Global warming's effects on marine and coastal environments: Students' knowledge, attitudes, and environmental behaviour

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Abstract
Global warming poses serious threats to marine and coastal environments, especially in island and shoreline communities like Kijang Kota in the Riau Islands, Indonesia. Despite the urgency of this issue, research on how students in such vulnerable areas understand and respond to global warming remains limited. This study aims to assess the knowledge, attitudes, and environmental behaviors of junior high school students in Kijang Kota regarding global warming and its effects on the marine and coastal environment. Using a descriptive quantitative approach, data were collected through tests and questionnaires from a sample of 304 students, selected through stratified random sampling. The findings reveal that students' knowledge was generally low, with an average score placing them in the "poor" category. However, their attitudes toward environmental issues were "very good," reflecting high awareness and concern. In terms of environmental behavior, most students were in the "good" category, showing moderate engagement in eco-friendly actions. The results highlight a gap between students' strong environmental concern and their limited understanding and actions, pointing to the need for more practical, context-based environmental education in coastal schools. This research offers insights that can help improve climate education and promote more sustainable behavior in island and coastal communities.

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1. Introduction

The environmental issue that has become a concern for the world community in recent decades is global warming (Dhillon & von Wuehlisch, 2013; Nukusheva et al., 2021). This is a result of the rising levels of greenhouse gases accumulating in the atmosphere (Neubauer, 2021). Global warming has led to numerous issues on the planet, including a rise in Earth's overall temperature (Al-Ghussain, 2019; Kabir et al., 2023), which in turn contributes to the melting of polar glaciers and ice sheets (Kovadlo et al., 2022; Mutascu, 2025). Even more concerning, global warming has led to climate disruptions known as climate change (Abbass et al., 2022; Iyer et al., 2022; Lenton et al., 2023).

It is well known that the majority of the Earth's surface is covered by oceans. The Earth's oceanic expanse is significantly larger than its land area, with approximately 70% of the planet's surface covered by seas, leaving the remaining portion as land (Román-Palacios et al., 2022). With a very wide area coverage, the marine environment is also inseparable from the effects of global warming (Kang et al., 2021; Wang et al., 2024). Some of the detrimental effects on the marine environment include the increase in temperatures and rising sea levels (Martyr-Koller et al., 2021; Tebaldi et al., 2021a). Not only the marine environment, the coastal environment is affected by global warming (P. Roy et al., 2023; Subramanian et al., 2023). One of the consequences is tidal flooding in coastal regions as a result of rising sea levels (Aksa & Afrian, 2022; Pareja-Roman et al., 2023).

Human activities are the primary drivers of global warming. Several human activities, including the combustion of fossil fuels (Azni et al., 2023; Yue & Gao, 2018), deforestation (Panja, 2021), emissions from industrial exhausts (A. Roy & Pramanik, 2024), and motor vehicles use (Ercan et al., 2022) lead to increased levels of greenhouse gases in the atmosphere, intensifying the worldwide effects of climate change. These various activities are what cause the increasing temperature on Earth (Soeder, 2025), so that the Earth becomes vulnerable to various disasters (Abbass et al., 2022).

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Global warming, which is mostly caused by various human activities, indicates low environmental awareness and concern in humans (Yilmaz & Can, 2020). Although humans are concerned about the effects of global warming (Munguia et al., 2023), many people continue to engage in activities that contribute to the acceleration of global warming (Lynas et al., 2021). This is in contrast to the ideal behavior, where it would be more beneficial for humans to adopt environmentally friendly practices (Farrukh et al., 2022). Human indifference to the environment not only damages the environment but will have bad consequences for human life itself (Gill et al., 2021; Liana et al., 2023; Sarkity et al., 2023).

Schools play a crucial role in fostering environmentally aware individuals by imparting knowledge and promoting character development (Zsóka et al., 2013). This is true for all schools, including those located in coastal regions. Given that the Earth is predominantly covered by oceans, the effects of global warming are particularly pronounced in marine and coastal areas, as discussed earlier. With the very real damage to the marine environment (Shukla et al., 2021) and coastal (Griggs & Reguero, 2021) due to global warming, schools in coastal areas should be pioneers in facing the challenges of climate change actively and sustainably (Roukounis et al., 2025).

Riau Islands (Kepri) is one of the provinces in Indonesia that has many islands and is dominated by coastal areas (Sidabutar & Indra, 2021). With these geographical conditions, Kepri has a long coastline (Wulandari et al., 2023). Given these regional characteristics, most people, including those attending schools, live in coastal areas. The substantial effects of global warming on marine and coastal environment pose both difficulties and prospects for schools in these areas (Gough, 2017). Such schools hold a key responsibility in fostering early awareness, shaping attitudes, and encouraging behaviors that highlight the importance of protecting coastal environments, especially in the face of global warming (Altassan, 2023). However, the extent to which this has been implemented remains unclear. Naturally, this can be incorporated through various subjects, such as Natural Science lessons for junior high school students. At this stage, students undergo cognitive and emotional development towards maturity, enabling them to think logically, grasp cause-and-effect relationships, and be receptive to the development of values and attitudes.

Although marine and coastal areas face pressing environmental challenges, there is a significant gap in research regarding how students in island and coastal communities perceive and react to the consequences of global warming. Most prior studies focus on broader populations or urban contexts, neglecting the specific vulnerabilities and environmental risks experienced by those living close to the sea (Ardoin et al., 2020; Simeoni et al., 2023). Furthermore, marine and coastal topics are insufficiently incorporated into formal environmental education programs, particularly in developing countries such as Indonesia (Glaser et al., 2015; Liefländer et al., 2013; Pazoto et al., 2023). The middle school period an essential phase for developing lasting environmental values has received little attention in climate education research (Stevenson et al., 2019; Szczepankiewicz et al., 2021). Additionally, although students often show concern for environmental problems, this concern does not consistently lead to concrete actions (Otto & Pensini, 2017), especially in regions already affected by climate change (Günther et al., 2022).

Consequently, this study aims to investigate the knowledge, attitudes, and environmental behaviors of junior high school students in Kijang Kota, Riau Islands, regarding global warming and its effect on marine and coastal environments. The research intends to evaluate students' understanding and examine the relationship between their awareness and actions, with the objective of guiding more effective environmental education tailored for coastal schools.

2. Method

This research was conducted from April to November 2024 in Kijang Kota, Bintan Regency, involving junior high schools in the area. It used a descriptive survey method with a quantitative approach. The participants were all junior high school students in Kijang Kota. This town was chosen because it is a coastal area where many people rely on the sea. As a result, students there may experience the direct effects of global warming, such as rising sea levels and changes in marine life. Studying students in this area helps us understand how they see these problems and how they act on them. Since it is a developing area, schools may not fully teach topics about the sea and coast. This study can help improve environmental education in similar coastal communities. Overall, the research stages are illustrated in the Figure 1.

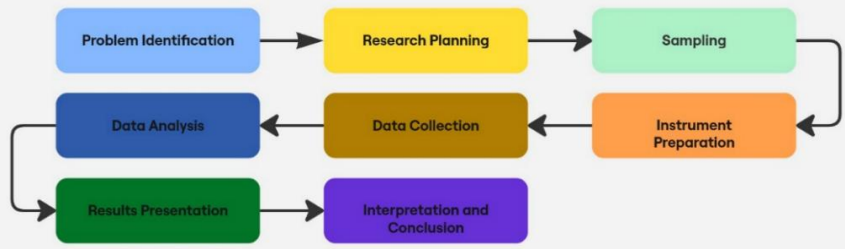

Figure 1. The research stages

There are two junior high schools in the area, and the details of the total population are provided in Table 1.

Table 1. Research population

No.	Name of schools	Number of students
1	X Junior High School	730
2	Y Junior High School	529
	Total	1.259

Using the Slovin Formula, a total of 304 students were selected as representative samples for this study. The required research sample, determined through the Stratified Random Sampling method (Patten & Newhart, 2017), is presented in Table 2.

Table 2. Research samples

No.	Name of schools	Number of students
1	X Junior High School	176
2	Y Junior High School	128
	Total	304

This study collected data through the use of tests and questionnaires. The test evaluated students' understanding, while the questionnaire assessed their attitudes and environmental behaviors concerning global warming and its effects on marine and coastal environment. All instruments used in this research were confirmed to be valid and reliable (Sarkity et al., 2024), with the reliability coefficients of the instruments outlined in Table 3.

Table 3. Reliability coefficients of the research instruments

No.	Instruments	Reliability coefficients
1	A test measuring students' knowledge	0,707
2	Questionnaire measuring students' attitudes	0,834
3	Questionnaire measuring students' environmental behavior	0,919

The grid of all research instruments is shown in Table 4 (Burkett & Davidson, 2012; Dong et al., 2024; Kah et al., 2021; McKinley et al., 2021; Singh, 2024; Takeshige et al., 2013; Ting & Stagner, 2021; Trégarot et al., 2024; Williamson & Guinder, 2021),

Table 5 (Bonneuil et al., 2021; Change & Behaviour, 2022; Chongkolrattanaporn, 2022; Dechezleprêtre et al., 2022; Thanya & Suganthan, 2023; UNEP, 2023), and Table 6 (Aoyagi et al., 2020; Banjac, 2024; Hamanaka & Didham, 2010; Kamil et al., 2020; King et al., 2021; Pickard et al., 2022; Rustam et al., 2020; Shutaleva et al., 2021; Yee et al., 2021; Yusliza et al., 2020).

Table 4. Grid of instrument for measuring the knowledge aspect

No.	Indicators	Number of items
1	Comprehension of the global warming concept	3
2	Knowledge about global warming's effects on the marine environment	4
3	Knowledge about global warming's effects on the coastal environment	3
4	Ability to analyse and evaluate challenges caused by global warming in the marine and coastal environment	3
5	Awareness and proactive measures to address the effects of global warming	2
	Total	15

Table 5. Grid of instrument for measuring the attitude aspect

No.	Indicators	Number of items
1	Awareness of global warming's effects on the marine and coastal environment	4
2	Attitudes toward taking action to protect marine and coastal environments from the effects of global warming	4
3	Participation in Environmental Activities	3
4	Attitudes towards Environmental Policy	3
5	Ability to convey and influence others regarding global warming	4
6	Involvement in Environmental Education	4
7	Attitudes towards Marine Resource Conservation	3
	Total	25

Table 6. Grid of instrument for measuring the environmental behavior aspect

No.	Indicators	Number of items
1	Involvement in environmental conservation efforts	3
2	Taking part in cutting carbon emissions	7
3	Use of environmentally friendly energy sources	3
4	Advocacy and educational initiatives	5
5	Participation in environmental policy development	4
6	Contribution to environmental research and monitoring	3
	Total	25

Analysis of research data was carried out using a Likert scale (Albaum, 1997) using the following Equation 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Descriptions:

P = obtainted score (%)

f = actual score

N = maximum score

The percentage of students' environmental knowledge, attitudes, and behaviors, based on the data analysis, is categorized according to the criteria outlined in Table 7 (Riduwan, 2018).

Table 7. Categories of knowledge, attitudes, and environmental behavior

No.	obtained score (%)	Categories
1	$75 \leq P \leq 100$	Very good (VG)
2	$50 \leq P < 75$	Good (G)
3	$25 \leq P < 50$	Poor (P)
4	$0 < P < 25$	Very poor (VP)

After being categorized, the data from the analysis results are descriptively presented in various representations in the form of tables or graphs. Tables and graphs are ways of presenting descriptive data that can make it easier for readers to understand research information (Schwabish, 2023).

3. Results and Discussion

The findings of this study will be presented in three sections, corresponding to the variables assessed, with the following details.

3.1. Students' knowledge

According to the research findings, students' knowledge regarding global warming and its effects on the marine and coastal environment falls into several categories for each question indicator. The categories of students' knowledge, based on the question indicators, are presented in Table 8 as follows.

Table 8. Categories of students' knowledge

Indicators	Score obtained (%)	Categories
1	42.98	P
2	52.80	G
3	37.94	P
4	53.40	G
5	43.75	P
Average	46.17	P

The results in Table 8 show that students' knowledge about global warming and its effects on the marine and coastal environment is generally low. Out of the five indicators assessed, only two—knowledge about effects on the marine environment and ability to evaluate challenges—were in the G category. The other three indicators, including understanding of global warming and its impact on the coast, fell into the P category. The average score for all indicators also places students in the P category.

In addition to this, Figure 2 shows how individual students were grouped based on their level of knowledge. Most students were still in the P category, confirming that their understanding of global warming remains limited. This lack of knowledge is concerning, especially because global warming is a major global issue that continues to affect marine and coastal areas (Bonneuil et al., 2021; Lincoln et al., 2021; Tebaldi et al., 2021b). One of the most effective ways to address this issue is through education (Jones & Davison, 2021; Leal Filho et al., 2021). Education can help students understand how global warming works and what its long-term impacts are (Aini et al., 2023; Molthan-Hill et al., 2019; Safarati & Zuhra, 2023).

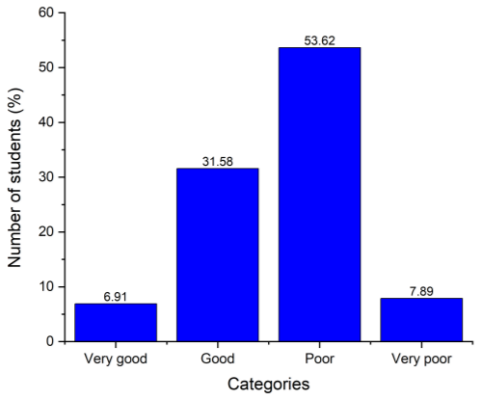

Figure 2. Categorization of students in each knowledge category.

It's important to teach students about global warming from an early age, especially in areas vulnerable to climate change (Morote & Hernández, 2022). They are the future generation who will be responsible for protecting the environment (Dzimińska et al., 2020; Ningsih & Akhyar, 2024; Sarkity et al., 2023). With better knowledge, students can develop stronger awareness and responsibility, which may lead to more positive attitudes and actions to reduce the impact of global warming (Dhir et al., 2021; Fu et al., 2020; Kurup et al., 2021; Tolppanen et al., 2022).

3.2. Students' attitudes

According to the research findings, students' attitudes fall into several categories for each question indicator. The categorization of students' attitudes regarding global warming and its effects on these environments is presented in Table 9 as follows.

Table 9. Categories of students' attitudes

Indicators	Score obtained (%)	categories
1	79.95	VG
2	83.18	VG
3	74.07	G
4	79.99	VG
5	72.27	G
6	71.40	G
7	82.40	VG
Average	77.61	VG

The results in Table 9 show that students' overall attitudes toward global warming and its effects on the marine and coastal environment fall into the VG category, with an average score of 77.61%. Out of the seven attitude indicators, four fall in the VG category, including awareness of global warming, support for environmental policies, and marine conservation. The remaining three—participation in environmental activities, influencing others, and involvement in environmental education—are in the G category.

Figure 3 shows the distribution of individual student attitudes. Most students (62.17%) are in the VG category, while 37.83% fall into the G category. Importantly, none of the students were categorized as having P or VP attitudes, which shows a generally strong environmental concern among them.

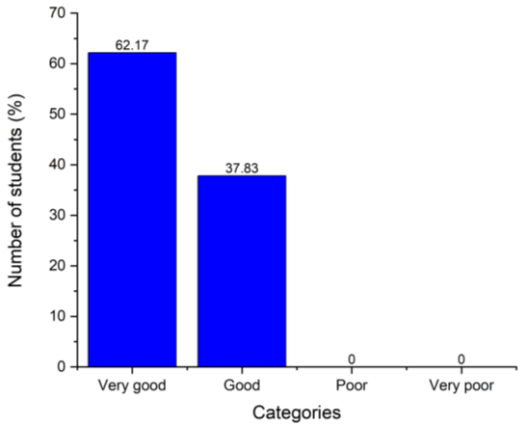

Figure 3. Categorization of students in each attitude category.

However, when compared to their knowledge, a contrast appears. While students show strong attitudes, their knowledge is still low, as previously shown in Table 8. Many students struggle to understand the basic concept of global warming and its coastal impacts. This reflects earlier studies that found limited integration of marine and coastal issues in environmental education in countries like Indonesia (Liefländer et al., 2013; Pazoto et al., 2023).

The gap between high attitudes and low knowledge might be explained by external influences, such as social media, public campaigns, or community discussions, which can shape students' views even if schools don't teach much about these topics (Getie, 2020; Goodwin, 2020; Zhang et al., 2022). While strong attitudes are a good foundation, they need to be supported by solid knowledge and real-world experiences. Schools should include local examples and offer more hands-on environmental activities to help students better connect their feelings with actions (Ardoin et al., 2020; Leal Filho et al., 2021; Stevenson et al., 2019).

3.3. Students' environmental behaviour

According to the research findings, students' environmental behavior falls into several categories for each question indicator. The categorization of students' environmental behavior related to global warming and its effects on the marine and coastal environment is presented in Table 10 as follows.

Table 10. Categories of students' environmental behavior

Indicators	Score obtained (%)	categories
1	51.89	G
2	69.26	G
3	57.57	G
4	48.66	VG
5	59	G
6	52.15	G
Average	56.42	G

Based on the results in Table 10, students' overall environmental behavior related to global warming and its effects on the marine and coastal environment is rated as G, with an average score of 56.42%. Among the six indicators, five fall into the G category, such as participation in conservation, reducing emissions, using clean energy, and supporting environmental policies and research. Only one indicator—Advocacy and Education—was rated VG, suggesting that students are confident in spreading awareness and educating others about environmental issues.

Figure 4 shows the distribution of students by environmental behavior category. Most students (44.41%) showed G behavior, 18.75% were in the VG group, and 36.84% were in the P category. None of the students were placed in the VP category.

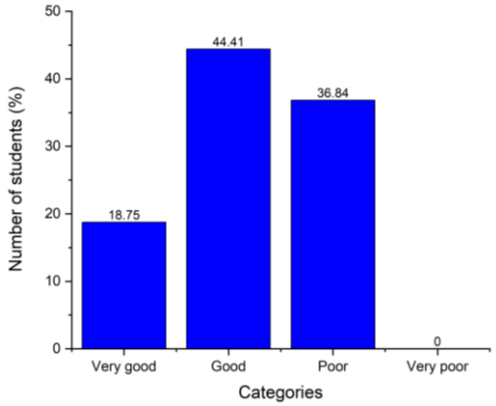

Figure 4. Categorization of students in each environmental behavior category

These results are encouraging but also highlight areas for improvement. While students have positive attitudes, many are not yet taking consistent environmental actions in their daily lives. This gap between attitudes and behavior is common and has been noted in earlier studies (Fu et al., 2020; Otto & Pensini, 2017). Some reasons for this may include a lack of access to eco-friendly options, limited real-life experience, or low confidence in their ability to make a difference (Shafiei & Maleksaeidi, 2020).

Since human behavior is a key driver of global warming (Lynas et al., 2021; Yoro & Daramola, 2020), improving students' environmental behavior is especially important in vulnerable areas like coastal regions. It's not just about reducing carbon emissions (Ahmed Ali et al., 2020), but also about engaging students in local conservation projects, sustainable practices, and environmental monitoring (Grilli & Curtis, 2021; Kamil et al., 2020; Senbel et al., 2014). To improve student behavior, schools need to offer more practical, hands-on learning opportunities, especially in coastal communities. Education should help students connect knowledge and attitudes with real-world action by involving them in projects, community activities, and programs that build environmental responsibility and leadership (Ardoin et al., 2020; Leal Filho et al., 2021; Molderez & Fonseca, 2018).

4. Conclusion

The results showed that students' knowledge about global warming and its effects on marine and coastal environments was in the P category. Many students struggled to understand the basic concepts of global warming and its specific effects on marine and coastal environment. In contrast, their attitudes were in the VG category. Most students demonstrated strong concern for environmental issues, including support for environmental policies, awareness of climate change, and commitment to marine conservation. Their environmental behavior was in the G category overall. While students were active in advocacy and sharing information, their participation in direct actions such as conservation efforts, reducing emissions, and using eco-friendly energy was still limited. These findings highlight a clear gap between students' knowledge, attitudes, and environmental behavior. While they care deeply about the environment, their understanding and daily actions do not always align, suggesting a need for more hands-on and locally relevant environmental education.

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All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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