



Preparing Future Biology Teachers for Sustainability: The Role of Environmental Literacy in Achieving Sustainable Development Goals (SDGs)

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Abstract

Environmental challenges such as ecosystem degradation, biodiversity loss, and pollution have become major threats to sustainability worldwide. Despite the growing importance of environmental literacy for achieving sustainability goals, limited studies have examined the environmental literacy of prospective biology teachers, particularly within wetland ecosystem contexts. This study aimed to assess the environmental literacy of biology education students and explore its contribution to achieving Sustainable Development Goals (SDGs) through sustainability oriented education. This research employed a convergent mixed methods approach involving 58 biology education students selected through purposive sampling. Data were collected using questionnaires and interviews and analyzed through descriptive statistics and thematic analysis. The findings revealed high levels of environmental knowledge, awareness, and conservation attitudes among students, whereas pro-environmental behavior remained at a moderate level, indicating a gap between environmental understanding and actual practice. Students also demonstrated strong awareness of the importance of conserving wetland ecosystems and recognized the role of education in promoting sustainability. These findings highlight the importance of strengthening environmental literacy among prospective biology teachers to support SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 15 (Life on Land) through sustainability oriented education.

Keywords: biology education; environmental literacy; future biology teachers; sustainability; wetland ecosystem

INTRODUCTION

Global environmental issues are becoming increasingly complex and are a major concern in global development (Katila *et al.*, 2020; Abdellatif, 2022). Phenomena such as climate change, declining biodiversity, ecosystem degradation, and increasing environmental pollution show that environmental sustainability is a major challenge for the global community (Servaes, 2017; Trott & Trott, 2019). These conditions require joint efforts from various sectors to achieve sustainability oriented development (Nerini *et al.*, 2019; Liu *et al.*, 2021; Munir & Fadhilah, 2023). To address these challenges, the international community has developed the SDGs, which highlight the importance of balancing environmental conservation, economic development, and social welfare. Of these, SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 15 (Life on Land) are closely connected to environmental sustainability. Education serves a crucial function in realizing these objectives by providing individuals with the knowledge, skills, and values essential for tackling environmental challenges (Husamah *et al.*, 2024; Haque

et al., 2026).

Education for Sustainable Development (ESD) is an approach that integrates sustainability principles into the learning process (Ekamilasari *et al.*, 2021; Sihombing *et al.*, 2024). ESD seeks to provide learners with the knowledge, skills, values, and attitudes necessary to make responsible choices for environmental sustainability and economic fairness. Through ESD, students are expected to develop critical thinking, environmental awareness, and the ability to make responsible decisions. The success of ESD significantly relies on educators' environmental skills, especially their degree of environmental literacy (Suwanto *et al.*, 2021; Pratiwi *et al.*, 2025). In this context, developing environmental literacy is one of the important competencies that biology education students need to have. Environmental literacy includes the ability to understand environmental systems, recognize ecological problems, and have attitudes and behaviors that support environmental conservation efforts (Barclay & Barker, 2020; Abdellatif, 2022).

Environmental literacy is the main foundation for educators to integrate sustainability principles into learning (Wajdi *et al.*, 2022; Husamah *et al.*, 2024; Rofiqi, 2024). People with strong environmental literacy can comprehend the connection between humans and the environment and have the capacity to act responsibly to ensure the sustainability of ecosystems. Without adequate environmental literacy, biology teachers will only teach biology as memorized text, rather than as a living science that is relevant to the crises happening before their students' eyes (Qiang *et al.*, 2020; Hunter & Jordan, 2022). In South Kalimantan, environmental concerns are strongly connected to the preservation of wetland ecosystems. As an area rich in peatlands, rivers, and mangrove forests, South Kalimantan now faces serious threats due to land conversion, massive coal mining, and water and air pollution forest and land fires (Qiang *et al.*, 2020; Judijanto & Adiwijaya, 2024). Data shows that environmental degradation in South Kalimantan has a direct impact on the decline in the quality of life of the community and the loss of endemic species.

Higher education has an important role in developing environmental literacy. Biology Education Study Programs have a strategic responsibility in preparing prospective teachers to have awareness and understanding of sustainability issues (Alkaher & Goldman, 2017; Kencanasari *et al.*, 2019; Lange *et al.*, 2020). Therefore, strengthening environmental literacy among biology education students is particularly important to support local environmental conservation efforts. Nonetheless, multiple studies indicate that the degree of environmental literacy among students remains quite divergent (Altin *et al.*, 2014; Berger & Wyss, 2021). Earlier research indicates that university students typically possess a considerable amount of environmental knowledge, yet often display diminished pro-environmental behaviors. This condition shows that strengthening environmental literacy at the higher education level remains a challenge that needs further attention (Lange *et al.*, 2020; Berger & Wyss, 2021).

However, most of these studies focus on general student populations and rarely examine prospective teachers as future agents of change. In addition, limited research has specifically explored environmental literacy within the context of wetland ecosystems, particularly in South Kalimantan. This indicates a lack of empirical evidence on how environmental literacy among prospective biology teachers contributes to the achievement of SDGs, especially those related to education, climate action, and ecosystem conservation. This indicates a gap between knowledge and practice that requires further investigation. This study seeks to evaluate the environmental literacy of biology education students and assess its contribution to the attainment of SDG 4, 13, and 15 within the framework of wetland ecosystems in South Kalimantan. This research aims to enhance the progress of sustainability focused biology education and reinforce the position of upcoming educators as catalysts for environmental transformation.

METHOD

This research utilized a convergent mixed methods approach, where both quantitative and qualitative data were gathered at the same time, analyzed independently, and subsequently merged during the interpretation phase to offer a thorough understanding of environmental literacy (Creswell & Creswell, 2018). This design was selected because it allows the researcher to combine numerical data on environmental literacy levels with in depth insights into students' perceptions, thereby strengthening the validity of the findings through triangulation. The mixed methods strategy was selected to offer a thorough

insight into the research issue by combining quantitative information gathered from surveys and qualitative information obtained from interviews. The quantitative component was used to measure students' environmental literacy levels, while the qualitative component was used to explore students' perceptions regarding the role of environmental literacy in supporting sustainability oriented education. This integration allowed the researchers to obtain both measurable patterns and in depth insights related to environmental literacy among prospective biology teachers.

The participants in this study were undergraduate students enrolled in the Biology Education Study Program at the Faculty of Teacher Training and Education, Lambung Mangkurat University, located in South Kalimantan, Indonesia. The research sample included 58 biology education students selected via purposive sampling. This sampling technique guaranteed that participants had relevant academic knowledge of environmental matters. The inclusion criteria required that students had completed courses in environmental science or ecology, enabling them to provide informed responses on sustainability and environmental literacy subjects. These students were considered appropriate participants because they represent future biology teachers who will help integrate environmental awareness and sustainability concepts into future biology education.

Data was collected using two research instruments (questionnaires and interviews). The survey was created to gauge the degree of environmental knowledge among students studying biology education. The tool was created using essential metrics of environmental literacy, such as environmental knowledge, awareness of ecological problems, attitudes regarding environmental protection, and environmentally friendly behavior. The survey included various statements assessed on a five point Likert scale, from strongly disagree to strongly agree. The survey yielded quantitative information detailing students' environmental literacy levels in relation to the four indicators. To guarantee the instrument's quality, content validity was determined via expert assessment with two specialists in environmental education. The evaluation of construct validity was conducted by examining the correspondence between items and theoretical indicators. The questionnaire's reliability was assessed through Cronbach's alpha, where a coefficient exceeding 0.70 signifies acceptable internal consistency.

To complement the questionnaire data, structured interviews were conducted with 10 biology education students. Each interview lasted approximately 30–45 minutes and was conducted face-to-face, recorded, and transcribed for analysis. The interview guide included questions related to students' understanding of environmental literacy, their views on its importance in education, and their perceptions of the role of future biology teachers in promoting sustainability and the SDGs. These interviews provided deeper insights into students' experiences and perspectives regarding environmental literacy and sustainability education. The research was conducted through several sequential activities. Initially, the researchers developed and validated the research instruments, including the environmental literacy questionnaire and interview guide. The questionnaire was then distributed to 58 biology education students who met the sampling criteria, and participants responded to each statement using a Likert scale. After the questionnaire data were collected, structured interviews were carried out with selected students to obtain more detailed information and to enrich the quantitative findings. Finally, all questionnaire and interview data were compiled, organized, and prepared for further analysis.

The information gathered in this study was examined through both quantitative and qualitative analysis methods. The quantitative data collected from the questionnaire were examined through descriptive statistical analysis, which included percentages and classification of environmental literacy levels. The results of the analysis were subsequently organized into distinct categories to illustrate the general environmental literacy level of the participants. Qualitative data gathered from interviews were examined through thematic analysis. The analytical procedure included multiple phases, such as data reduction, data presentation, and conclusion formulation. In this process, the researchers recognized important themes concerning students' comprehension of environmental literacy and its role in facilitating the attainment of the SDGs. Through the integration of findings from both quantitative and qualitative analyses, this research offers a thorough insight into the environmental literacy among biology education students and its possible contribution to enhancing sustainability focused education.

RESULT AND DISCUSSION

The analysis of the questionnaire results indicates that biology education students generally possess a fairly good level of environmental literacy across various indicators evaluated in this research. In this study, environmental literacy was evaluated using four primary indicators: environmental knowledge, understanding of environmental issues, attitudes towards conservation, and pro-environmental actions. These four indicators represent the cognitive, emotional, and behavioral aspects that are essential for fostering sustainable awareness and personal accountability regarding the environment. Assessing these indicators is important because they provide a comprehensive picture of students' readiness to contribute to environmental sustainability and sustainable development efforts. The results of the study presented in Table 1 illustrate the degree of environmental literacy among students.

Table 1. Outcomes of the environmental literacy tool for biology education students

No.	Environmental Literacy Indicators	Sub Indicators	Average Score	Percentage (%)	Std	Category
1	Environmental Knowledge	The basic concepts of wetland ecosystems	4.02	80.4	0.61	Tall
		Understanding the ecological function of wetlands	3.95	79	0.58	Tall
		Knowing the biodiversity	3.87	77.4	0.63	Tall
		Understanding threats to wetland ecosystems	3.92	78.4	0.59	Tall
		Understanding the importance of wetland conservation	3.98	79.6	0.57	Tall
		Importance of preserving wetlands	3.88	77.6	0.60	High
		Impact of environmental damage	3.81	76.2	0.64	High
2	Environmental Awareness	Caring about local environmental issues	3.76	75.2	0.67	High
		Role of the community	3.84	76.8	0.62	High
		Importance of environmental education	3.79	75.8	0.65	High
		Supporting wetland conservation	3.72	74.4	0.68	High
		The existence of wetland ecosystems	3.70	74	0.70	High
		Supporting environmental conservation policies	3.66	73.2	0.72	High
		Committed to protecting the environment	3.74	74.8	0.69	High
3	Attitudes Toward Environmental Conservation	Supporting environmental learning	3.81	76.2	0.65	High
		Reducing environmentally damaging behavior	3.35	67	0.74	Medium
		Participating in environmental conservation activities	3.28	65.6	0.76	Medium
		Conserving the use of natural resources	3.41	68.2	0.71	Medium
		Responsible waste management	3.30	66	0.75	Medium
		Supports environmental education activities	3.22	64.4	0.79	Medium
4	Pro-Environment Behavior					

Based on the Table 1, the environmental knowledge indicator showed the highest average score (3.95; high category). This indicates that biology education students have a fairly good understanding of ecosystem concepts, ecological functions of the environment, and threats to environmental sustainability. In terms of environmental knowledge, most students demonstrated a fairly good understanding of basic ecological concepts and various environmental issues. In the context of the research area, students also demonstrated an understanding of the characteristics of wetland ecosystems, which are an important part of the environment in South Kalimantan. Wetland ecosystems in this region have very important ecological functions, including flood control, carbon storage, and habitat for various organisms that have ecological and economic value for the community (Yikii *et al.*, 2017; Oliveira *et al.*, 2024).

The interview results reinforced these findings, with several students stating that wetlands are an important part of the environmental system in South Kalimantan that needs to be preserved for sustainability. Students also recognize that various human activities such as land conversion, water pollution, and exploitation of natural resources can put pressure on the sustainability of wetland ecosystems (Muth *et al.*, 2020; Husamah *et al.*, 2022; Fakhriyah *et al.*, 2024). This understanding shows that students not only understand environmental concepts theoretically, but are also able to relate them to the local environmental conditions they face. Theoretically, environmental knowledge is the main cognitive component of environmental literacy. Environmental literacy involves not just knowing ecological facts, but also comprehending the connection between human actions and the sustainability of ecosystems (Abdellatif, 2022; Ainin & Asafri, 2023; Rofiqi, 2024).

Environmental literacy includes understanding environmental issues, the ability to interpret ecological phenomena, and the ability to make responsible decisions regarding the environment. Furthermore, in the context of this study, students' knowledge of wetland ecosystems shows that the biology learning process they received has provided a conceptual basis regarding ecosystem functions, biodiversity, and interactions between humans and the environment (Berger & Wyss, 2021; Rofiqi, 2024; Husamah *et al.*, 2025). The questionnaire results indicate that students possess a fairly high level of awareness regarding different environmental issues present in wetland regions. The environmental awareness metric reveals an average value that is also classified in the high range (3.82). This suggests that students possess a reasonably high awareness of different environmental concerns, such as ecosystem degradation and changes in the environment.

Students recognize that harm to wetland ecosystems can significantly affect people's lives, leading to heightened flooding risks, worsening water quality, and diminished biodiversity. Environmental awareness is a crucial aspect of environmental literacy as it pertains to a person's capacity to identify and comprehend the effects of human actions on the environment. People who possess strong environmental awareness are usually more attuned to ecological concerns like pollution, ecosystem damage, and biodiversity loss (Alkaher & Goldman, 2017; Sen *et al.*, 2021; Hunter & Jordan, 2022). This awareness is also an important stage that connects knowledge with environmental attitudes and behaviors. Without awareness of environmental issues, ecological knowledge will not automatically result in actions that support environmental sustainability (Afroz & Ilham, 2020; Ekamilasari *et al.*, 2021; Pada *et al.*, 2025).

Interview outcomes further corroborate these findings, indicating that students view wetland preservation as an essential effort for harmonizing human actions with ecological sustainability. Numerous students stated that education is essential for enhancing public understanding of the importance of conserving wetland ecosystems. This shows that students understand the importance of education in promoting environmental consciousness (Randers *et al.*, 2019; Leal *et al.*, 2021). Their high level of environmental awareness indicates that these future biology teachers have the potential to become agents of change in environmental education in the future (Varoglu *et al.*, 2018; Rahayu *et al.*, 2021). Regarding attitudes on environmental conservation, the study's findings indicate that the majority of students hold favorable views on efforts to protect the environment. The study's findings indicate that the mean score for environmental attitudes falls within the high range (3.74). This shows that students possess favorable attitudes toward environmental preservation and endorse efforts aimed at conserving ecosystems. Students expressed that efforts for environmental conservation, including wetland ecosystems, require a collective responsibility among different stakeholders, such as the government, the community, and educational

institutions.

In studies of environmental psychology, environmental attitudes refer to people's emotional assessments of environmental matters. These attitudes can influence individuals' intentions and behaviors in protecting the environment (Hanif *et al.*, 2019; Lange *et al.*, 2020; Untari *et al.*, 2023). Research shows that environmental attitudes act as a mechanism that bridges knowledge and environmental actions. The Knowledge Attitude Behavior (KAB) model explains that environmental knowledge shapes individuals' attitudes toward the environment, and these attitudes subsequently influence environmental behavior. In other words, attitudes are important mediators in the process of environmental behavior change (Cogut *et al.*, 2019; Vesela *et al.*, 2023; Salins & Aithal, 2023; Singh, 2025). Thus, the results of this study show that biology education students not only understand environmental issues cognitively, but also have values and attitudes that support environmental conservation efforts.

The findings from the interview indicate that students consider biology education essential for fostering sustainability values in them. Students expressed that biology education should not solely emphasize teaching scientific concepts, but must also incorporate environmental issues pertinent to daily life. In South Kalimantan, wetland environments serve as a relevant learning resource to aid students in grasping ecological concepts and the importance of environmental conservation. However, in terms of pro-environmental behavior indicators, the questionnaire results show that students' environmentally friendly practices are still in the moderate category (3.36). Although students have sufficient knowledge, awareness, and attitudes towards environmental conservation, the application of these behaviors in their daily lives is not yet optimal. These results show that a disparity exists between understanding environmental issues and practicing eco-friendly behaviors (Amelia *et al.*, 2020; Sen *et al.*, 2021; Lu & Chen, 2025).

Several studies show that environmental knowledge does not always directly influence environmental behavior because behavior is influenced by various other factors such as social norms, personal experiences, and individual habits. In addition, other studies show that environmental attitudes have a stronger influence on behavior than knowledge alone. The relationship between attitudes and behavior is often stronger than the relationship between knowledge and behavior (Al-naqbi & Alshannag, 2018; Varoglu *et al.*, 2018; Mganga *et al.*, 2021). The interview results also show that some students are aware of the gap between their understanding of the importance of protecting the environment and their daily behavior. This indicates that environmental education in higher education still needs to be strengthened with more practical learning experiences so that students can develop behaviors that support environmental sustainability (Cogut *et al.*, 2019; Lam, 2019; Olsson *et al.*, 2019).

Improving environmental literacy requires not only strengthening cognitive aspects, but also needs to be supported by contextual and applied learning experiences in order to encourage real behavioral change (Chordnork & Yuenyong, 2014; Gunamantha & Dantes, 2025). The results of this study also show that biology education students are aware of their important role as future teachers in instilling sustainability values in their students. Through contextual biology learning, teachers can help students understand the relationship between biological concepts and environmental issues occurring around them. In the context of wetlands in South Kalimantan, wetland ecosystems can be used as a relevant learning resource to improve students' understanding of various ecological concepts, such as interactions between organisms, material cycles, and ecosystem balance. By utilizing the local environment as a learning resource, biology learning can become more contextual and meaningful for students (Barclay & Barker, 2020; Sari & Wardani, 2025).

Students in biology education, as future educators, mentioned in interviews that experiences connected to the surrounding environment, like field observations, practical activities, or environmental initiatives, can enhance their comprehension of the significance of environmental preservation. These hands on learning experiences can help students connect the theoretical knowledge they acquire in class with the real environmental conditions they encounter (Alkaher & Goldman, 2017; Afroz & Ilham, 2020). Consequently, initiatives aimed at enhancing environmental literacy in biology students are crucial for facilitating the attainment of SDGs. Environmental literacy equips individuals with the understanding, consciousness, and perspectives needed to comprehend the diverse environmental issues confronting society today.

In the South Kalimantan wetland region, enhancing environmental literacy is crucial due to its unique ecosystem and significant role in sustaining environmental balance. As prospective teachers, students hold significant potential to aid in environmental conservation through education. The findings of this study are also in line with the Education for SDGs approach, which emphasizes the importance of integrating sustainability values into the education system. Sustainability oriented education is expected to equip students with critical thinking skills, environmental awareness, and the skills to make environmentally responsible decisions. High environmental literacy among prospective teachers plays a strategic role in supporting the implementation of sustainable education (Clarisa *et al.*, 2020; Suwanto *et al.*, 2021; Sihombing *et al.*, 2024).

Students' environmental literacy influences their grasp of environmental challenges and can also aid in fostering more sustainable community growth. Efficient environmental education can foster individuals' awareness, attitudes, and actions that promote environmental sustainability (Suwanto *et al.*, 2021; Pratiwi *et al.*, 2025). In the context of biology education, strengthening environmental literacy among prospective teachers can be an important strategy in integrating sustainability concepts into the learning process. Through education based on the local environment, students can directly understand the relationship between biological concepts and real environmental conditions. Therefore, enhancing environmental literacy in biology students is crucial not only for boosting their academic skills but also for promoting the conservation of wetland ecosystems and sustainable development in the South Kalimantan area. In general, the results of this research provide a significant contribution to the advancement of environmental education in Indonesia.

The findings indicate that enhancing environmental literacy in biology education students preparing to be teachers is crucial for increasing environmental awareness and promoting sustainable education practices. Given Indonesia's rich ecosystem diversity, particularly in South Kalimantan's wetland ecosystems, enhancing environmental literacy among future educators can play a crucial role in fostering environmental conservation initiatives via education. This study additionally offers empirical proof regarding the significance of incorporating the local environmental context into biology instruction. Leveraging the surrounding environment as a resource for learning can make the educational process more contextual and pertinent to the environmental challenges encountered by the community. This method could enhance young individuals' understanding of the significance of environmental sustainability. Furthermore, this research also aids in enhancing the application of sustainable education in Indonesia. The environmental knowledge of upcoming biology educators can contribute to developing an educational framework that prioritizes not just understanding scientific principles but also encouraging responsible environmental attitudes and actions. Thus, the results of this study can act as a basis for developing educational policies and creative learning methods that aid in achieving SDGs in the education field.

CONCLUSION

The results of this research show that biology education students exhibit a relatively high degree of environmental literacy, especially regarding their knowledge, awareness, and attitudes concerning environmental conservation. Nonetheless, their eco-friendly actions stay at a moderate level, emphasizing a disconnect between comprehension and practical implementation. This research verifies that environmental literacy is essential for promoting sustainability focused education, especially regarding wetland ecosystems in South Kalimantan. Moreover, the findings highlight the significance of combining experiential and contextual learning methods to enhance students' environmental behavior. This research supports the attainment of SDG 4, SDG 13, and SDG 15 by emphasizing the role of prospective biology educators as change agents in fostering environmental sustainability. This research offers valuable perspectives for enhancing curriculum development and environmental education approaches in higher education at the national level to promote sustainable development.

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