Reinventing Ecopedagogy and Its Implication on Enhancing Climate Action in Indonesian *Adiwiyata* School

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ABSTRACT

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| **Aims:** Addressing climate change requires collective action and stakeholder collaboration to protect, restore, and sustain ecosystems and natural resources. Sustainable Development Goal 13 on Climate Action emphasizes enhancing education, awareness, and participation in climate change mitigation and adaptation. This study investigates the role of ecopedagogy in activating students’ climate action in *Adiwiyata* schools, a government-led initiative that promotes sustainability-based curricula in schools. It examines how this program influences students' climate-related knowledge, understanding, and behaviors and identifies barriers that hinder their active participation.  **Study design:** This research employs a mixed-method approach, integrating quantitative survey data with qualitative insights from interviews to provide a comprehensive understanding of students’ climate engagement.  **Place and Duration of Study:** The study was conducted in *Adiwiyata* schools located in Semarang and Magelang, Indonesia, over 12 months, from March 2024 to February 2025.  **Methodology:** A survey of 362 students (aged 14–15; 40.88% male, 59.12% female) from 4 *Adiwiyata* schools assessed climate knowledge, awareness, and sustainable practices. In-depth interviews were conducted with 4 school task forces, 5–7 teachers per school, and environmental agency officials to explore institutional factors.  **Results:** Students demonstrate relatively low to moderate knowledge of climate change, with mean scores ranging from 2.23 to 2.78. Their understanding remains low to moderate, and their participation in mitigation and adaptation actions is also relatively low. The regression analysis reveals a significant correlation between students' climate knowledge and their climate-friendly behaviors (R² = 0.476, p < 0.001). However, a substantial gap exists between knowledge and action, indicating that awareness does not necessarily translate into concrete environmental practices. Moreover, institutional barriers further hinder the effectiveness of sustainability education in *Adiwiyata* schools. These include the limited integration of environmental education into formal curricula, teachers' insufficient expertise in environmental education, and weak evaluation mechanisms. Without addressing these structural challenges, the program’s impact remains constrained.  **Conclusion:** These findings underscore the need for a systematic integration of sustainability education into formal curricula to address the gap between students' climate knowledge and their actions. Enhancing teacher expertise in environmental education and establishing rigorous assessment frameworks are essential to overcoming institutional barriers and improving Adiwiyata program's effectiveness. |

***Keywords:*** *Ecopedagogy, Adiwiyata Schools, Climate Action, Environmental Education, Sustainability Learning*

1. INTRODUCTION

Climate change is not merely an environmental issue; it has profound social, economic, and political implications. Vulnerable communities, such as farmers, fishermen, and coastal populations, face disproportionate risks due to climate-induced disruptions (Abbass et al., 2022). Agricultural systems are increasingly threatened, clean water scarcity is becoming more pronounced, and climate-induced mass migration poses significant challenges for many societies (Prajapati et al., 2024). The "Climate Change 2023 - Synthesis Report" by the Intergovernmental Panel on Climate Change (IPCC) affirms that climate change is a reality driven by human activities, with significant and far-reaching consequences (IPCC, 2023). Addressing climate change necessitates collective action and cross-sectoral collaboration to protect, restore, and sustainably manage ecosystems and natural resources to mitigate adverse effects.

Education plays a critical role in fostering awareness and catalyzing actions that mitigate the negative impacts of climate change (Neurohr et al., 2024; Sauvé, 2005). However, research indicates that knowledge alone is insufficient to drive meaningful behavioral change(Kollmuss & Agyeman, 2002). Environmental awareness consists of multiple dimensions, including cognitive, affective, and behavioral components(Clayton, 2024; Stern, 2000). Studies have shown that a strong knowledge base does not always translate into pro-environmental behaviors (Bauske et al., 2022; Lange, 2023; Liu et al., 2020), suggesting that environmental education must move beyond information dissemination to actively engage students in experiential and participatory learning (Sterling, 2011).

Environmental education is fundamental to climate change mitigation efforts(Michelsen & Wells, 2017; UNESCO, 2017). It provides individuals with a comprehensive understanding of the intricate interactions between human activities and the natural environment, encompassing global warming, air and water pollution, deforestation, and the urgency of resource conservation (Sterling, 2021). Through education, individuals gain access to in-depth knowledge about environmental issues, develop an awareness of the need for sustainability, and recognize the long-term consequences of human activities on the planet (Reid et al., 2021).

Ecopedagogy emphasizes the integration of environmental awareness with critical consciousness, encouraging individuals to question unsustainable practices and engage in transformative actions(Hossain, 2024). Beyond promoting eco-friendly habits like reducing plastic use and conserving biodiversity, ecopedagogy fosters a deep, systemic understanding of human-environment interactions and the socio-political structures influencing ecological degradation(Misiaszek, 2015). This approach not only instills ethical responsibility but also equips learners with the critical thinking skills needed to challenge dominant paradigms and advocate for sustainable alternatives (Norat et al., 2016).

While the importance of environmental education is globally recognized within the Sustainable Development Goals (SDGs), the specific indicators used to measure progress vary across countries. In Indonesia, one of the key indicators for SDG 13.3 is indicator 13.3.1.a, which assesses the number of formal education institutions and community-based organizations actively engaged in environmental education and sustainability initiatives. This indicator is particularly reflected in the *Adiwiyata* School Program, a national initiative designed to integrate environmental values into school curricula. However, in an international context, similar efforts can be observed in programs such as UNESCO's Education for Sustainable Development (ESD) framework, which promotes integrating sustainability principles in education systems worldwide.

Education is inherently linked to curriculum design, which determines the direction and execution of learning processes (Bellino & and Adams, 2017; Stanišić & and Maksić, 2014). Indonesia's Merdeka Curriculum integrates sustainability-oriented learning principles to prepare students for active participation in global sustainable development and resilience-building. This curriculum aligns with the *Adiwiyata* School Program, an Indonesian Ministry of Environment and Forestry initiative to cultivate environmental awareness and sustainability-oriented school cultures. *Adiwiyata* schools are evaluated based on their implementation of sustainability-based curricula (Haris et al., 2019). Effective implementation of such curricula requires the active involvement of teachers as facilitators, supportive school policies, and the realization of sustainable programs. Teachers are crucial in enhancing students' knowledge, awareness, and actions regarding climate change.

One of the core evaluation criteria for *Adiwiyata* schools is the integration of environmental education into the curriculum. However, the current assessment system primarily focuses on documenting lesson plans and related materials rather than evaluating the actual implementation and learning outcomes. In many cases, the assessment process relies heavily on the quantity of planning documents rather than on their execution in real classroom settings. Consequently, a misalignment between documented plans and actual practices may arise, undermining the effectiveness of environmental education. As a result, students may not fully comprehend or implement environmental concepts in their daily lives, contributing to the persistence of behaviors that exacerbate climate change. Therefore, this study seeks to explore the level of knowledge, understanding, and actions of *Adiwiyata* School students regarding climate change and identify how school-based factors support or hinder their learning process.

2. methodology

This study employs a mixed-method approach, combining quantitative and qualitative research methods to comprehensively assess students' knowledge, understanding, and actions regarding climate change in *Adiwiyata* Schools. The study was conducted in three *Adiwiyata* Schools in Semarang and two *Adiwiyata* Schools in Magelang.

**2.1 Quantitative Phase**

**2.1.1 Research Design**

The quantitative phase involved a survey-based assessment of 363 students from the selected *Adiwiyata* Schools. This study was conducted in four selected *Adiwiyata* Schools, two in Semarang and two in Magelang. These schools were chosen based on their active participation in the *Adiwiyata* program and their contrasting environmental contexts, with Semarang representing a coastal area and Magelang representing a mountainous region. The total sample consisted of 363 students, who were selected using a stratified random sampling technique to ensure a balanced representation across schools.

To ensure proportional representation, each of the four schools was assigned a quota of 50 students, with the total number adjusted to 363 based on school size and participation rates. Stratified random sampling was chosen to maintain an equal distribution of participants across schools while capturing potential differences in student awareness and behavior.

The selection focused exclusively on 8th and 9th-grade students, as 7th-grade students had only recently been introduced to the *Adiwiyata* curriculum and had not yet experienced its full implementation. Within each school, students were randomly selected using a random number generator applied to official student lists provided by the schools. This approach also allowed for a more accurate assessment of the impact of climate education, as students with more prolonged exposure to the *Adiwiyata* program were more likely to demonstrate meaningful differences in their knowledge, understanding, and actions regarding climate change.

**2.1.2 Research Instrument**

The survey instrument measured three key variables:

1. Knowledge of climate change (causes, consequences, and mitigation strategies).
2. Understanding of environmental sustainability and climate adaptation efforts.
3. Actions related to pro-environmental behavior in daily life.

To ensure validity and reliability, the study adopted two established instruments: the Climate Change Attitude Survey (CCAS) and the Climate Stewardship Survey (CSS). The CCAS is designed to measure students' beliefs and intentions regarding climate change (Christensen & Knezek, 2015), while the CSS assesses the knowledge, perception, and trusted sources of climate change information (Walker & Mcneal, 2013). The questionnaire incorporated elements from these instruments, adapted for the context of *Adiwiyata* schools.

The questionnaire was closed-ended and used a 5-Likert scale to quantify students' responses. The data were analyzed using descriptive and inferential statistical methods, including mean comparisons and correlation analysis, to determine students' levels of knowledge, understanding, and actions.

**Table 1. Distribution of Survey Questions and Corresponding References**

|  |  |  |
| --- | --- | --- |
| **Variables** | **Indicators** | **References** |
| **Knowledge** | Carbon dioxide (CO₂) in the atmosphere is one of the greenhouse gases and affects climate change. | CCAS (2015) |
|  | Riding bicycles and walking when traveling can reduce the negative impact of climate change. | CCAS (2015) |
|  | Elements that influence climate change include temperature, wind, air pressure, humidity, and rainfall. | CCAS (2015) |
|  | Global warming is an increase in the average temperature of the atmosphere, Earth, and oceans, which is closely related to climate change. | CCAS (2015) |
|  | Climate change is a significant alteration in climate patterns, such as air temperature or rainfall, over a period of 30 years or more. | CCAS (2015) |
|  | Humans are one of the main causes of climate change. | CCAS (2015) |
|  | The *Adiwiyata* school program is a form of initiative that supports climate change mitigation. |  |
| **Understanding** | Prolonged drought is one of the impacts of climate change. | CCAS (2015) |
|  | Climate and weather play an essential role in sustaining life. | CCAS (2015) |
|  | Differences in climate across various regions in Asia are largely influenced by topography. | CSS (2013) |
|  | The agricultural sector is highly vulnerable to climate change as it affects planting patterns, crop cycles, production, and yield. | CSS (2013) |
|  | Climate is closely linked to rainfall, with influencing factors such as air temperature, humidity, wind speed, and wind direction. | CSS (2013) |
|  | The greenhouse effect results from burning fossil fuels without environmental considerations, leading to climate change. | CSS (2013) |
|  | Hot weather, drought, and clean water crises in various regions are adverse impacts of climate change. | CSS (2013) |
| **Action** | I sort and dispose of waste according to its category. | CSS (2013) |
|  | I turn off lights and other electronic devices when not in use. | CSS (2013) |
|  | I use public transportation. | CSS (2013) |
|  | I share information or participate in climate awareness activities such as campaigns or discussions. | CSS (2013) |
|  | I read or seek information about climate change from various sources. | CSS (2013) |

**2.1.2 Research Hypothesis**

This study investigates the extent to which students' knowledge and understanding of climate change influence their climate-friendly behaviors. Based on existing literature on environmental education, it is hypothesized that:

**H₀:** There is no significant relationship between students' knowledge and understanding of climate change and their climate-friendly behaviors.

**H₁:** Students' knowledge and understanding of climate change significantly predict their engagement in climate-friendly behaviors.

Given the ecological focus of *Adiwiyata* schools, where environmental education plays a central role, it is expected that both knowledge and understanding will have a positive effect on pro-environmental actions.

**2.1.3 Regression Analysis Procedure**

A multiple linear regression analysis was conducted to examine the impact of knowledge and understanding on climate-friendly behavior. The dependent variable was climate-friendly behavior, while knowledge and understanding served as independent variables.

1. Model Fit & Explanatory Power

The R-squared value was assessed to determine how much variance in climate-friendly behavior could be explained by the independent variables.

1. Significance Testing

An ANOVA test was conducted to verify whether the regression model was statistically significant. Individual predictors were evaluated using t-tests and p-values to assess their contribution to explaining the dependent variable.

**2.2 Qualitative Phase**

Following the quantitative survey, a qualitative study was conducted to gain deeper insights into the implementation of climate education and sustainability programs. This phase involved:

1. In-depth interviews were conducted with four task forces from SMPN 1 Mungkid, SMPN 1 Borobudur, SMPN 13 Semarang, and SMPN 39 Semarang to explore their role in integrating climate education into the curriculum. Each school involved 5–7 teachers in a focus group discussion (FGD) to gain deeper insights into their experiences, challenges, and strategies in implementing climate-related learning.
2. Observations in schools to examine sustainability initiatives and learning environments.
3. Interviews with officials from the Environmental Agency to understand policy support and challenges in *Adiwiyata* program implementation.

The findings from the quantitative survey were triangulated with qualitative data to provide a comprehensive understanding of climate education effectiveness in *Adiwiyata* Schools. This convergent mixed-method design ensures that the study captures both measurable outcomes and contextual factors influencing students' knowledge, understanding, and actions toward climate change.

3. results and discussion

This section presents the study's findings, beginning with the demographic characteristics of the respondents. Understanding the demographic profile is essential for analyzing students' levels of knowledge, understanding, and action regarding climate change, particularly within the context of *Adiwiyata* schools. As institutions committed to environmental education, these schools implement ecopedagogy to foster students' awareness and pro-environmental behaviors. The demographic distribution of the respondents is summarized in Table 2.

**Table 2. Respondent Demographic**

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | Values | n | % |
| Gender | Male | 148 | 40,88% |
|  | Female | 214 | 59,12% |
| School | SMP Negeri 1 Mungkid | 56 | 15,47% |
|  | SMP Negeri 1 Borobudur | 54 | 14,92% |
|  | SMP Negeri 13 Semarang | 167 | 46,13% |
|  | SMP Negeri 39 Semarang | 85 | 23,48% |
| Grade | 8 | 141 | 38,95% |
|  | 9 | 221 | 61,05% |
| Transportation Mode | Walk | 8 | 2,21% |
|  | Bike | 40 | 11,05% |
|  | Motorcylce | 279 | 77,07% |
|  | Car | 3 | 0,83% |
|  | Public Transportation | 32 | 8,84% |
| Total n = 363 |  |  |  |

The data on students' transportation modes reveal that the majority of respondents (77.07%) rely on motorcycles as their primary means of commuting to school. This high percentage suggests that motorized transport is the dominant choice among students, which may affect environmental sustainability, given its contribution to carbon emissions. In contrast, only 2.21% of students walk to school, indicating a low level of engagement in more sustainable and physically active commuting options. Similarly, public transportation (8.84%) and bicycles (11.05%) remain relatively limited, reflecting either a preference for private transport or a lack of accessible public transit infrastructure. Notably, the most minor proportion of students (0.83%) commute by car, suggesting that personal car ownership is not a common option among respondents.

**3.1 Students Knowledge, Understanding and Action**

A crucial aspect of eco pedagogy is ensuring that students acquire knowledge about environmental issues, develop a deep understanding, and take meaningful action toward sustainability. Table 3 presents the survey results regarding students' knowledge of climate change, including its causes, consequences, and mitigation strategies.

**Table 3. Student's Knowledge Level Results**

|  |  |  |
| --- | --- | --- |
| **Indicators** | **M** | **SD** |
| Carbon dioxide (CO₂) in the atmosphere is one of the greenhouse gases and affects climate change. | 2,30 | 1,17 |
| Riding bicycles and walking when traveling can reduce the negative impact of climate change. | 2,43 | 1,53 |
| Elements that influence climate change include temperature, wind, air pressure, humidity, and rainfall. | 2,52 | 1,15 |
| Global warming is an increase in the average temperature of the atmosphere, Earth, and oceans, which is closely related to climate change. | 2,28 | 1,20 |
| Climate change is a significant alteration in climate patterns, such as air temperature or rainfall, over a period of 30 years or more. | 2,61 | 0,95 |
| Humans are one of the main causes of climate change. | 2,32 | 1,25 |
| The *Adiwiyata* school program is a form of initiative that supports climate change mitigation. | 2,31 | 1,48 |

The survey results indicate that respondents' knowledge of climate change is relatively low to moderate, with mean scores ranging from 2.23 to 2.78. The standard deviation values are quite high (0.95 to 1.53), suggesting significant variation in respondents' understanding. The highest mean score (2.78) is associated with the statement about the greenhouse effect resulting from burning fossil fuels, indicating that respondents are more familiar with this concept compared to other aspects of climate change. However, their knowledge of fundamental climate change elements, such as temperature, wind, air pressure, humidity, and rainfall (M = 2.52, SD = 1.15), remains moderate. This suggests that while some respondents possess a solid understanding, many still lack comprehensive knowledge about climate change and its causes.

A deeper understanding enables students to connect theoretical knowledge with real-world environmental challenges. Table 4 presents the survey results regarding students' understanding of climate change, precisely their understanding of its causes, impacts, and interconnections with various environmental and societal factors.

**Table 4. Student's Understanding Level Results**

|  |  |  |
| --- | --- | --- |
| **Indicators** | **M** | **SD** |
| Prolonged drought is one of the impacts of climate change. | 2,30 | 1,25 |
| Climate and weather play an essential role in sustaining life. | 2,23 | 1,32 |
| Differences in climate across various regions in Asia are largely influenced by topography. | 2,54 | 1,00 |
| The agricultural sector is highly vulnerable to climate change as it affects planting patterns, crop cycles, production, and yield. | 2,57 | 1,20 |
| Climate is closely linked to rainfall, with influencing factors such as air temperature, humidity, wind speed, and wind direction. | 2,56 | 1,04 |
| The greenhouse effect results from burning fossil fuels without environmental considerations, leading to climate change. | 2,78 | 1,07 |
| Hot weather, drought, and clean water crises in various regions are adverse impacts of climate change. | 2,55 | 1,36 |

Respondents' understanding of the impacts of climate change is also at a low to moderate level, with mean scores ranging from 2.23 to 2.57. The standard deviation values (1.00 – 1.36) indicate slightly less response variability than knowledge-related items. Notably, respondents seem to have more understanding of climate change's impact on the agricultural sector (M = 2.57, SD = 1.20) and its link to rainfall and other climatic factors (M = 2.56, SD = 1.04). This suggests they recognize how climate change affects food production and natural weather patterns. However, the relatively lower scores for statements related to climate and weather's essential role in sustaining life (M = 2.23, SD = 1.32) indicate that respondents may not fully grasp the broader ecological consequences of climate change.

Translating climate change knowledge and awareness into concrete actions is a critical aspect of ecopedagogy. Table 5 presents the survey findings on students’ self-reported engagement in climate change mitigation activities, highlighting the extent to which they incorporate pro-environmental actions into their daily lives.

**Table 5. Student's Action Level Results**

|  |  |  |
| --- | --- | --- |
| **Indicators** | **M** | **SD** |
| I sort and dispose of waste according to its category. | 2,28 | 1,27 |
| I turn off lights and other electronic devices when not in use. | 2,47 | 1,61 |
| I use public transportation. | 2,09 | 1,08 |
| I share information or participate in climate awareness activities such as campaigns or discussions. | 2,83 | 1,19 |
| I read or seek information about climate change from various sources. | 2,12 | 1,26 |
| I sort and dispose of waste according to its category. | 2,28 | 1,27 |
| I turn off lights and other electronic devices when not in use. | 2,47 | 1,61 |

Respondents' engagement in climate change mitigation activities also falls within the low to moderate range, with mean scores between 2.09 and 2.83. The standard deviation values (1.07 – 1.61) indicate considerable variation in individual actions. The highest mean score (2.83) is found in sharing information or participating in climate awareness activities, suggesting that respondents are more inclined to spread awareness rather than take direct action. In contrast, the lowest mean score (2.09) is related to using public transportation, indicating a reluctance to adopt environmentally friendly commuting habits. Other mitigation behaviors, such as turning off lights and electronic devices (M = 2.47, SD = 1.61) and sorting waste properly (M = 2.28, SD = 1.27), also show relatively low adoption rates. This highlights the need for more substantial initiatives to encourage behavioral change beyond information-sharing efforts.

**3.2 Regression Analysis Results**

The regression analysis aims to examine the relationship between respondents' knowledge and understanding of climate change and their climate-friendly behaviors. The results indicate a strong correlation, with an R-squared value of 0.476, meaning that approximately 47.6% of the variance in climate-friendly behaviors can be explained by the respondents' knowledge and understanding.

The ANOVA test confirms that the regression model is statistically significant (F = 163.05, p < 0.001), suggesting that at least one of the predictor variables significantly contributes to explaining the dependent variable.

Table 6 below presents the detailed regression coefficients. Both knowledge (β = 0.275, p = 0.001) and understanding (β = 0.430, p < 0.001) show significant positive relationships with climate-friendly behavior. This implies that as knowledge and understanding of climate change increase, individuals are more likely to engage in environmentally friendly actions.

**Table 6. Regression Analysis Results**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Predictor** | **Coefficient** | **Standard Error** | **t-Stat** | **P-Value** | **Lower 95%** | **Upper 95%** |
| **Intercept** | 0,431 | 0,0722 | 5.944 | 6.57E-09 | 0,288 | 0,574 |
| **Knowledge** | 0,191 | 0.084 | 3.284 | 0.001 | 0,0764 | 0,305 |
| **Understanding** | 0,299 | 0.089 | 4.829 | 2.04E-06 | 0,1770 | 0,420 |

These results highlight the importance of moving beyond basic knowledge dissemination to achieve a deeper understanding of climate change, particularly in *Adiwiyata* schools, which emphasize environmental education. Educational programs should not only provide factual information but also encourage critical thinking, problem-solving, and real-world applications of climate concepts (Cross & and Congreve, 2021).

**3.3 Challenges in Integrating Sustainability into *Adiwiyata* Schools**

The *Adiwiyata* program is designed to create environmentally responsible schools through sustainability-oriented curricula and initiatives. Quantitative analysis indicates that while students demonstrate moderate knowledge and understanding but lower engagement in climate action. These findings are reinforced by qualitative data from teacher and administrator interviews, which highlight that *Adiwiyata* programs predominantly focus on extracurricular activities rather than integration into formal learning. The findings from both the survey and interviews reveal three key challenges: the dominance of extracurricular activities in *Adiwiyata* implementation, the gap between sustainability integration and classroom learning, and teachers’ limited capacity to teach sustainability

**3.3.1 The Dominance of Extracurricular Activities in *Adiwiyata* Implementation**

Interview data reveal that most *Adiwiyata* programs are extracurricular rather than embedded into the curriculum. The task force at SMPN 1 Borobudur emphasized that environmental projects are often integrated into competitions rather than routine activities, which may explain why students struggle to apply sustainability concepts in daily life.

Many *Adiwiyata* initiatives, such as waste recycling and energy conservation projects, require external support from government agencies, private companies, or community organizations. However, interviews revealed that funding remains a significant obstacle. Schools rely on a mix of parent contributions, student fundraising (e.g., weekly donations), and corporate sponsorships (e.g., a partnership with Danone to promote reusable water bottles). Despite these efforts, task force members at SMPN 39 Semarang stated that *“some projects require external funding, but partnerships with environmental organizations remain limited.”* The limited financial resources restrict schools from expanding sustainability efforts beyond routine activities like waste segregation and occasional clean-up days. Without long-term financial planning and stronger collaborations with external stakeholders, schools may struggle to sustain and scale up impactful climate initiatives.

Apart from those, *Adiwiyata* schools rely on student-led programs, such as *Kader Adiwiyata*, to encourage peer participation in environmental activities. However, task force leader stated, *"Kader Adiwiyata struggles to mobilize their classmates, as many students need constant reminders to engage in eco-friendly behaviors."* This finding is consistent with the survey results, which show that students were more likely to participate in awareness-spreading activities (M = 2.83, SD = 1.19) rather than actively engage in behaviors like sorting waste (M = 2.28, SD = 1.27) or using sustainable transportation (M = 2.09, SD = 1.08). The discrepancy suggests that while students are willing to discuss climate issues, translating discussion into consistent behavioral change remains challenging.

Similarly, responses from SMPN 1 Mungkid (MGKD 1) highlight that while students participate in monthly activities like "Jumat Bersih" (Clean Friday) and manage school garden projects, these efforts are often short-term and lack long-term reinforcement strategies. This suggests that project-based learning in *Adiwiyata* schools needs to be sustained over time to encourage long-lasting behavioral change.

**3.3.2 The Gap Between Sustainability Integration and Classroom Learning**

While *Adiwiyata* assessment criteria require sustainability to be integrated into learning modules, implementation in classrooms remains minimal. Although sustainability-based learning modules exist, findings from SMP 1 Borobudur and SMP 13 Semarang task forces suggest that sustainability topics are only embedded in specific subjects, such as Science and Social Studies, while other disciplines remain largely uninvolved. Regression analysis further indicates that deeper environmental understanding (β = 0.43, p < 0.001) significantly contributes to student participation in climate action. However, students struggle to internalize sustainability concepts in different learning contexts without a cross-disciplinary approach.

**3.3.3 Teachers’ Limited Capacity to Teach Sustainability**

A major obstacle in integrating sustainability into classroom instruction is teachers’ lack of expertise and training in environmental education. Although sustainability topics are integrated into the *Adiwiyata* curriculum, many teachers lack the confidence and expertise to teach climate-related subjects effectively. Focus group discussion with 5-7 teachers from each school indicated that while some teachers actively engage with environmental issues, others struggle to incorporate climate content due to insufficient training and resources. Without proper instructional support, students may acquire factual knowledge but lack the deeper comprehension necessary for behavioral change.

**3.3.3 Weak Monitoring and Evaluation in *Adiwiyata* Implementation**

A structural weakness in the *Adiwiyata* program is the monitoring and evaluation system, which focuses more on documenting extracurricular activities than assessing sustainability integration in formal education. Document analysis reveals that indicators require schools focus on administrative reports and activity records rather. This weak evaluation framework allows schools to fulfill *Adiwiyata* requirements without genuinely integrating sustainability into their curricula.

Interviews with the Environmental and Forestry Agency (DLHK) reveal *Adiwiyata* programme actually prioritize context-based environmental solutions, such as SMPN 39 Semarang’s biopore system addressing local water management issues, but most schools still focus on infrastructure provision rather than curricular integration. DLHK acknowledges that only a small portion of *Adiwiyata*’s assessment criteria directly evaluate the extent to which sustainability is embedded in formal learning, limiting its impact on students' ecological literacy.

The findings of this study indicate that students in *Adiwiyata* schools possess low to moderate levels of climate change knowledge, with variations in their comprehension of key environmental concepts. While students may be aware of climate change as a general phenomenon, their understanding of specific causes, impacts, and mitigation strategies remains limited. These findings align with previous studies highlighting the challenges in climate change education, particularly among secondary school students (García-Vinuesa et al., 2024; Shepardson et al., 2011).

A study by Kim et al. (2024) in South Korea and Indonesia found similar trends, where students demonstrated a basic awareness of climate change but lacked in-depth comprehension of its scientific mechanisms and long-term consequences. This gap underscores the need for more targeted educational interventions to enhance students’ conceptual understanding.

The knowledge-action gap in *Adiwiyata* schools stems from an overreliance on extracurricular activities like tree planting and waste management campaigns, which, while raising awareness, fail to integrate sustainability into formal learning. This fragmented approach aligns with Tilbury (2011), who argue that effective environmental education requires curricular integration rather than peripheral activities. Studies by Mogensen & Schnack (2010) and Ardoin et al. (2018) further highlight that student-led initiatives alone rarely lead to lasting behavioral change without structured teacher involvement and systematic monitoring.

Our findings suggest that environmental topics are not comprehensively embedded in the curriculum, leading to an inconsistent and moderate understanding of climate change among students. Studies have shown that effective environmental education requires interdisciplinary integration, where climate change concepts are incorporated into science, social studies, and even mathematics (Monroe et al., 2019; Stevenson et al., 2018). However, in *Adiwiyata* schools, such integration remains minimal, largely due to teachers’ limited knowledge and pedagogical preparedness in environmental education.

Many educators lack specialized training or access to updated materials on environmental issues, leading to a reliance on generic textbook content that fails to capture the urgency and complexity of climate change. This gap is not only a matter of individual teacher preparedness but also reflects broader structural barriers within the school ecosystem. Institutional support, including education policies that mandate ecopedagogical integration, targeted teacher training, and systematic curriculum development, is often insufficient. Research underscores that professional development and institutional commitment are critical for fostering effective environmental education (Ardoin et al., 2018; Reid et al., 2021). Without these systemic supports, teachers struggle to contextualize climate-related content, limiting students' ability to translate theoretical knowledge into meaningful climate action.

4. Conclusion

In conclusion, the inability of *Adiwiyata* schools to bridge the knowledge-action gap from an overreliance on extracurricular activities, weak curriculum integration, insufficient teacher knowledge, and ineffective monitoring systems. Future policies should focus on embedding environmental education across disciplines, providing teachers with continuous professional development, and establishing clear indicators to assess the impact of *Adiwiyata* programs on student behavior.

This study has several limitations. First, while the quantitative analysis establishes the relationship between knowledge, understanding, and action, it does not explore the underlying cognitive or motivational factors that influence this process. Lastly, future research should explore intervention models that integrate ecopedagogy principles into teacher training programs, ensuring that sustainability is not only taught but critically examined and internalized by both educators and students.

**Disclaimer (Artificial intelligence)**

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Details of the AI usage are given below:

1. Chat GPT on reviewing the initial translation of the manuscript from authors native language to English.

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