; specimen collection should only be conducted when permitted and genuinely necessary for learning purposes. Field activities should obtain permission from site

Copyright © the Author(s)

managers, and the use of local knowledge should be based on consent and respect for the communities from which that knowledge originates. The recommendations in this section are practical proposals developed by the authors based on implementation risks and needs reported in the literature; they are not a safety protocol that has been directly tested as an integrated package in previous studies.

Assessment should also evaluate the learning process rather than merely attendance or descriptive reports. Rubrics may include the accuracy of observations, the quality of questions, consistency of data, acknowledgement of limitations, links between evidence and conclusions, and proposed conservation actions. The need for such structure is consistent with guided-inquiry findings: classification showed the greatest improvement, whereas hypothesis formulation remained a relatively weaker aspect (Siregar et al., 2025).

Access, Cost, and Inclusion

Distant destinations, difficult terrain, transportation costs, weather conditions, and visitor capacity can limit who is able to participate in field-based learning experiences. The Olaya mangrove natural laboratory plan considered distance from settlements, site accessibility, forest condition, and community support (Verawati & Idrus, 2023). These considerations should also be extended to accessibility for students with mobility, health, or sensory needs.

Pedagogical solutions do not always require a full-day visit. Schools can use nearby locations, establish observation stations around the school, combine field data collected by small groups, or organize visits in stages. However, digital substitutes or secondary data are not equivalent to direct experience; instructional design should therefore specify which competencies can still be achieved and which cannot (Andayani et al., 2026; Kurnia & Suryadharma, 2016).

Ecological Integrity and Community Relations

Destinations used as classrooms may experience additional pressure if group size, specimen collection, or visitor behavior is not controlled. Therefore, activities should respect carrying capacity, avoid habitat damage, minimize organism collection, and involve site managers and local communities as knowledge partners. The natural laboratory concept in Olaya was designed not only for educational purposes but also to support local communities in managing regional potential while maintaining mangrove ecosystems (Verawati & Idrus, 2023).

Community relations also shape the scientific and ethical legitimacy of the learning process. Local knowledge should be properly acknowledged, sensitive claims should not be exploited as spectacles, and educational and economic benefits should be discussed transparently. The Depati VII model, which integrates local technologies and ecological norms, provides an example of this direction, although existing studies have rarely examined the distribution of benefits or changes in community workload (Nengsih et al., 2026).

Context of Application in Indonesia and Transfer Potential

The use of ecotourism as a natural laboratory in Indonesia can be developed by utilizing the diversity of destinations and adapting learning activities to the curriculum and students' needs. Studies in Lombok indicate opportunities to build networks of learning resources, while ecosystem variation in other regions provides contexts for comparing scientific phenomena. These opportunities are also relevant to preservice teacher education because field experiences can serve as a foundation for instructional design. However, implementation across different locations and participant groups needs to consider ecosystem

Copyright © the Author(s)

characteristics, observation procedures, and the limits of evidence transferability. These four aspects are discussed in the following subsections (Yuliani et al., 2026; Muliadi et al., 2026; Nengsih et al., 2026; Yamin et al., 2025; Andayani et al., 2026).

Lombok as a Networked Learning Ecosystem

Evidence from Lombok reveals a range of locations that can complement one another, including traditional villages, mangrove areas, nature tourism parks, and conservation areas. Sade provides phenomena spanning physics, biology, chemistry, and culture (Yuliani et al., 2026); Gili Sulat provides a context for mangrove ecosystems and coastal protection (Verawati & Idrus, 2023); Gunung Tunak and Kerandangan serve as sites for learning about the ecology and conservation of *M. reinwardt* among preservice biology teachers (Yamin et al., 2025); and Kerandangan has also been used in a butterfly edu-ecotourism program within the context of community and children's education (Insani et al., 2025). These findings indicate that the pedagogical function of each site should be interpreted according to the participant group and learning objectives examined in the respective studies.

For school students, the evidence more strongly supports the use of the environment as a contextual learning resource for biodiversity observation, guided inquiry, and the development of teaching materials. For preservice teachers, the evidence includes field practicums, scientific literacy, critical thinking, and more complex inquiry experiences. Studies involving teachers, meanwhile, primarily provide information on implementation readiness, the feasibility of teaching materials, and practical constraints. Therefore, findings from university students should not be automatically generalized to school students, and findings from teachers should not be treated as direct evidence of student learning outcomes.

Geographical proximity does not automatically guarantee continuity across learning experiences. Each site requires objectives, instruments, levels of task complexity, and assessment formats that are adapted to the characteristics of the participants. Coastal destinations should not be treated simply as "forest" versions using the same worksheet, and wildlife-related objects require different observation protocols from architectural objects or food-processing activities. Accordingly, a network of sites is better positioned as a set of adaptable learning resources suited to different educational levels and participant characteristics, rather than as a uniform instructional package. Curriculum development should therefore be based on concept maps and local problems rather than merely on lists of tourist destinations (Muliadi et al., 2026; Yuliani et al., 2026).

Biogeographical Diversity as a Basis for Comparison

Indonesia provides opportunities for comparative learning across ecosystems, including mangroves, forests, agroforestry systems, rivers, plantations, and cultural villages. Pemepek connects riparian ecosystems, hydrology, energy, biodiversity, symbiosis, and biotechnology within a single area (Muliadi et al., 2026). Depati VII adds mountain microclimates, multistrata agroforestry, and Kerinci cultural identity (Nengsih et al., 2026). Such comparisons can help students understand that scientific principles may be general, while their manifestations and management practices are place-dependent.

Comparative potential should, however, be accompanied by methodological control. If students compare biodiversity, they need to standardize observation time, transect area, identification procedures, and sampling effort. If they compare temperature or water quality, instruments, units, and weather conditions should be recorded. Without minimum

Copyright © the Author(s)

standardization, observed differences may reflect procedural variation rather than ecosystem differences (Siregar et al., 2025; Muliadi et al., 2026).

Alignment with the Curriculum and Preservice Teacher Education

Indonesian studies frequently position preservice teachers as early users of natural laboratories. Ecotourism-based practicums have been shown to improve scientific literacy compared with conventional practicums (Yamin et al., 2025), while the *M. reinwardt*-based model has been reported to enhance critical thinking (Yamin et al., 2026). This dual impact is important because preservice teachers who experience field-based instructional designs as learners are more likely to understand the requirements of instruction, assessment, and risk management when they later enter professional teaching practice.

Edu-ecotourism teaching materials implemented in schools in East Lombok received positive responses from teachers, although constraints related to time and site visits remained (Andayani et al., 2026). This suggests that curricular adoption requires a reduction in the burden of individual instructional design. Modules, concept maps, safety protocols, and assessment formats should ideally be co-developed by teachers, destination managers, and science education lecturers to ensure that they remain scientifically sound, locally relevant, and practically feasible.

Limits to the Transferability of Evidence

The available evidence does not support the claim that every ecotourism area will improve learning outcomes. Some studies mapped destination potential through qualitative observation (Yuliani et al., 2026); others developed teaching materials or instructional frameworks (Muliadi et al., 2026); and several employed quasi-experimental or pretest–posttest designs to examine specific outcomes (Yamin et al., 2025). These differences in research design mean that the degree of certainty associated with the resulting conclusions is not equivalent.

Transfer to other regions should preserve the underlying learning mechanisms rather than replicate the same objects. These mechanisms include authentic phenomena, guided questions, evidence collection, dialogue with local knowledge, reflection, and assessment. The learning objects themselves may vary from mangroves to rivers, coffee plantations, forests, or traditional villages. On this basis, natural laboratory development can remain adaptive without claiming that findings from one site are universally applicable (Nengsih et al., 2026; Muliadi et al., 2026).

Methodological Comparison

This comparison reveals a clear gradation in the strength of evidence. Mapping and phenomenological studies are useful for identifying objects, meanings, and design requirements, but they are limited in their capacity to support causal inference. Quasi-experimental studies are more relevant for comparing learning outcomes, although they still require more complete reporting of sample characteristics, implementation fidelity, effect sizes, and follow-up duration. Single-group studies may show substantial change, but they cannot isolate the effect of the intervention. Therefore, the most defensible conclusion is that ecotourism represents a promising learning context when combined with structured pedagogical models, rather than that tourism sites independently cause improvements in learning outcomes (Muliadi et al., 2026; Siregar et al., 2025; Yamin et al., 2025).

The synthesis presented in Table 1 indicates that the use of ecotourism as a natural laboratory is supported by evidence of varying strength. Exploratory studies make an important contribution by identifying the potential science phenomena available at a

Copyright © the Author(s)

particular site, but they cannot yet explain instructional effectiveness in causal terms. In contrast, quasi-experimental studies provide stronger information regarding changes in learning outcomes, although other factors such as instructional design, the quality of teacher facilitation, intervention duration, and learner characteristics must still be considered.

These findings indicate that the success of ecotourism as a natural laboratory is determined not merely by the richness of natural objects, but by the ability to transform those phenomena into structured learning experiences. From the perspective of Barbour et al. (1999), the educational value of an ecological environment lies in understanding relationships among the components of a community, rather than simply identifying individual organisms. Accordingly, learning activities in ecotourism areas should be directed toward analyzing organismal interactions, ecological functions, and the impacts of human activities on environmental systems. The relationships among ecotourism potential, pedagogical design, scientific learning processes, learning outcomes, and implementation conditions are summarized in Figure 2.

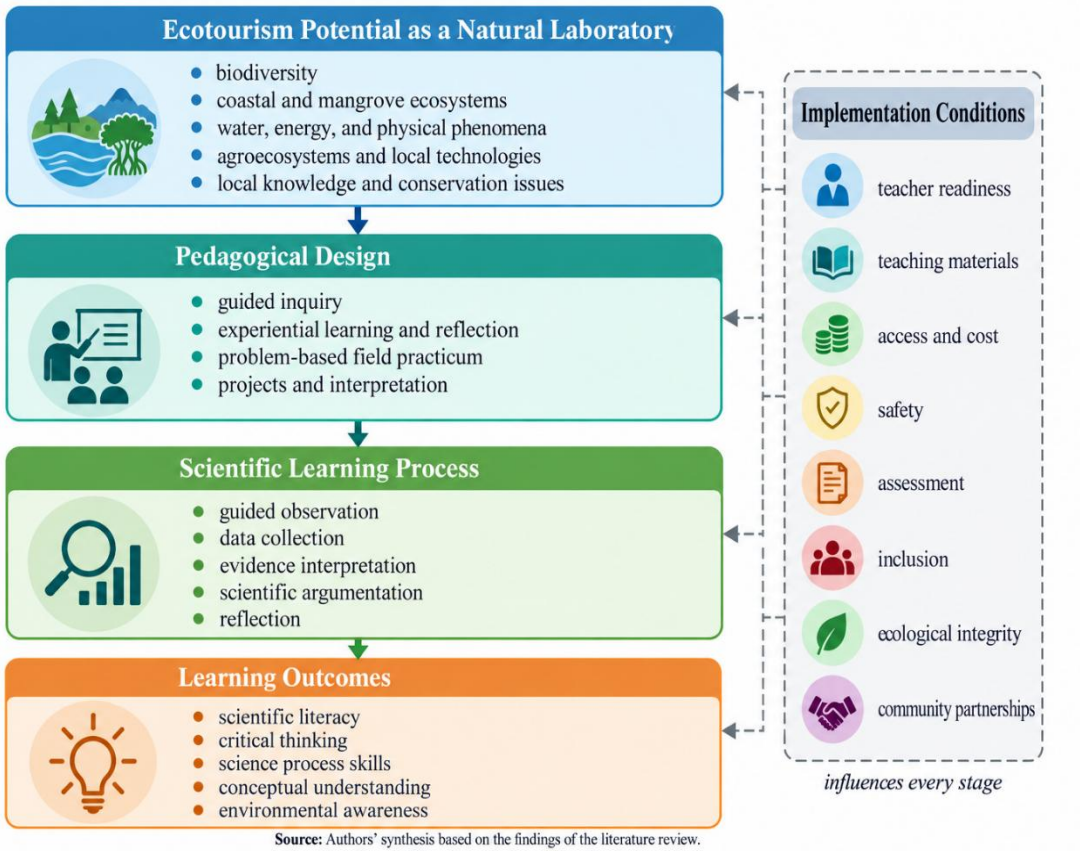


Figure 2. Synthesis Framework of Ecotourism as a Natural Laboratory for Science Learning. The visualization was created with the assistance of generative AI and verified by the authors.

Figure 2 illustrates that the use of ecotourism as a natural laboratory for science learning does not occur directly, but rather through the interconnections among the available phenomena, pedagogical design, scientific learning processes, and learning outcomes. These relationships are influenced by a range of implementation conditions, including teacher readiness, the availability of teaching materials, access and cost, safety, assessment, inclusion, ecological integrity, and partnerships with local communities. This framework emphasizes that

Copyright © the Author(s)

the success of ecotourism-based learning is determined not only by the richness of natural resources, but also by how such potential is transformed into a structured learning experience. To show the empirical basis supporting this synthesis, the methodological characteristics, main findings, and interpretive limitations of each study are presented in Table 1 (Muliadi et al., 2026; Nengsih et al., 2026; Siregar et al., 2025; Yamin et al., 2025).

Table 1. Comparison of Research Designs, Findings, Interpretive Limitations, and Recommended Ecotourism Locations

Study	Design or Method	Sample or Context	Main Findings	Interpretive Limitations	Recommended Location and Strengths
Sade Village contextual science learning	Descriptive-exploratory qualitative field observation (Yuliani et al., 2026)	Sade Village, Lombok; architecture, weaving, and ecological practices (Yuliani et al., 2026)	Identified 13 scientific phenomena across three domains (Yuliani et al., 2026)	Mapped educational potential but did not examine changes in learning outcomes (Yuliani et al., 2026)	Sade Village: architecture, weaving, and ecological practices for culturally based integrated science learning.
Pemepek ecotourism science materials	Descriptive qualitative study using observation and a science-concept rubric (Muliadi et al., 2026)	Lembah Datu, Pindah Alam, and KHDTK Rarung (Muliadi et al., 2026)	Developed a concept mapping of ecosystems, hydrology, energy, biodiversity, and biotechnology (Muliadi et al., 2026)	Did not provide a comparative test of learning outcomes (Muliadi et al., 2026)	Lembah Datu: riparian ecosystems and simple machines; Pindah Alam: hydrology and energy; KHDTK Rarung: biodiversity, symbiosis, and biotechnology.
Gili Sulat mangrove practicum	Exploratory study using questionnaires and interviews (Verawati & Idrus, 2023)	Ten fifth-semester Biology Education students (Verawati & Idrus, 2023)	Participants reported improved understanding of the role of mangroves and greater inspiration to protect the environment (Verawati & Idrus, 2023)	Small purposive sample and perception-based evidence (Verawati & Idrus, 2023)	Gili Sulat: mangrove ecosystems and coastal protection as objects for ecological and conservation observation.
Ecotourism -based field practicum	Quasi-experimental pretest–posttest control-group design; Mann–	Biology Education students; Gunung Tunak and Kerandangan compared	Scientific literacy N-Gain was 57% in the experimental group and 51% in the control group; p =	Details on sample size and follow-up were limited in the available passage	Gunung Tunak and Kerandangan: wildlife ecology and conservation for scientific literacy

Copyright © the Author(s)

Study	Design or Method	Sample or Context	Main Findings	Interpretive Limitations	Recommended Location and Strengths
	Whitney test (Yamin et al., 2025)	with conventional laboratory practicum (Yamin et al., 2025)	0.038 (Yamin et al., 2025)	(Yamin et al., 2025)	practicum.
Ecotourism-based field learning	Quasi-experimental pretest–posttest control-group design; N-Gain and Mann–Whitney analyses (Yamin et al., 2026)	Biology Education students; ecology and conservation of *M. reinwardt* (Yamin et al., 2026)	Improvement in critical thinking differed significantly between the experimental and control groups (Yamin et al., 2026)	Effect-size values and sample size were not detailed in the available passage (Yamin et al., 2026)	*M. reinwardt* conservation area: wildlife ecology for critical-thinking development; the specific destination was not detailed in the manuscript.
Outdoor guided inquiry bio-diversity	One-group pretest–posttest design; Wilcoxon test and N-Gain (Siregar et al., 2025)	Nineteen Grade 10 MIA students; garden and plantation environments (Siregar et al., 2025)	Science process skills increased from 43.79 to 90.11; N-Gain = 0.82; $p < 0.001$ (Siregar et al., 2025)	No comparison group was used (Siregar et al., 2025)	Garden and plantation environments used in the study: biodiversity for guided inquiry; the specific destination was not detailed in the manuscript.
Discovery-based outdoor learning in Papua	Design-based research involving validation, practicality testing, and effectiveness testing (Linda et al., 2025)	Phase E students at SMAN Khas Papua; biodiversity and local wisdom (Linda et al., 2025)	Mean overall understanding increased from 62.40 to 84.80; $p = 0.000$ (Linda et al., 2025)	Sustainability and large-scale replication require further testing (Linda et al., 2025)	Papuan local-wisdom-based environment: biodiversity and conservation practices; the specific destination was not detailed in the manuscript.
East Lombok implementation	Descriptive mixed-evidence study using questionnaires, observations, and interviews (Andayani et al., 2026)	Science Teachers' Association (MGMP IPA) teachers and implementation of edu-ecotourism teaching materials	Eighty-five percent reported that the materials helped achieve learning objectives; approximately 40% reported constraints	Primarily measured implementer responses rather than controlled student learning outcomes (Andayani et	Mangrove areas in East Lombok: integration of science, local wisdom, and socioscientific issues; the specific destination was not detailed.

Copyright © the Author(s)

Study	Design or Method	Sample or Context	Main Findings	Interpretive Limitations	Recommended Location and Strengths
		(Andayani et al., 2026)	related to time and site visits (Andayani et al., 2026)	al., 2026)	
Bagek Kembar biopreneurship science module	Research and development (R&D) using the ADDIE model; needs analysis and module validation using Aiken's V (Hidayat et al., 2024)	Bagek Kembar Ecotourism Area; needs analysis involving four teachers and 24 students, followed by expert validation	The project-based biopreneurship module was judged valid; Aiken's V was 0.95 for cover size/appearance, 0.95 for design, 0.93 for content, and 0.94 for language. The module integrated scientific literacy, environmental literacy, and entrepreneurial motivation.	Evidence primarily demonstrated product feasibility and validity; the study did not provide comparative evidence of improved student learning outcomes after implementation	Bagek Kembar, Sekotong: mangrove ecosystems, conservation, beekeeping, and biopreneurship; relevant as a natural laboratory for scientific and environmental literacy.
Jonggol Teaching and Research Farm edu-ecotourism planning	Field survey, resource inventory, management interviews, and descriptive and spatial analyses (Hikmah et al., 2025)	Jonggol Teaching and Research Farm, IPB University; agricultural systems, livestock, field laboratories, flora and fauna, and landscape	Identified 10 tourism attractions as well as resources comprising 31 flora species, 2 cultivated animal species, and 20 wildlife species; produced plans for spatial organization, circulation, green zones, activities, and edu-ecotourism interpretation services.	Focused on site inventory and planning rather than direct testing of student learning outcomes.	Jonggol Teaching and Research Farm: agriculture, livestock, biodiversity, soil, geology, and agricultural innovation; strong potential as a multidisciplinary field laboratory and for environmental character education.
Kerandangan butterfly edu-	Community-service/KKN program	Children and communities surrounding	Activities introduced butterfly	A community-service activity rather	Kerandangan Nature Tourism Park: butterfly

Copyright © the Author(s)

Study	Design or Method	Sample or Context	Main Findings	Interpretive Limitations	Recommended Location and Strengths
ecotourism	using a participatory approach involving socialization, education, demonstrations, observation, and evaluation of participant responses (Insani et al., 2025)	Kerandangan Nature Tourism Park, West Lombok; butterfly edu-ecotourism and conservation	diversity, ecological functions, and conservation, and were reported to increase participants' knowledge and environmental concern through direct experience in the environment.	than an experimental study; changes in knowledge were primarily assessed through monitoring, observation, and feedback without a comparison group or effect-size estimate.	diversity, pollination, organism interactions, and conservation; suitable for experiential learning and environmental education.
Depati VII Coffee & Resort bio-edutourism	Qualitative phenomeno-logical study using in-depth interviews, participatory observation, documentation, data condensation, horizontali-zation, and thematic analysis (Nengsih et al., 2026)	Four biology teachers, 24 Grade 10–11 students, two tour guides, and two managers; Depati VII Coffee & Resort, Kerinci	Produced a Three-Subsystem Bio-Edutourism Framework integrating ecological, ethno-pedagogical, and pedagogical subsystems. Coffee agroforestry functioned as a natural laboratory for biology concepts, local wisdom, and experiential learning.	Findings were phenomenologi cal and based on participants' experiences; the study did not experimentally test changes in learning outcomes. It also identified tourism-related distraction, limited field time, and the need for structured observation guides.	Depati VII Coffee & Resort, Kerinci: coffee agroforestry, mountain microclimate, biodiversity, Rumah Basilo, and local technologies; strong potential for ecology, adaptation, conservation, and ethnopedagogy.
Iboih marine ecotourism as a biology learning resource	Descriptive qualitative study using exploration and direct observation, followed by descriptive analysis and reconstruction of local	Iboih ecotourism area, Sabang Island; coastal and marine resources as objects of biological study	Local potential in Iboih can be reconstructed as a learning resource for ecosystems, biodiversity, and ecological interactions, thereby supporting	Focused on exploration and mapping of potential learning resources; it did not involve an instructional intervention or measurement	Iboih, Sabang: coral reefs, reef fish, starfish, sea cucumbers, sea urchins, coastal vegetation, and marine activities; highly relevant for marine ecology, biodiversity,

Copyright © the Author(s)

Study	Design or Method	Sample or Context	Main Findings	Interpretive Limitations	Recommended Location and Strengths
	potential as a contextual learning resource (Noviyanti et al., 2025)		contextual biology learning.	of changes in student learning outcomes.	ecological interactions, and pollution.
Ngawonggo Partitraan Site ecotourism and biology education	Descriptive analysis using literature review, interviews, field observation, and SWOT analysis (Rachmawati et al., 2025)	Ngawonggo Partitraan Site; managers and visitors, with a focus on biodiversity, history, culture, and the potential of biology learning resources	Demonstrated substantial potential in the form of higher plants, medicinal plants, bamboo, springs, and cultural values that can support contextual biology learning and the integration of local wisdom.	A preliminary study assessing site potential; it did not test instructional implementation or its effects on student learning outcomes.	Ngawonggo Partitraan: plant biodiversity, medicinal plants, bamboo, springs, ethnobotany, and cultural heritage; potentially valuable for biodiversity, ecosystems, conservation, and science–culture relationships.

Table 1 demonstrates that the type of research question determines the strength of the conclusions that can be drawn. Mapping studies conducted in Sade and Pemepek successfully identified scientific phenomena and their relationships with science concepts, but their descriptive designs did not examine the effects of the learning process (Yuliani et al., 2026; Muliadi et al., 2026). The Gili Sulat study provided additional information on students' experiences in understanding mangrove ecosystems; however, the small sample size and reliance on perception-based data limit the generalizability of the findings (Verawati & Idrus, 2023). Therefore, studies mapping educational potential should be followed by instructional testing using clearly defined learning-outcome measures.

Studies employing comparison groups provide a stronger basis for evaluating learning outcomes. The ecotourism-based field practicum reported a scientific literacy N-Gain of 57% in the experimental group and 51% in the control group, with $p = 0.038$ (Yamin et al., 2025). The source article reported 60 students divided equally into an experimental group of 30 students and a control group of 30 students. The mean pretest scores were 38.6 and 39.0, respectively, whereas the mean posttest scores increased to 71.3 and 63.0. The Mann–Whitney test indicated no significant difference in initial ability ($p = 0.673$), whereas the posttest scores differed significantly ($p = 0.038$). However, the results table in the source article presented complete data for only 28 participants in the experimental group and 27 participants in the control group; this inconsistency in participant numbers limits the precision with which the findings can be interpreted. The article also did not report a standardized effect size. The observed difference indicates variation between the groups within the specific context and participants studied, but it does not demonstrate that the ecotourism component alone caused the improvement; inquiry activities, lecturer guidance, and group work may also have

Copyright © the Author(s)

Vol.4, No.2 (October – 2026)
E-ISSN: 2987-4343
pp. 138-162

contributed. Moreover, N-Gain values of 57% and 51% represent normalized change rather than standardized effect sizes; therefore, the six-percentage-point difference does not by itself indicate the magnitude of educational significance.

Supporting findings were also reported by Siregar et al. (2025) using a one-group pretest–posttest design without a comparison group. The study reported an increase in the mean science process skills score from 43.79 to 90.11, with an N-Gain of 0.82 and a Wilcoxon test result of $Z = -3.826$, $p < 0.001$. Although the increase was statistically significant, the absence of a control group limits causal attribution of the observed change to the intervention. The source article also showed an inconsistency in sample size, reporting 19 participants in the methods section and Wilcoxon analysis but 20 participants in the descriptive statistics table; therefore, the results should be interpreted cautiously. The N-Gain of 0.82 indicates a high level of normalized change according to the category used by the authors, but it is not a standardized effect-size measure. Future studies should provide clearer information on baseline group equivalence, instructional procedures, effect sizes, and the durability of learning outcomes after the intervention has ended (Yamin et al., 2025; Siregar et al., 2025).

Overall, natural laboratories are more appropriately designed as a sequence of activities that connect observation, data recording, evidence interpretation, and reflection. Findings on edu-ecotourism-based teaching materials and field-learning models indicate the need for observation guides and assessment procedures that are aligned with science concepts (Andayani et al., 2026; Yamin et al., 2025). This synthesis therefore directs future recommendations toward testing the mechanisms of learning and the constraints of implementation, so that conclusions regarding the potential of particular destinations do not extend beyond the evidence available.

Conclusion

The results of the analysis and synthesis indicate that the potential of ecotourism as a natural laboratory for science learning is determined by the alignment between the available phenomena and the intended learning objectives. The strength of the recommendation for each destination varies according to the type of evidence available. Exploratory studies, potential-mapping studies, and the development of learning resources demonstrate pedagogical potential, whereas claims of effectiveness should be restricted to studies that directly test learning outcomes through instructional interventions.

Based on exploratory and mapping evidence, Sade Village has the potential to support contextual science learning through architecture, weaving, and ecological practices; Pemepek through riparian ecosystems, hydrology, energy, biodiversity, and biotechnology; Iboih through marine ecosystems and biodiversity; Ngawonggo Partitraan through plant biodiversity, medicinal plants, bamboo, and ethnobotany; Depati VII Coffee & Resort through coffee agroforestry and local wisdom; and Jonggol Teaching and Research Farm through agricultural systems, livestock, biodiversity, and environmental contexts. Implementation evidence indicates that Gili Sulat, Kerandangan Nature Tourism Park, and edu-ecotourism teaching materials in East Lombok can support contextual learning experiences, although not all of these studies provide controlled evidence of learning outcomes. Relatively stronger evidence comes from studies that directly assessed learning outcomes, such as the ecotourism-based field practicum at Gunung Tunak and Kerandangan and environment-based guided inquiry

Copyright © the Author(s)

conducted in outdoor settings. Nevertheless, claims of effectiveness remain limited to the specific contexts, participants, and interventions that were actually tested.

The strengths of each location need to be translated into inquiry questions, observation guides, systematic data recording, reflection activities, and assessment procedures, accompanied by teacher readiness, safety measures, inclusive access, ecosystem protection, and partnerships with local communities. Ecotourism is therefore more appropriately positioned as a pedagogically designed complement to school laboratories. Further research is still needed on retention, transfer to conservation behavior, cost, and the sustainability of learning outcomes before broader recommendations can be made.

Recommendations

First, research needs to move beyond the inventory of potential toward more rigorous evaluation of learning. Many studies have successfully identified phenomena and mapped scientific concepts, but have not yet determined whether students understand those concepts better than through conventional school-based learning. Future research should employ comparable groups and report sample sizes, effect sizes, uncertainty intervals, and relevant teacher and student characteristics.

Second, learning outcomes need to be measured across time and contexts. Current evidence consists mainly of immediate post-intervention scores, perceptions, or intentions to revisit the site. It remains unclear whether students retain concepts, transfer skills to new problems, or demonstrate changes in conservation behavior several months later. Follow-up assessments, transfer tasks, portfolios, and behavioral observations could help address these gaps.

Third, pedagogical mechanisms need to be disentangled. Studies comparing field-based and laboratory learning do not always clarify whether the observed advantages arise from the authenticity of the learning objects, inquiry processes, group work, teacher quality, the novelty of the experience, or longer learning time. Factorial designs or process studies that record teacher–student interactions, types of questions, and the use of data could provide stronger evidence concerning these mechanisms.

Fourth, research needs to incorporate cost, access, safety, and inclusion as design outcomes. Time and visitation constraints were reported by approximately 40% of teachers in one implementation study, but transportation costs, access for students with disabilities, community burden, and ecological carrying capacity have rarely been quantified. Without such analysis, a model that appears effective may still prove impractical for large-scale implementation.

Fifth, the quality of partnerships with local communities needs to be evaluated. Studies incorporating local wisdom emphasize place identity and conservation, but they do not yet sufficiently explain who determines the narratives, how local knowledge is acknowledged, or how educational and economic benefits are shared. Participatory research involving teachers, students, site managers, and local communities could strengthen social validity while helping to prevent the commercialization or inappropriate appropriation of local knowledge.

Acknowledgements

This article was prepared as part of academic activities in the course *Ecotourism-Based Science Learning*. The authors gratefully acknowledge the guidance and feedback provided

Copyright © the Author(s)

throughout the learning process and the preparation of this article, as well as the contributions of all group members to the literature review and refinement of the manuscript.

References

Andayani, Y., Syukur, A., Ramdani, A., Yustiqvar, M., Muntari, Martin, N., & Pratiwi, N. A. (2026). Analysis of the implementation of science teaching materials based on ecotourism education at SMPN East Lombok Regency. *Journal of Educational Studies, 4*(1), 484–490. https://doi.org/10.58218/jes.v4i1.3566

Annam, S. (2026). Ecotourism as a source of science learning in Indonesia: A systematic literature review. *Journal of Biology, Environment, and Edu-Tourism, 2*(2), 235–242. https://doi.org/10.65622/jbee.v1i3.271

Barbour, M. G., Burk, J. H., Pitts, W. D., Gilliam, F. S., & Schwartz, M. W. (1999). *Terrestrial plant ecology* (3rd ed.). Menlo Park, CA: Benjamin/Cummings.

Green, B. N., Johnson, C. D., & Adams, A. (2006). Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *Journal Of Chiropractic Medicine*, *5*(3), 101–117. https://pubmed.ncbi.nlm.nih.gov/19674681/

Hidayat, X. Z. A., Artayasa, I. P., & Jufri, A. W. (2024). Feasibility of biopreneurship project-based science module for students in the Bagek Kembar Ecotourism Area. *Jurnal Penelitian Pendidikan IPA, 10*(10), 7756–7764. https://doi.org/10.29303/jppipa.v10i10.9278

Hikmah, Z., Muntasib, E., & Kosmaryandi, N. (2025). Edu-ecotourism planning based on tourist attractions at Jonggol Teaching and Research Farm, Institut Pertanian Bogor (IPB) University. *Jurnal Ilmu Kehutanan*. https://doi.org/10.22146/jik.v19i2.18797

Insani, R. F., Habibah, H., Yasa, I. P., Azfani, L. A., Hilmi, M., Nanisfi, M., Azizah, N., Alawiyah, R., Diniah, S., & Imami, V. S. (2025). Application of the concept of butterfly edu-ecotourism as a manifestation of real work lecture activities at the Kerandangan Nature Tourism Park. *Jurnal Pengabdian Masyarakat Tropis Indonesia, 1*(1), 17–21. https://journals.widhatulfaeha.id/index.php/jpmti/article/view/126

Kurnia, R. P., & Suryadharma, I. G. P. (2016). Perangkat pembelajaran biologi kegiatan ecotourism untuk mengasah keterampilan proses sains dan sikap peduli lingkungan. *Jurnal Inovasi Pendidikan IPA, 2*(2), 230–240. https://doi.org/10.21831/jipi.v2i2.12252

Linda, E., Rakhmawati, A., & Paidi. (2025). Development of discovery-based outdoor learning integrated with Papua Local Wisdom to improve cooperation and understanding of the biodiversity concept of students of phase e of SMAN Khas Papua. *Jurnal Penelitian Pendidikan IPA, 11*(8), 328–336. https://doi.org/10.29303/jppipa.v11i8.12140

Mann, J., Gray, T., Truong, S., Brymer, E., Passy, R., Ho, S., Sahlberg, P., Ward, K., Bentsen, P., Curry, C., & Cowper, R. (2022). Getting out of the classroom and into nature: A systematic review of nature-specific outdoor learning on school children's learning and development. *Frontiers in Public Health, 10*, 877058. https://doi.org/10.3389/fpubh.2022.877058

Muliadi, I., Irama, A., & Zana, M. Z. N. (2026). Analysis of ecotourism-based science learning materials: A case study of tourism in Pemepek Village. *Journal of Biology, Environment, and Edu-Tourism, 2*(1), 211–219. https://doi.org/10.65622/jbee.v2i1.258

Copyright © the Author(s)

Nengsih, R., Qadariah, N., & Hastutin, S. Y. (2026). Exploring the potential of Depati VII Coffee and Resort as a bio-edutourism site in high school biology education: A phenomenological study. Jurnal Pijar MIPA, 21(4), 796–802. https://doi.org/10.29303/jpm.v21i4.12009

Noviyanti, A., Ismulyati, S., Febriyanti, D., & Aswita, D. (2025). Exploring the local potential of marine ecotourism in Sabang Island as a contextual-based resource for biology learning. *BIOTIK: Jurnal Ilmiah Biologi Teknologi Dan Kependidikan, 13*(2), 180–192. https://doi.org/10.22373/biotik.v13i2.31339

Rachmawati, R. N., Mulyani, D. T., Rizkiyah, F., & Maulanid, H. E. (2025). Exploring the local potential of the Ngawonggo Partitraan Site: Integrating ecotourism into biology education. *Jurnal Kajian Pendidikan IPA, 5*(2), 155–171. https://doi.org/10.52434/jkpi.v5i2.42526

Siregar, S. D., Saefudin, S., & Riandi, R. (2025). Improving student's science process skills through environment-based guided inquiry on biodiversity in outdoor learning. *JPBI (Jurnal Pendidikan Biologi Indonesia), 11*(3), 841–847. https://doi.org/10.22219/jpbi.v11i3.41236

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Suryaningsih, Y. (2018). Ekowisata sebagai sumber belajar biologi dan strategi untuk meningkatkan kepedulian siswa terhadap lingkungan. *Bio Educatio, 3*(2), 59–72. https://doi.org/10.31949/be.v3i2.1142

Verawati, N. N. S. P., & Idrus, A. A. (2023). Mangrove ecotourism as an education and learning facility. *Bioscientist: Jurnal Ilmiah Biologi, 11*(2), 1409. https://doi.org/10.33394/bioscientist.v11i2.10028

Yamin, M., Jufri, A. W., Gunawan, G., & Andriyan, A. (2026). The effectiveness of field learning based on Megapodius reinwardt ecotourism in improving the critical thinking skills of biology education students. *Jurnal Pijar MIPA, 21*(2), 370–375. https://doi.org/10.29303/jpm.v21i2.11760

Yamin, M., Jufri, A. W., Hakim, A., Gunawan, G., & Riyanto, A. A. (2025). Effectiveness of ecotourism-based field practicum model in improving scientific literacy of prospective biology teacher students. *Jurnal Pijar Mipa, 20*(3), 564–569. https://doi.org/10.29303/jpm.v20i3.8899

Yuliani, N., Faridatunnisa, & Hidayatullah, L. F. J. (2026). Ecotourism-based contextual science learning: The potential of Sade Village as an outdoor science laboratory. *Journal of Biology, Environment, and Edu-Tourism, 2*(1), 203–210. https://doi.org/10.65622/jbee.v2i1.249

Copyright © the Author(s)