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Education for Sustainable Development: The *Bekarang* Tradition as an Educational Tool for Teaching Biology

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ABSTRACT

The *Bekarang* tradition, a communal fishing practice in South Sumatra, reflects sustainable river management but faces threats from modernization. Preserving it through education requires aligning its cultural meaning with learning contexts. This qualitative study examines the significance of Bekarang and its potential integration into Biology education through interviews with cultural and pedagogical experts, as well as a literature review. Thematic analysis identified key themes for contextualizing Biology learning, followed by interpreting indigenous science through socio-scientific issues. Findings reveal that the *Bekarang* embodies a blue economy philosophy, addressing SDGs by fostering cooperation, responsibility, and environmental stewardship. It aligns with Biology topics like ecosystem, conservation, and biodiversity, and suits pedagogical models. This study highlights the *Bekarang's* value as an educational tool for culturally rooted and sustainable science learning.

Keywords
Biology
Indigenous
Pedagogy
Science Learning
SDGs

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Introduction

The landscape of South Sumatra, Indonesia, is shaped by its nine major rivers *(Batanghari Sembilan),* such as Kelingi, Beliti, Lakitan, Rawas, Rupit, Batang Leko, Ogan,

Komering, and Lematang. For centuries, these waterways have served as the lifeblood of the region, functioning as critical trade routes that connected South Sumatra to local and international markets, particularly during the peak of the spice trade. These rivers have sustained generations of local communities through fishing, agriculture, and commerce, while simultaneously embodying profound cultural significance. Contemporary research underscores their enduring economic importance, despite escalating threats from anthropogenic activities such as resource overexploitation and pollution. The interplay between their historical legacy, present-day socioeconomic value, and environmental vulnerabilities positions the Batanghari Sembilan rivers as a pivotal focus for interdisciplinary research on sustainable development, cultural preservation, and aquatic ecosystem conservation.

South Sumatra has historically implemented traditions of good river management, including the *Bekarang* or *Bekarang Iwak* tradition [1]. It represents a significant cultural heritage practice involving communal fishing activities, traditionally conducted post-harvest or during specific periods determined by coastal communities along South Sumatra's river systems [1]. However, this tradition currently confronts multiple sustainability challenges in the contemporary era, including ecological degradation, lifestyle modernization shifts, COVID-19 pandemic impacts, and evolving aquatic resource management policies. Current preservation initiatives include the cultural festival, digital conservation through the Giwang SumSel website platform, and various social media campaigns organized by South Sumatra's Tourism Office. Another means to preserve the *Bekarang* tradition is through education.

Studies have recommended the integration of local wisdom themes into learning as an effective means to pass on cultural values, maintain identity, and encourage appreciation for cultural heritage [2]-[4]. Unfortunately, research on the internalization of these traditional values into educational practices remains scarce. Existing studies on this South Sumatran swamp fishing tradition have predominantly focused on historical and technical implementation aspects [1], [5], [6], without exploring its potential as a contextual learning resource. In reality, this tradition contains numerous elements that could serve as a foundation for locally-based learning media, particularly in Biology education. However, no study has comprehensively examined which biological aspects, such as swamp ecology, fish adaptation, or biodiversity, are embedded in the *Bekarang* practices. Furthermore, effective pedagogical approaches for integrating this tradition, whether through culture-based projects, simple experiments, or ethnobiological analysis, remain underexplored. The most significant challenge in the integration process is to identify the meaning of core values embedded in the tradition to provide relevance to the context and content of the pedagogy [7]-[14]. Therefore, this study aims to address this gap by analyzing the relevance of the *Bekarang* tradition to the

Biology subject matter while designing an instructional model that synergizes local wisdom with modern science.

This study explores the meaning of this tradition as a prospective local wisdom element to be incorporated in Biology lessons for senior high school. This aligns with the spirit of deep learning policy, which requires students to meaningfully engage in learning so they can adaptively create solutions to local issues in their communities. It is also consistent with the curriculum's objective of enhancing graduates' adaptive problem-solving competencies. By integrating tradition into Biology instruction, students explore alternative solutions for addressing environmental pollution in their surroundings through the practice of the tradition. Integrating the tradition into Biology learning is expected to enrich students' understanding of the significance of the tradition to their ecological sustainability and encourage them to partake in measures of overcoming environmental issues and preserving rivers in South Sumatra.

Literature Review

A. The Role of Local Wisdom in the Learning Construction

The integration of local wisdom into Indonesia's national curriculum has been implemented across various educational levels and subjects, reflecting a growing emphasis on cultural preservation and contextualized learning. Indonesia's educational system has systematically incorporated indigenous knowledge systems across diverse academic disciplines and grade levels, evidencing their multifaceted role in developing learners' adaptive capacities, ecological consciousness, and value systems [15]. Contemporary disaster education paradigms strategically reinterpret traditional knowledge frameworks to address modern challenges, providing students with empirically-grounded survival competencies. The STEM disciplines similarly employ ethnocultural frameworks to enhance pedagogical relevance, simultaneously advancing both sustainability competencies and academic achievement while nurturing moral development [16]. Primary education initiatives exemplify this through the institutionalization of Rejang communal principles within formal and non-formal learning matrices [17]. Parallel implementations in secondary education demonstrate the efficacy of localized value systems in addressing contemporary social challenges through disciplinary integration [18]. Modern instructional methodologies like PBLM-e exemplify the convergence of ancestral knowledge systems with progressive pedagogy through authentic, culture-bound problem-solving scenarios [19]. Ecological education further demonstrates this synthesis by employing indigenous environmental epistemologies to foster place-based stewardship [18]. These collective reforms manifest the paradigm-shifting capacity of traditional knowledge systems in fostering pedagogies that are simultaneously culturally-grounded and academically rigorous.

Incorporating the elements of local wisdom (e.g., local values, fairy tales, advice, myths, and practices) in the senior high school curriculum provides contexts that resonate with the teachers' and students' experiences of the surrounding environment, culture, and traditions in their community [20]. It makes learning activities more relevant, meaningful, and understandable for students and encourages them to appreciate and preserve valuable cultural heritage and local identity [21], [22]. The integration also lends teachers insights into long-existing traditional knowledge to improve their teaching approach and create a more enjoyable and effective environment. Local wisdom also plays a role in promoting awareness of cultural diversity and perspectives that lead to more tolerant, inclusive, and empathetic citizens [23]. In addition, local wisdom can be a source of additional knowledge for educators. Lastly, the integration of local wisdom in learning opens up space for innovation and development, allowing students and teachers to identify potential in the surrounding environment and seek creative solutions to the challenges faced by their communities [24]. Reconstructing learning by appreciating and utilizing local wisdom results in more inclusive, meaningful, and relevant education for students, teachers, and society as a whole [25]. The relevance of local wisdom is very important in improving the quality of science learning [26]. Local wisdom includes traditional knowledge, practices, and understanding of the nature, environment, and natural phenomena that have been passed down from generation to generation [21]. By linking science materials to everyday life and the surrounding environment, students will find it easier to understand scientific concepts in a real and applicable way [27], such as agriculture, navigation systems, nature conservation, and others. This will strengthen students' interest in science and motivate them to participate more actively in the learning process [21], [22], [28]-[30]. When teachers use examples or stories from local wisdom, students can easily identify science concepts in a more familiar and meaningful context. This helps reduce the gap between traditional knowledge and modern scientific concepts. The relevance of local wisdom also plays a role in increasing student engagement in the science learning process. Students will feel more motivated and challenged when they see how science learning contributes to the understanding and preservation of their own cultural knowledge [20], [27]. Traditional knowledge about plants, medicinal herbs, or ways of adapting to the natural environment can be a source of inspiration for future scientific research and development [20]. Thus, the relevance of local wisdom in science learning not only improves the quality of education but also fosters students' sense of pride and identity in their culture and traditions.

B. Preserving the Tradition of River Conservation with Education for Sustainable Development

The tradition of preserving rivers is common among communities that are greatly dependent on the natural resources around the river. River conservation traditions often

involve active community participation in river conservation and management efforts, incorporating local wisdom and traditional knowledge about natural resource management. The following presents examples of river conservation integration into education systems in other regions/countries.

In England, river science is included in physical geography curricula, emphasizing the socio-political dimensions of river management and the importance of understanding environmental processes to improve resilience [31]. Universities play a crucial role in empowering communities and professionals with knowledge and skills for sustainable river management [31]. In Melbourne, community members are educated on behaviors that protect waterways, such as reporting pollution and participating in environmental volunteering [32]. In Budapest, the DANCERS Project focuses on integrating education for sustainable water management with broader educational and economic development, highlighting the need for dedicated training programs and improved access to technical training [33]. In Mukim Bota, Malaysia, educational programs have increased community awareness about river terrapins, leading to better conservation outcomes [34]. In Zimbabwe, the Gwayi Valley Conservation Area, frequent awareness campaigns have led to the establishment of active conservation groups and reduced harmful behaviors such as poaching and streambank cultivation [35]. The last, in Austria, the "Traisen.w3" project involves high school students in river landscape management research, significantly increasing their understanding of river ecosystems and promoting sustainable planning [36].

The tradition of preserving rivers is closely related to the concept of education for sustainable development or ESD [3], [37]. In ESD, environmental awareness is the main focus to teach the current and future generations and the community about their interactions with the environment and their impact on the ecosystem [37], [38]. It encourages active community participation to achieve sustainable goals, including participatory approaches in planning and decision-making [38]. Also, ESD recognizes and values traditional knowledge for understanding and maintaining the environment and harnessing natural resources responsibly and sustainably, with a minimum amount of ecological damage, so they can be passed on to future generations [4].. In short, the combination of river conservation traditions and ESD features the heritage and modern values and practices to create a society that is more aware, responsible, and committed to protecting the river ecology and natural resources for current and future well-being to achieve sustainable development [38]. Several studies indicate that ESD has been effective in enhancing knowledge, attitudes, and behaviors among students, communities, and local populations [32], [34]-[36]. Educational integration of river conservation has shown positive implications for increasing awareness and changing

behaviors. Programs that involve community participation and provide interdisciplinary training are particularly effective in promoting sustainable river management and conservation efforts. The evidence suggests that educated communities and students are more likely to engage in conservation activities and adopt behaviors that support environmental sustainability.

Material and Methods

This research is qualitative research with a focus group discussion approach [39]. Data were collected through interviews with experts in culture and history and through a literature review. The interviews were aimed at revealing information about the philosophy, history, and integral values in the *Bekarang* tradition, and observed themes emerging from the data. The research instrument for the interviews had been validated and revised. The literature review collected robust data from journal articles and mass media to support the themes emerging from the interview results.

Table 1. Indicators for Interviews with Historians/Culture Experts

Indicators	Description
Philosophy	Identify the philosophy of the *Bekarang* tradition that can inspire attitude, knowledge, and skills
History	Identify the historical aspects of *Bekarang* traditions that have been passed down through generations.
Values	Identify the integral values of the *Bekarang* tradition.

Table 2. Indicators for Interviews with Experts in Biology Learning

Indicators	Description
Verification	Identify the compatibility between the values of the *Bekarang* tradition and the essence of Biology learning
Materials	Identify materials relevant to the *Bekarang* tradition
Design	Identify the feasible syllabus design

The data collection in this qualitative research was conducted in four stages according to a previous study [40]. Step 1 was the identification of locations/individuals/groups of people, Step 2 was the assurance of permits and access for the data collection process, Step 3 was the undertaking of data collection, and Step 4 was the data analysis, interpretation, and discussion. The collected data were then subjected to qualitative analysis in six stages [40]: 1) data processing and preparation; 2) data reading, 3) data coding and recording using NVivo 12; 4) coding application to describe the setting, participants, categories, and themes for analysis, 5) presenting the theme descriptions into narratives, and 6) data interpretations for integration with Biology learning. In stage 6, data were interpreted through 2 stages [7], namely thematic analysis on potential examples of topics to use as the context for science learning, and interpretation of the context and content of indigenous science (ISc) for science

education based on Socio-Scientific Issues (SSI). Data triangulation was carried out by comparing data obtained in previous studies with other previous literature documentation related to the *Bekarang* tradition [40]. Further data analysis is described as follows:

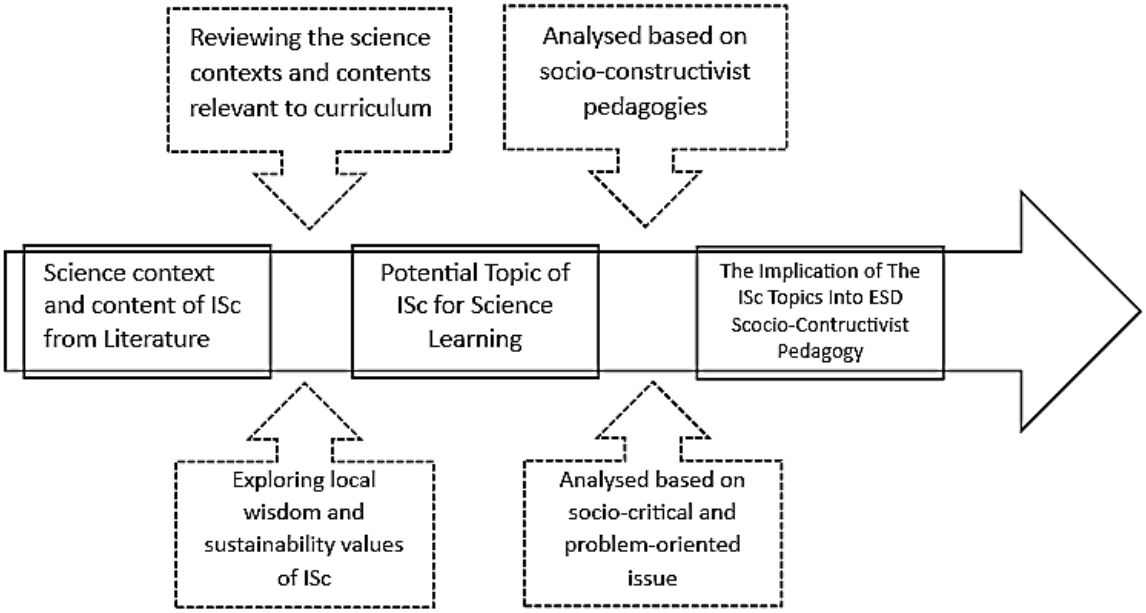


Fig. 1. Analysis of Reconstruction Data of Bekarang Tradition in Biology Learning [7]

Results and Discussions

A. Philosophy of the *Bekarang* Tradition

The *Bekarang* tradition is interpreted as a tradition of catching fish (or iwak in local dialect) in the river, then collecting the catch for further selection. The small fish are released, while the larger ones will be sold, and the money is spent on building public amenities, such as roads, bridges, and mosques. The philosophy of the *Bekarang* tradition illustrates a balanced interaction pattern between the community and the river ecosystem. It is not an exaggeration to say that the *Bekarang* tradition symbolizes the blue economy at the regional level, because it preserves the environment while striving for economic development for the neighboring community. The *Bekarang* philosophy also served as the basis for customary law or unwritten law, which laid the groundwork for government legislation during the Palembang Sultanate. One example is *Simbur Cahaya* Law Chapter III Article 34, which discusses farming regulations as an appeal to maintain the rivers. When associated with the field of education, *Bekarang* philosophy can be applied using the concept of eco pedagogy, where students develop their concern for the environment, especially the river ecosystems in South Sumatra. The philosophy of the *Bekarang* tradition is one of the pillars that form and strengthen the cultural identity of the local South Sumatran people.

The aspects of the relationship between the *Bekarang* tradition philosophy and the cultural identity of the South Sumatran people were as follows. First, the preservation of the *Bekarang* tradition is an integral part of the cultural heritage of the South Sumatran people. The practices, beliefs, and values in the *Bekarang* tradition have been passed on through generations, playing an important role in maintaining and preserving local cultural identity. Second, the preservation of the *Bekarang* tradition philosophy represents the traditional values of the South Sumatran people, including balance, harmony, solidarity, and local wisdom, which reflect the way of life and worldview of the people. This philosophy helps strengthen and preserve the important values in their culture. Third, the *Bekarang* tradition is connected to ancestors and nature through its philosophy that bridges the relationship between humans and nature. This philosophy is important to maintain the spiritual relationship and traditional cosmology of the people. Fourth, the *Bekarang* tradition is one of the characteristics and identities of the South Sumatran people. The practices and symbols in this tradition reflect the uniqueness of their culture. Through participation in the *Bekarang* tradition, the South Sumatran people feel connected to their roots and celebrate their identity as the people of South Sumatra. Fifth, the arts and cultural expressions of the *Bekarang* tradition are present in several regions, such as the *Bekarang* dance in *Prabumuli* as a means of cultural and identity expression through unique arts and beautiful heritage. Overall, the philosophy of the *Bekarang* tradition has substantially shaped and strengthened the cultural identity of the people of South Sumatra. This close relationship influences their perspectives, values, and cultural expressions, and helps preserve the local cultural heritage through generations.

B. The History of the *Bekarang* Tradition

South Sumatra is surrounded by nine large rivers called *Sungai Batang Hari Sembilan,* which consists of Kelingi River, Beliti River, Lakitan River, Rawas River, Rupit River, Batang Leko River, Ogan River, Komering River, and Lematang River. According to historical records, the people of South Sumatra first practiced *Bekarang* in prehistoric times because they were highly dependent on nature for food supplies, and used wooden tools to catch fish in the river [1]. This fishing activity has been known as *Bekarang* [1]. *Bekarang* is traditionally practiced during Eid al-Fitr, Eid al-Adha, weddings, cultural festivals, and major harvest celebrations [1], [5], [41], [42]. Besides in the rivers, *Bekarang* is also practiced in *lebung-lebung*, a deep puddle formed during the rainy season that is mixed with river water and is home to many fish. *Bekarang* is carried out in groups of 15 or more people in a designated river or pond [1], [43]. They will enter the river and beat the water surface repeatedly until the water becomes murky because the mud at the river bed rises. This movement makes fish drunk and weak, so they are easy to catch [1] either with bare hands or tools made of woven wooden branches, held by several people, and pulled to river riverbank [1]. Another way of fishing involves fewer people

(2-3) and uses *tuba*, a root bark that can intoxicate fish [41]. The bark is crushed, mixed with water, and then poured into the dammed downstream of rivers or ponds at a distance of 20-30 meters. Shortly after the tuba is inserted, the fish will become drunk and float on the surface of the water, making it easy to catch. The present *Bekarang* activities still mirror those in the prehistoric time [1].

C. Integrating Values of the *Bekarang* Tradition

The *Bekarang* is a traditional communal fishing practice originating from South Sumatra, Indonesia, characterized by collective fish harvesting using artisanal tools and plant-based piscicides. This cultural practice employs indigenous techniques, including woven traps *(serkap),* nets, and natural toxins derived from botanical sources (particularly tuba roots containing rotenone compounds), which temporarily stun fish while maintaining ecosystem balance [41]. Anthropologically, *Bekarang* serves as a socio-ecological ritual performed during five culturally significant occasions: (1) Islamic festivals (Eid al-Fitr and Eid al-Adha), (2) wedding ceremonies, (3) community cultural festivals, (4) harvest celebrations, and (5) seasonal riverine abundance periods [1], [41]. The practice embodies principles of traditional ecological knowledge (TEK), where the use of biodegradable materials and dose-controlled plant toxins demonstrates sustainable resource management prior to modern conservation concepts. Its group-based operation reinforces social cohesion, with role differentiation between net handlers, toxin preparers, and fish gatherers.

There are three integral values ingrained in the *Bekarang* tradition. The first is perseverance and hard work. The participants have to stay in the river from morning to evening, enduring the changing weather, which adds to the already challenging tasks of catching fish [1]. Second, Trust and responsibility. The participants are divided into teams to share responsibility and trust while avoiding interference, and the role of each respective team member [1], [5], [6]. Lastly, the imperative of caring for the environment finds critical expression in the preservation of fish populations and associated biotic riverine ecosystems [6]. This ecological stewardship transcends mere conservation by integrating three fundamental sustainability principles [44]-[46]: (1) biodiversity maintenance through the protection of endemic ichthyofauna (e.g., *Puntius javanicus* in South Sumatran rivers), (2) habitat integrity conservation via riparian buffer zone management, and (3) trophic cascade stabilization by safeguarding keystone species. The degradation of these aquatic systems precipitates multidimensional crises from collapsed artisanal fisheries (affecting SDG 14) to disrupted nutrient cycles (impacting SDG 15.1).

The benefits of this tradition are part of the goals of sustainable development (SDGs) in building a better world. The *Bekarang* cultural tradition is a manifestation of act locally, think

globally. The *Bekarang* cultural tradition exemplifies the *"act locally, think globally"* principle through its synergistic integration of indigenous ecological knowledge with contemporary sustainability goals. As a communal fishing practice rooted in South Sumatra's riverine ecosystems, *Bekarang* operationalizes local wisdom, such as the use of biodegradable plant-based piscicides (tuba roots) and seasonal fishing taboos that align with global frameworks for sustainable resource management (SDG 14: Life Below Water). This tradition demonstrates how hyperlocal practices can inform universal challenges. Local cultural values are the roots of facing global challenges.

D. Integrating Relevant Topics into Implementable Biology Learning Frameworks

The *Bekarang* tradition carries meaning that has been instilled through generations, namely preserving the river ecosystem through teamwork, patience, mutual trust, and shared responsibility. These values are in conjunction with Biology learning, but mainly the ecosystem conservation and harnessing natural resources wisely for the present and future generations. *Bekarang* tradition emphasizes responsible fishing activities with minimum threats to the ecosystem rather than catching the most fish possible. In the current Indonesian curriculum in senior high schools, the learning outcomes in Biology that are relevant to the values of the *Bekarang* tradition are that students can create solutions to problems based on local, national, or global issues related to understanding the diversity of living things and their roles. Also, students have the ability of ecosystem components and interactions between components and environmental changes. There is an evident relevance between the values of the *Bekarang* tradition and the nature of Biology learning.

The *Bekarang* Traditions have knowledge that is relevant to the context and content of Biology learning. The results of data analysis show that there are three themes that are relevant to Biology learning. These themes are then identified in which content is relevant to be contextualized for Biology learning in secondary and higher education. As shown in Table 3.

Table 3. Reconstruction of Bekarang Traditions in Biology Learning

Themes	ISc of The *Bekarang* Traditions	Science Background	Related Science Content	Suggested Educational Level
Conservation and changes of the ecosystem	This communal fishing tradition is carried out in two ways. The first is using traditional tools from tree twigs fashioned into cast nets, spears, and *ubai*. The other method is using tuba, a tree bark that induces intoxication in fish.	Environmental conservation is an effort to maintain the sustainability of the ecosystem, natural resources, and biodiversity on Earth.	This tradition is carried out to raise community awareness and understanding of preserving the rivers by not catching fish using chemicals	Senior High School dan Higher Education

Themes	ISc of The *Bekarang* Traditions	Science Background	Related Science Content	Suggested Educational Level
			or electric shock.	
Ecosystem	*Bekarang* Tradition guides the community to not poison the fish with chemical synthesis.	The ecosystem includes the complex interaction between living organisms and the environment, and the exchange of energy and materials between the two entities.	Knowledge instilled in the *Bekarang* tradition fosters positive interactions between living organisms in and around the river ecosystem. The prohibition of synthetic chemicals is intended to maintain the pH level of the river (abiotic component).	Senior High School dan Higher Education
Biodiversity	*Bekarang* tradition involves the community in separating the catch. The small fish are released, whereas the bigger ones are sold and consumed. Heavy equipment is not used for catching fish.	Biodiversity emphasizes the variation and diversity of living organisms from plants to animals and microorganisms, and the genes and ecosystems they live in.	*Bekarang* tradition is an effort to protect biodiversity in the local ecosystem.	Senior High School dan Higher Education

Based on Table 3, the *Bekarang* tradition can provide contexts for three topics in Biology learning: biodiversity, ecosystems, and conservation. Learning about biodiversity enables students to develop an understanding of the importance of maintaining biodiversity on our planet. They can learn about endangered species, habitat degradation, and the negative impacts of human activities on the lives of other organisms. Meanwhile, gaining knowledge about ecosystems helps students understand how living organisms interact with each other and with their physical environment. Through this understanding, they can see the reciprocal relationship between humans and ecosystems, and the importance of maintaining ecosystem health for human well-being. The topic of conservation and management of natural resources introduces students to the concept of environmental preservation, responsible use of natural resources, and sustainable management steps for river ecosystems.

This tradition inspires and helps students to achieve a deeper understanding of Biology. However, to optimize the benefits of the *Bekarang* tradition in biology learning, careful planning and a structured approach are needed. Teachers need to ensure that learning

objectives are clear, necessary resources are available, and student safety is a top priority during outdoor activities. Based on this, an analysis of the required learning outcomes and a good syllabus is mandatory. The results of our analysis are shown in Table 4.

Table 4. Analysis of Learning Outcome, Learning Objectives, and Learning Instruction

Elements	Learning outcomes	Learning objectives	Learning Instruction
Understanding of Biology	1. Students can propose solutions for problems on the local, national, or global level in the context of understanding conservation and changes in the ecosystem.	2. Students have an attitude of caring for the environment around the river ecosystem (attitude learning outcome). 3. Students analyse the local wisdom that can prevent an imbalanced ecosystem by weighing the ecosystem components and the interactions between components (knowledge learning outcome). 4. Students make a plan and investigate to identify the cause and effect of environmental changes and campaign for the mitigation efforts (psychomotor learning outcome).	1. Students analyze the targeted learning outcomes. 2. Students observe the phenomena of environmental changes in South Sumatra through the news, scientific journals, and videos. Then, the students are asked to reflect on previous natural disasters. 3. Students formulate questions about the causes of disasters and the solutions for conservation. 4. Students plan a field practicum of the *Bekarang* tradition through a literature review (tools, materials, and techniques of *Bekarang* fishing). 5. Students collect information about the efforts of river ecosystem conservation from the field practicum of the *Bekarang* tradition. 6. Students form associations with the results of the field practicum. 7. Students communicate the findings of the field practicum. 8. Students evaluate the results of learning outcomes and evaluate the prepared planning. 9. Students modify the prepared plan into a new plan in case they find a suboptimal evaluation outcome.
Process skills	1. Observation 2. Inquiry 3. Planning and investigation 4. Process 5. Evaluation and reflection 6. Result dissemination		

E. Further Implications

The potential Biology syllabus proposed in this study is based on culture/local wisdom or ethnobiology issues. The recommended models are problem-based learning (PBL), project-based learning (PjBL), role playing, and Science-Based Self-Regulated Learning (SBSRL). These models require students to think critically to solve problems about the river ecosystem

through a group-work project. These models allow students to learn actively, develop collaboration skills, creativity, critical thinking, environmental care attitude, and experience the direct impact of their actions [47]-[52].

The PBL model engages students with interdisciplinary challenges related to river ecosystem conservation. Through this pedagogical approach, learners investigate real-world scenarios by applying scientific methodologies while integrating socioeconomic dimensions. The PBL framework cultivates critical competencies, including systems thinking, data literacy, and stakeholder engagement [53]-[55]. PBL transforms classrooms into microcosms of sustainable development practice, aligning with SDG 4.7's emphasis on education for sustainability while fostering actionable solutions for SDG 6 (Clean Water) and SDG 15 (Life on Land).

PjBL model immerses students in authentic tasks, and tasks them with investigating pressing issues. Within this pedagogical framework, learners systematically analyze problems through scientific inquiry. This process cultivates higher-order thinking skills [19], [56], [57]as students synthesize interdisciplinary knowledge (spanning environmental science, chemistry, and social studies) to propose evidence-based solutions. PjBL not only advances SDG 4.7's target of education for sustainable development but also empowers youth as change agents in achieving SDG 6 (clean water) and SDG 14 (aquatic conservation).

In some literature, role playing can also raise the value of the local wisdom of the community in the classroom [58]. This learning model involves students in simulations or role-playing related to river ecosystems. For example, they can play the role of a community that is carrying out the *Bekarang* tradition. This model encourages systemic thinking, collaboration, and a deep understanding of various perspectives related to river environmental issues.

The elaboration of the *Bekarang* tradition in biology classrooms through a Self-Regulated Learning (SBSRL) model facilitates a structured, inquiry-based exploration of aquatic ecosystems while preserving local ecological wisdom. This nine-phase pedagogical framework begins with (1) Analyzing, where students deconstruct learning objectives related to ichthyology and sustainable fisheries, followed by (2) Observing contemporary environmental challenges in South Sumatran watersheds through news media analysis to establish a real-world context. The SBSRL cycle then progresses to (3) Asking student-generated questions about *Bekarang*'s ecological impacts, which inform (4) Planning field practicums through literature reviews of traditional fishing implements (e.g., serkap traps), plant-derived piscicides (tuba roots), and seasonal fishing calendars. During (5) Collecting Information, learners gather empirical data on river conservation outcomes through hands-on *Bekarang* simulations, subsequently (6) Associating these findings with biological concepts like trophic

cascades and benthic habitat preservation. The model emphasizes metacognition through (7) Communicating results via scientific posters or community presentations, (8) Evaluating both learning outcomes and methodological efficacy against pre-established rubrics, and culminates in (9) Modifying approaches based on identified deficiencies—for instance, adjusting fish sampling protocols to minimize ecosystem disturbance.

Biology learning is not only focused on the theories contained in textbooks, but can also be connected to local wisdom and cultural traditions that exist in the community. *Bekarang* tradition has been ingrained in the coastal community of Palembang, South Sumatra, as a way of communal fishing in swamps or rivers. *Bekarang* is usually held after the dry season and before the rainy season, when water supply is abundant. The relevance of the *Bekarang* tradition and Biology learning lies in several elements, such as ecosystem, biodiversity, and conservation.

Previous research has consistently demonstrated that incorporating local traditions into pedagogical practices significantly enhances student motivation by fostering cultural relevance and personal connection to learning materials [20], [26], [59]. This phenomenon is particularly evident in environmental science education, where contextually grounded learning experiences bridge abstract biological concepts with students' lived realities. The *Bekarang* tradition, as a culturally embedded practice of aquatic resource management, offers an ideal framework for such integration, serving as both a motivational anchor and a vehicle for authentic scientific inquiry. When learners recognize their own cultural heritage within academic content, cognitive engagement and knowledge retention improve substantially in concept mastery in comparable ethnoscience studies [19], [57].

Within aquatic ecosystem studies, the *Bekarang* provides a comprehensive medium for investigating the structure and function of riverine, lacustrine, and palustrine environments characteristic of South Sumatra's watersheds. This tradition facilitates hands-on examination of trophic relationships across biological organizational levels from microscopic plankton communities to endemic fish species (e.g., *Puntius javanicus*) and their associated flora (e.g., *Nymphaea nouchali*). Project-based learning methodologies transform *Bekarang* into a living laboratory where students can: quantify biodiversity indices across wetland habitats, analyze physicochemical water parameters affecting species distribution, and document traditional ecological knowledge regarding seasonal variations. Such immersive experiences enhance 21st-century skills [19].

The systematic incorporation of *Bekarang* into biology curricula enables learners to visualize and interrogate the complex interplay between biotic and abiotic ecosystem components. Through guided investigations, students discover tangible manifestations of ecological principles, how dissolved oxygen levels influence fish behavior, how riparian

vegetation stabilizes microhabitats, or how traditional fishing calendars align with lunar cycles and spawning periods. This pedagogical approach achieves dual outcomes: it grounds abstract scientific concepts (nutrient cycling, adaptive traits) in observable phenomena while validating Indigenous knowledge systems as complementary to Western scientific paradigms [57].

The *Bekarang* is carried out in groups by the community, and this reflects cooperation and social interaction in utilizing natural resources. Students can be taught about the importance of collaboration in maintaining ecosystem sustainability through this activity. The relevance of the *Bekarang* tradition to biology learning is very broad and can cover various biological concepts, ranging from ecosystems, biodiversity, and conservation. By integrating local traditions in biology learning, students can learn more contextually, relevantly, and meaningfully.

Conclusion

The *Bekarang* tradition reflects the balance of interaction between the community and the river ecosystem, becoming a symbol of sustainable economy at the regional level. In *Bekarang* philosophy, it is important to preserve the environment while still developing the local economy. This philosophy also forms the basis of customary law or oral law that applies. Since the prehistoric era, the people of South Sumatra have carried out *Bekarang* as part of their lifestyle, which is very dependent on nature, especially in finding food and using traditional tools such as wooden spears to catch fish in the river. This practice developed because of the geography of the South Sumatra region, which is surrounded by rivers. This tradition instills the values of cooperation, responsibility, and care for the environment. *Bekarang* has an important meaning in maintaining the sustainability of the river ecosystem. The values of local wisdom that are passed down from generation to generation are well maintained, including cooperation in community groups that work together in teams with their respective tasks. In addition, this tradition also teaches patience, hard work, mutual trust, and responsibility among team members. These values are closely related to Biology Learning, especially in increasing awareness of caring for the environment, and become the foundation for maintaining and using natural resources wisely in the future. Relevant materials/themes in integrating this tradition are about conservation, ecosystems, and biodiversity. Some learning models that can be used as alternatives include project-based learning (PjBL), problem-based learning (PBL), scientific-based self-regulated learning (SBSRL), and role playing.

Limitations and Suggestions

This study has several limitations that warrant consideration. First, the research primarily relied on qualitative data from interviews and literature reviews, which may limit the generalizability of the findings. Future studies could employ mixed-methods approaches, incorporating quantitative surveys or experimental designs to validate the effectiveness of integrating the *Bekarang* tradition into Biology learning. Additionally, the study focused on senior high school students in South Sumatra, expanding the research to other educational levels or regions with similar traditions could provide broader insights. Further investigation is also needed to explore the long-term impact of such integration on students' environmental attitudes and academic performance (experimental or R&D), as well as the potential challenges teachers might face in implementing these culturally contextualized pedagogies. Addressing these gaps would strengthen the theoretical and practical contributions of this research.

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Conflict of Interest

The authors declare no conflict of interest.

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