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Climate Change Awareness for a Sustainable Future: Exploring the Using of Eco-Friendly Transportation among Indonesian Students and Campuses

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Abstract: Universities such as higher education institutions and science and technology developers also have a responsibility in developing a sustainable campus environment. The implementation and provision of Eco-Friendly Transportation (EFT) is one way to achieve environmental sustainability in the campus environment. This study aims to decide student perceptions of climate change mitigation awareness on the use of EFT, decide the implementation of innovative strategies for providing EFT, and analyze the barriers and opportunities for EFT implementation on several campuses in Indonesia. This research is a type of mixed methods research with survey, direct systematic observation, walk-in audits, and descriptive qualitative. Data analysis was conducted using descriptive statistics with the help of the SPSS version 22 application. The results show that student perceptions of climate change mitigation awareness at mean score 78.82, the indicator with the highest score is environmental attitudes at mean score 33.4. In addition, statistical analysis showed a good correlation between students' perceptions and field observations, which showed that many students use EFT on campus for their mobility. This study provides recommendations for practical steps that can be taken to overcome existing barriers, while creating a greener and more sustainable campus environment.

Keywords: Climate change awareness; Eco-Friendly Transportation; Green campus; Sustainable campus environment; Pro-environmental behavior; Sustainable future

1 Introduction

Motor vehicles, which are heavily dependent on fossil fuels, are the main cause of carbon emissions on Earth and continue to increase every year. Motor vehicles produce and release 87% of hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and fine particles (PM) into the atmosphere [1, 2]. CO emissions from motor vehicles rose from five billion tons per year to thirty-five billion tons per year during the 20th century. As the number of students at Indonesian universities has increased, so has the use of motor vehicles on campus. This also indicates an increase in carbon emissions due to the use of motor vehicles in campus areas. The increase in carbon emissions from motor vehicles necessitates the extended use of more environmentally friendly vehicles as an effort to reduce carbon emissions in the air within campus areas. The increased use of motor vehicles on campus can lead to an imbalance in environmental sustainability. As a result, the effort to utilize environmentally friendly vehicles is the responsibility of all academics on campus to support environmental sustainability.

Efforts to use environmentally friendly vehicles can be implemented in the form of Eco-Friendly Transportation (EFT) modes. This can increase the involvement of the academic community in shaping a sustainable campus ecosystem. EFT is an important component in the broader field of sustainable development, while the choice to use motorized vehicles has significantly increased pollution and greenhouse gas emissions, demanding an immediate solution to this problem [3]. The use of EFT is often considered to have barriers and constraints in creating a sustainable campus environment.

Barriers and challenges to sustainable transportation implementation on several campuses around the world. Barriers to the selection of environmentally friendly transportation modes are related to the availability of transportation modes, accessibility, time constraints, financial situation, and other individual factors [4–6]. Several studies have revealed that the main barrier to cycling is the lack of adequate cycling infrastructure [7, 8]. Some people also stated

that using sustainable modes of transportation is not cool [8, 9]. Using EFT such as cycling and walking may result in coworkers not respecting the efforts made [9]. Pollution caused by motorized vehicles can also discourage the academic community from walking or cycling. Pollution caused by motorized vehicles can also discourage the academic community from walking or cycling [10–12]. Broken bus stops and long shuttle bus waiting times result in the academic community choosing other modes of transportation [13, 14]. Therefore, various obstacles and barriers to the use of EFT must be minimized by continuing to monitor and evaluate the provision of EFT to provide a sense of security and comfort for its users.

One of the steps to monitor and assess the provision of EFT in the campus area is to implement a green campus program. Green campus as an initiative to build a sustainable campus environment has indicators related to the implementation of EFT which is presented in Table 1 [15, 16]. Indicators that can be used to assess the sustainability of the campus environment in the transportation sector include the availability of EFT modes, the number of initiatives to reduce the use of motorized vehicles, the provision of pedestrian facilities and accessibility for people with disabilities, and the number of vehicles entering the campus area [15, 17]. Through this green campus program, it can also encourage the implementation of sustainable practices in the campus area by examining the challenges and obstacles in implementing EFT. Therefore, the implementation of the green campus program has great urgency to build an EFT ecosystem in the campus area.

Table 1. University of Indonesia (UI) green metric indicators on transportation criteria

No.	Indicators
TR1	The total number of vehicles (cars and motorcycles with combustion engines) divided by the total campus' population
TR2	Shuttle services
TR3	Zero Emission Vehicles (ZEVs) availability on campus
TR4	The total number of Zero Emission Vehicles (ZEVs) divided by the total campus population
TR5	The ratio of the ground parking area to total campus area
TR6	Program to limit or decrease the parking area on campus for the last 3 years
TR7	Number of initiatives to decrease private vehicles on campus
TR8	Pedestrian path on campus

Source: UI GreenMetric, 2024. https://greenmetric.ui.ac.id/wp-content/uploads/2024/06/2024-UI-GreenMetric-Questionnaire-1.pdf

Creating an EFT ecosystem on campus and mainstreaming environmental education is a breath of fresh air in the sustainable development goals: quality education (SDG4) and sustainable communities and cities (SDG11). The quality of education services can also depend on the provision of environmentally friendly transportation. Successful implementation of sustainability practices on campus, model development, and monitoring and evaluation to guide and oversee sustainable approaches [18]. The impact of the EFT ecosystem on the quality of living environment in the campus area is huge and needs to be improved. Environmental and social aspects should be considered to determine the characteristics of environmentally friendly mobility [19]. Campuses have the capacity to change mobility behaviors and by measuring environmental impacts, campuses can address quality gaps that inhibit the use of EFT as an accelerated strategy for sustainable campus environments [20, 21].

EFT management in the campus environment enables constructive changes in the pro-environmental behavior of the academic community. In addition, improving the experience of using EFT, providing adequate facilities, and promoting well-being in using EFT can be an effort to familiarize the academic community to take part in keeping the quality of the campus environment. However, the scale of EFT implementation lacks support from the campus and needs to evaluate sustainability initiatives [22, 23]. Limited infrastructure, financing, and cultural resistance are some of the challenges the campus faces in implementing EFT. This shows the need for a comprehensive approach that includes education and habituation to encourage the use of EFT. Therefore, there is a need for collaboration between universities, the government, and the private sector in developing EFT infrastructure and technology.

Although many studies have explored environmentally friendly transportation in urban and institutional settings, few have specifically examined the behavioral relationship between climate change awareness and transportation choices among students, particularly within Indonesian higher education institutions. Existing literature often emphasizes the development of infrastructure, policy frameworks, or technical solutions to promote sustainable transportation, while the role of climate awareness and environmental values among students as drivers of environmentally friendly transportation choices remains under-explored.

Several studies in the Southeast Asian or Indonesian context often focus on general environmental attitudes without linking them to specific mobility behaviors in campus life. There is also a lack of comparative or context-sensitive analysis across various university environments in Indonesia, limiting the development of effective interventions tailored to student behavior and local environmental conditions. Therefore, this study offers a new contribution by examining how climate change awareness influences students' decisions to adopt environmentally friendly transportation and how campus-level sustainability efforts interact with individual environmental values. This

integrated approach bridges psychosocial and institutional perspectives in promoting sustainable mobility among young people.

The implementation of innovative strategies for providing EFT as an effort to create a sustainable campus is a possibility that can be realized. Based on many studies that have been conducted, the provision and implementation of EFT in the campus area gives an opportunity for the academic community and the surrounding community to take part in creating a sustainable campus environment ecosystem. Considering the potential, benefits, and challenges, this research looks to answer the question of what the level of climate change awareness among students is and whether innovative strategies for providing EFTs for a sustainable campus environment are possible to implement. Therefore, this study aims to decide student perceptions of climate change awareness, decide the implementation of innovative strategies for providing EFT, and analyze the barriers and opportunities for EFT implementation in among campuses in Indonesia.

2 Literature Review

2.1 Students' Climate Change Awareness

The topic of climate change is currently being discussed in various circles of society, and some have even made climate change a climate crisis status [24–26]. Global warming and weather anomalies have impacts of climate change that disrupt human activities. Increased carbon and greenhouse gas emissions are one of the main causes of climate change in the world. The widespread use of motorized vehicles plays a role in the increase of carbon emissions. Given the significance of climate change mitigation to prevent worse conditions, it is expected that university students, as the educated younger generation, are aware of the effects of climate change [27, 28]. Universities have a significant role in incorporating climate change issues into the curriculum, which can deepen students' understanding of climate change [29, 30]. Therefore, universities should promote climate change issues so that students understand how to respond to climate change.

In this context, universities play an important role in educating students on climate change issues through knowledge, values and attitudes [31, 32]. Understanding the cause-and-effect relationships and mechanisms behind behavior can be an opportunity to achieve desired outcomes through education, as education and awareness-raising can help individuals make more conscious and socially responsible decisions, thereby reducing climate change impacts and increasing community resilience [33, 34]. There is convincing evidence that education plays a significant role in preparing society for climate change [35] by increasing individual knowledge and awareness, thereby impacting behavior and lifestyle, and preparing students for a sustainable future [36–38]. Students' attitudes and behaviors regarding climate change are crucial for successful environmental conservation, as they will be the decision-makers in society in the future [39–41].

Generally, the level of college students' awareness of change differs from country to country [42–45]. Previous studies have prioritized different educational levels of students (e.g., middle school, high school, undergraduate, and graduate) [46]. However, they usually focus on one particular faculty or major, such as health, engineering, or business [47–49]. For example, studies [39, 40] investigated climate change understanding among nursing students in Spain, while study [50] explored university students' knowledge of climate change in Serbia. However, few studies have examined students' understanding of climate change across different educational institutions. Thus, the aim of this study was to understand students' views on climate change awareness across several Indonesian campuses.

RQ 1: How students' climate change awareness (SCCA) level among campuses in Indonesia?

2.2 Innovative Strategies for the Implementation of Eco-Friendly Transportation in Campuses

Universities have a significant role to play in promoting the use of green transportation. This has encouraged higher education institutions to demonstrate that there is added value in a higher education system that is conscious of environmental sustainability [28, 51, 52]. In addition, the implementation of EFT can show that the academic community and graduates have an understanding and awareness of the environment [52–54]. Most campuses have planning, management of green transportation development, and mobility-related goals for academicians [55–57]. Therefore, universities that want to develop an ecosystem of EFT need to consider access and infrastructure in the campus area.

Academics' mobility has a significant impact on transport mode choice and travel behavior to campus areas [56]. This influence on mobility and the relationship with distance, transportation mode choice, and infrastructure has implications for sustainability and environmental impacts. Most universities have made various efforts to create an environmentally friendly transportation ecosystem on campus [15, 28, 57]. The provision of electric vehicles, pedal bicycle facilities, cycling lanes, pedestrian walkways equipped with guiding blocks and lighting, shuttle services, and regulations relating to the provision of EFT in campus areas. Efforts to accelerate the use of EFT in the campus area cannot run optimally without the support of the local government. This is related to the provision of infrastructure and supporting modes of transportation in the area around the campus and where the academic community lives [58, 59]. Therefore, there is a need for collaboration between universities and local governments to realize the EFT ecosystem.

Green campus initiatives refer to the concept of developing a sustainable campus environment through the integration of university culture with increased environmental awareness and sustainability practices in all processes and activities. Learning activities, research, community service, and college governance through monitoring and evaluation must be based on sustainable environmental management. Green campus initiatives can improve the values and habits of the academic community and ensure the development of sustainable practices in society [55, 60]. Green campus programs can also stimulate the environmental awareness of academicians on the use of EFT in campus areas [61].

RQ 2: How innovative strategies for using EFT on several campuses in Indonesia?

2.3 Barriers and Opportunities of Implementation of Eco-Friendly Transportation in the Campuses

Higher education institutions support societal change by applying sustainability principles. Outlining a number of issues related to transportation sustainability in higher education institutions by reviewing available literature and assessing stakeholders' views on utilizing environmentally friendly modes of transportation [62, 63]. A number of constraints have been examined as major barriers affecting sustainable transportation systems in campus environments [64]. The results show that seven groups of safety factors, which include exposure to polluted environments, wild animal attacks, fear of heavy traffic, as well as inadequate infrastructure facilities, are considered as significant barriers to transportation sustainability [4].

The unavailability of representative infrastructure for efficient transportation operations also creates safety issues for individuals who use the same paths for walking and cycling as those used by public transportation services and private vehicles. Fewer parking facilities, no-motorized days, financial incentives for sustainable transportation users, as well as secure bicycle storage, can be implemented to improve sustainability conditions [60, 64]. Restricting heavy traffic in campus areas along with effective wildlife monitoring will also influence people's viewpoints and encourage a sustainable transportation culture. Longer distances and increased parking availability can reinforce the culture of private car use in campus areas [65]. Previous research has recommended the provision and use of safe cycling infrastructure [51, 56, 64, 66] as well as strategies to support bicycle use and shuttle services [67].

In the Indonesian context, students exhibit moderate to high environmental values but demonstrate inconsistency in their choices of sustainable mobility, often due to limited infrastructure, social norms, and comfort factors. Students' awareness of climate change is positively correlated with their attitudes toward the environment, but this is not consistently reflected in the use of environmentally friendly transportation such as cycling, walking, or public transportation. Exploring the role of campus-based environmental programs, the study found that institutional initiatives, such as green campus policies and transportation campaigns, significantly influence student behavior, but their effectiveness varies across universities. This reflects the need for localized strategies that integrate psychological factors (awareness and values) and structural factors (facilities and accessibility) in shaping sustainable transportation practices.

RQ 3: What are the barriers and opportunities in implementing EFT on several campuses in Indonesia?

3 Research Methodology

3.1 Research Design

This study applied quantitative and qualitative methods together in equal proportions. This method was used to address the research problem from both quantitative and qualitative perspectives, and to obtain more thorough, valid, reliable, and objective data. Various crucial steps were taken in the data collection process. Respondents were first selected based on their understanding and background relevant to the research topic. Secondly, each question in the questionnaire was carefully designed, so that respondents could understand the intended context and purpose. To ensure proper understanding, additional instructions and questionnaires distributed to respondents also provided the opportunity to complete informed consent for ethical considerations.

This process is expected to reduce the possibility of inappropriate answers or answers given without sufficient understanding of the research topic. To make the research instruments valid and dependable, validity and reliability testing was conducted on the questionnaire. In mixed-methods research, data validity testing is crucial for comparing findings from qualitative and quantitative methods. This is to ascertain whether the two types of data support, extend, deepen, or contradict each other. For the data obtained to be dependable, it is important to conduct prerequisite tests such as normality and homogeneity by utilizing IBM SPSS version 22 software.

3.2 Research Location

The research locations are divided into several universities in Indonesia that have conducted the concept of green campus in managing their campus environment. These universities include the University of Indonesia (UI), Bogor Agricultural Institute (IPB), Gadjah Mada University (UGM), Airlangga University (UNAIR), State University of Malang (UM), and Muhammadiyah University of Malang (UMM). Some of these universities were selected based on the UI GreenMetric ranking in 2024 on transportation criteria, which is presented in Table 2.

Table 2. University of Indonesia (UI) green metric ranking on transportation criteria in 2024

Universities	World Ranking	Indonesia Ranking	Score
Bogor Agricultural Institute (IPB)	26	3	1,700
Gadjah Mada University (UGM)	51	4	1,650
State University of Malang (UM)	128	10	1,575
Airlangga University (UNAIR)	140	12	1,550
University of Indonesia (UI)	192	17	1,500
Muhammadiyah University of Malang (UMM)	279	27	1,435

Source: UI GreenMetric, https://greenmetric.ui.ac.id/rankings/rankings-overview.

The selection of IPB University, UGM, UM, UNAIR, UI, and UMM was based on a purposive sampling strategy aimed at identifying the heterogeneity of higher education institutions in Indonesia. These six universities represent a cross-section of institutional types (public and private), academic orientations (general, agricultural, technological, medical, and pedagogical), and regional contexts with the highest student population density and campus-based environmental initiatives. Additionally, these universities are recognized for their advanced sustainability policies, involvement in green campus programs, and accessibility to various environmentally friendly transportation modes. They also differ in campus morphology (urban and peri-urban), student composition, and socio-environmental engagement levels, making them ideal for investigating the behavioral dimensions of climate change awareness in transportation choices.

From a theoretical perspective, the selection of these universities allows researchers to analyze the relationship between environmental attitudes, institutional influences, and behavior within diverse yet comparable campus transportation ecosystems. The diversity across the selected institutions strengthens the external validity of the research and enhances the transferability of its findings to the broader Indonesian higher education context, particularly in relation to studies on climate-responsive behavior and sustainable urban mobility.

3.3 Survey Method

This study used a cross-sectional survey method as a step to get responses from students regarding awareness of climate change. The questionnaire distributed consisted of several sections, including student perceptions based on demographics, understanding, behavior, habits, and intentions towards the use of transportation that has an impact on climate change. The questionnaire was validated through consultation with experts, who reviewed the questionnaire for content validation and pilot testing. The pilot evaluating the questionnaire was concerned with the ability of the questionnaire to accurately measure the variables in question.

The total population was 170,437 students across six campuses in Indonesia. To ensure representative data collection, this study applied a disproportionate stratified random sampling method to concentrate the selection on the six participating campuses. The six campuses were determined based on the UI GreenMetric ranking on transportation, while the campus selection was based on regional differences, namely campuses located in West Java, Yogyakarta, and East Java. The 347 participants consisted of students aged 19–25 years, with a gender composition of 53.1% male and 46.9% female, who came from various socio-economic backgrounds. The sampling method used Isaac and Michael's table with a significant level of 5%, which served to establish an appropriate and statistically valid sample size of 347 students, which is presented in Table 3.

Table 3. Number of research respondents

Universities	Number of Campus Members	Number of Respondents
Bogor Agricultural Institute (IPB)	18,876	38
Gadjah Mada University (UGM)	31,812	65
State University of Malang (UM)	34,033	69
Airlangga University (UNAIR)	27,342	56
University of Indonesia (UI)	29,995	61
Muhammadiyah University of Malang (UMM)	28,379	58
Total	170,437	347

The tool consists of 40 closed-ended questions, using a Likert scale of 1 (representing strongly disagree) to 4 (representing strongly agree). The quantitative measurement tool initially consisted of 45 questionnaire items, which were created with input from three experts. Subsequently, rigorous validity and reliability testing of the items

was conducted. In the initial stage, the validity of each item was measured using IBM SPSS software version 22, utilizing Pearson's Product Moment Correlation as a comparison tool. This analysis aims to determine the strength and direction of the linear relationship between two variables. SPSS version 22 was utilized in this study due to its reliability, user-friendly interface, and robust capabilities in handling social science data. It is well-suited for processing Likert-scale survey responses, performing data cleaning, and conducting both univariate and bivariate analyses efficiently.

Questionnaire items that showed a positive correlation with the total score were identified as empirically valid. The first stage focuses on the determination of variables, the selection of indicators drawn from existing data, the definition of instrument question items as elaborations of the indicators, and the drafting of the instrument. The measurement instrument framework was adapted from the UI GreenMetric indicators as a basic reference with modifications tailored to campus characteristics.

Item validation was conducted on a population that was different from the research sample but had similar characteristics. A total of 35 students were assessed with a 5% error rate, resulting in an r product moment table of 0.334. Thus, any item that has a Pearson correlation coefficient below this value is considered invalid. The final validity test yielded 40 valid questionnaire items, which were further assessed for reliability to ensure consistency in repeated application. The Cronbach's Alpha method was used, with reliability limits set at a value of more than 0.600. Based on the test results, the observed Cronbach's Alpha value was 0.824 for the 40 questionnaire items, indicating that the data has reliability and relevance in information collection.

Furthermore, the respondents' perspectives were evaluated, particularly the level of students' involvement in learning and research activities related to climate change issues, their level of knowledge on climate change issues, the extent to which students engage with climate change issues, and willingness to collaborate voluntarily in addressing climate change. Data analysis techniques using descriptive statistics assisted by SPSS version 22, descriptive analysis includes the calculation of mean, standard deviation, frequency tables, and graphs. Furthermore, this research delves deeper into the lifestyle of the academic community in using EFT observative to investigate activities, infrastructure availability, and utilization related to the use of EFT as an effort to mitigate climate change on campus. These analyses provide a foundational understanding of data patterns, support data quality assessment, and inform the selection of appropriate inferential techniques in subsequent stages.

3.4 Direct Systematic Observation and Walk-in Audits

Direct Systematic Observation is a direct observation method conducted with a systematic and structured approach to record certain behaviors, events, or conditions in an environment. In addition, Walk-in Audits are unannounced and unscheduled inspection methods conducted by going directly to the research site to evaluate the conditions, practices, and compliance with the use of EFT on campus. The data obtained is a series of photos that display the use of activities and environmentally friendly transportation facilities on campus. The technique of collecting data by selecting several locations that are in accordance with the research objectives, such as shuttle bus stops, bicycle parking locations, pedestrians, public electric vehicle charging stations, motorcycle parking locations, and campus gates. In addition, the research also traveled around the campus at various times and documented the mobility activities of the campus community. The qualitative visual materials approach is used to collect data in the form of photography that illustrates the situation and activities of using EFT in the campus area.

Data were analyzed quantitatively by calculating frequencies and percentages for each indicator across campuses, and qualitatively through field notes to capture contextual insights. Comparative analysis was employed to identify inter-campus variations, and findings were triangulated with survey responses to enhance validity. This approach enabled an objective assessment of the environmental conditions that may influence students' sustainable transport choices.

3.5 Documents Review

The document review method is a technique in qualitative research that aims to collect data through analyzing written documents relevant to the research topic. The purpose of using this method is to obtain in-depth information, confirm and strengthen quantitative data, and fill data gaps from other methods. The data obtained is the result of a documentary study that includes information on the barriers and opportunities perceived by the academic community in the use of environmentally friendly transportation. Data collection techniques used documentation studies, by reviewing campus planning documents, mobility policy data, and campus sustainability reports. Thematic analysis was used to identify themes related to barriers and opportunities for the use of environmentally friendly transportation on campus.

In mixed methods of research, process validation is crucial to ensure alignment between qualitative and quantitative data. This process aims to evaluate the appropriateness, explanations, depth, or differences of the results from both methods. In addition, data analysis plays a crucial role in understanding the relationship between research variables.

4 Results

4.1 Students' Climate Change Awareness in the Use of Eco-Friendly Transportation

The results of data collection on student perceptions of climate change awareness on the use of EFT involving 347 students from six campuses in Indonesia, showed scores in the excellent category. The climate change awareness questionnaire is designed to determine environmental knowledge (EK), environmental attitudes (EA), pro-environmental behavior (PEB), and environmental behavior intention (EBI) to conserve the environment to mitigate climate change using EFT on campus.

The results showed that most respondents gave scores of 4 (strongly agree) and 3 (agree) for all indicators of student sustainability awareness. Table 4 shows that students have a good perception (mean score 78.82) on using EFT and climate change mitigation on the campus. Indicators related to environmental attitudes received the highest number of strongly agree answers. Based on Figure 1 and Figure 2, it indicates that students have environmental awareness, which is manifested in their efforts to realize a sustainable university environment through EFT usage initiatives, utilization of new renewable energy sources, climate change mitigation strategies, and daily practices related to climate change mitigation. However, the level of environmental understanding shown by students is still relatively low. Indicators of environmental understanding relate to students' daily habits or activities that are consistent with student behavior towards the environment, in this case energy management and climate change mitigation.

Table 4. Result of students' climate change awareness (SCCA) on the use of Eco-Friendly Transportation (EFT) among Indonesian students

Variable	N	Mean	Median	Std. Deviation	Min	Max
SCCA	347	78.82	77.5	8.59	53.75	89.38

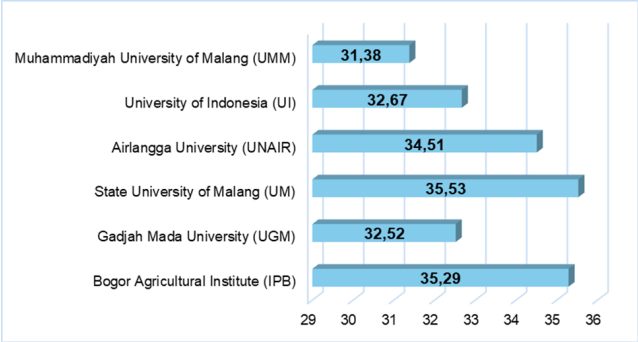

Figure 1. Result of students' climate change awareness (SCCA) mean score on the use of Eco-Friendly Transportation (EFT) by universities

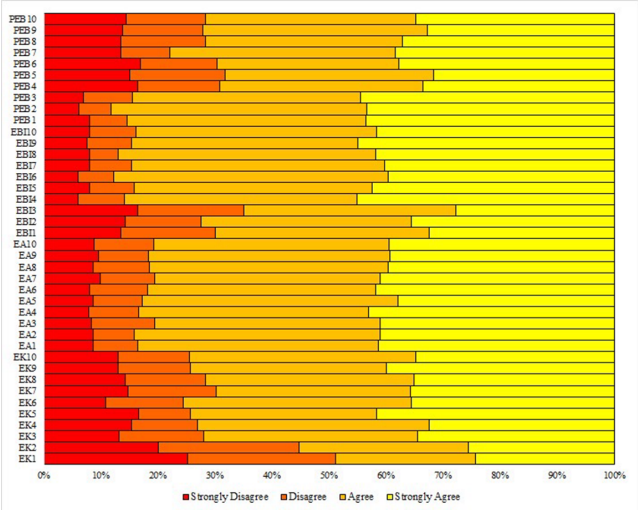

Figure 2. Percentage distribution of item responses

One important aspect of this research is the measurement of students' awareness of climate change, which is divided into several indicators. This is presented in Table 5, which shows that the environmental attitudes indicator has the highest mean value, which is 33.4. In addition, the environmental attitudes indicator gets a median value of 34, a mode value of 35, a standard deviation of 5.278, a minimum value of 15, and a maximum value of 40. The environmental behavior intention indicator gets an average value of 32.02, a median value of 32, a mode value of 34, a standard deviation of 4.843, a minimum value of 15, and a maximum value of 39. The pro-environmental behavior indicator gets an average value of 31.51, median value of 31, mode value of 34, standard deviation of 4.818, minimum value of 17, and maximum value of 38. The indicator that gets the lowest average score is environmental knowledge, which is 29.78, with a median value of 29, mode value of 33, standard deviation of 4.788, minimum value of 16, and maximum value of 37.

Table 5. Result of students' climate change awareness (SCCA) on the use of Eco-Friendly Transportation (EFT) based each indicator

Variable	N	Mean	Median	Std. Deviation	Min	Max
EK	347	29.78	29	4.788	16	37
EA		33.40	34	5.278	15	40
PEB		31.51	31	4.818	17	38
EBI		32.02	32	4.843	15	39

Note: EK: environmental knowledge, EA: environmental attitudes, PEB: pro-environmental behavior, EBI: environmental behavior intention.

Regression tests were conducted to determine the influence between SCCA variables. Regression tests were conducted to determine the influence of EK, EA, and EBI indicators on PEB. The results of this test are presented in Table 6. Based on the regression test results, variables with a significance level <0.05 indicate a significant influence between indicators. The findings indicate the EK and EBI variables have a significant influence on PEB, while the EA variable does not have a significant influence on PEB, which is presented in Table 7. Therefore, it can be concluded that EK and EBI can significantly increase PEB.

Table 6. Result of regression test of the pro-environmental behavior (PEB) as dependent variable

Variable	Adjust R Square	B	Std. Error	t	Sig.
(Constant)	0.143	17.361	1.900	9.316	0.000
EK		0.103	0.051	2.020	0.044
EA		-0.083	0.058	-1.415	0.158
EBI		0.392	0.062	6.331	0.000

Note: EK: environmental knowledge, EA: environmental attitudes, EBI: environmental behavior intention.

Table 7. Result of regression test of the environmental behavior intention (EBI) as dependent variable

Variable	Adjust R Square	B	Std. Error	t	Sig.
(Constant)	0.477	6.445	1.713	3.763	0.000
EK		-0.024	0.042	-0.572	0.567
EA		0.558	0.038	14.775	0.000
PEB		0.267	0.042	6.331	0.000

Note: EK: environmental knowledge, EA: environmental attitudes; PEB: pro-environmental behavior.

The characteristics of respondents in this study include university origin, year of entry, gender, age, and distance from residence to campus. The results of the demographic analysis of respondents are shown in Table 8. Based on the results of the demographic analysis of respondents, UM students filled out the questionnaire the most, namely 69 people (20%) and the least filled out the questionnaire were IPB students, namely 38 people (11%). Students who entered 2024 dominated in this study, with 110 people (31.7%) and the lowest were students who entered 2020 with 13 people (3.7%). In addition, more male students participated in this study, 187 people (53.9%) and 160 female students (46.1%). Students aged 20–22 years dominated this study with 142 people (40.9%) and students aged <20 years only numbered 23 people (6.6%). When viewed from the distance of the house to the campus, students who live within 1–3 km dominate as many as 140 people (40.4%) and the distance >6 km is the least, namely 15 people (4.3%).

Table 8. Demographic of respondents

Indicators	Description	F	%
Universities	Bogor Agricultural Institute (IPB)	38	11
	Gadjah Mada University (UGM)	65	18.7
	State University of Malang (UM)	69	20
	Airlangga University (UNAIR)	56	16
	University of Indonesia (UI)	61	17.6
	Muhammadiyah University of Malang (UMM)	58	16.7
Academic year	2020	13	3.7
	2021	55	15.8
	2022	73	21
	2023	96	27.8
	2024	110	31.7
Gender	Male	187	53.9
	Female	160	46.1
Age	<20	23	6.6
	20–22	142	40.9
	23–25	122	35.2
	>25	60	17.3
Distance from residence to campus	<1 km	82	23.6
	1–3 km	140	40.4
	4–6 km	110	31.7
	>6 km	15	4.3

4.2 Implementation of Innovative Strategies in the Use of Eco-Friendly Transportation

Based on observations, the implementation of EFT modes in the campus environment can form an environmentally friendly culture in the academic community and reduce the increase in carbon emissions. The development of infrastructure supporting environmentally friendly transportation ecosystems is also conducted by universities, such as providing pedestrians equipped with guiding blocks, Public Electric Vehicle Charging Stations (SPKLU), to provide EFT modes for free. The following are various innovative strategies for using EFT in several universities in Indonesia.

4.2.1 Bogor Agricultural Institute

IPB looks to reduce carbon emissions by improving the use of electric buses, which is presented in Figure 3. The replacement or addition of the campus bus fleet with electric buses is a significant step that is not only environmentally friendly but can be a pilot project for other campuses in Indonesia. In addition, the use of tracking technology to ensure the most efficient bus routes can reduce travel time and fuel usage. This reflects that the use of technology in campus transportation management is also a major focus of IPB. The development of a campus mobility application that provides real-time information on bicycle availability, bus position, and shuttle bus schedule is helpful in improving transportation efficiency. This application can also include a carpooling feature to encourage vehicle sharing among the academic community, thus reducing the number of private vehicles entering the campus.

Figure 3. Bogor Agricultural Institute (IPB) students utilize shuttle buses for mobility within campus

4.2.2 Gadjah Mada University

UGM's main initiatives is the use of Trans Gadjah Mada electric buses. This service is deliberately designed to provide environmentally friendly internal campus transportation for the academic community. These electric buses

not only help reduce carbon emissions but also provide comfort and efficiency in campus mobility. To increase the positive impact of Trans Gadjah Mada, UGM has made policies to expand the number of buses and bus stops and developed a mobile application that provides real-time information about routes, schedules, and surrounding traffic conditions. In addition, the "Bike to Campus" campaign and the provision of safe bicycle lanes have proven to help increase the participation of bicycle users, which is presented in Figure 4.

Figure 4. Gadjah Mada University (UGM) provides bicycles for mobility of academics and guests on campus

4.2.3 State University of Malang

UM is committed to creating an emission-free environment through various programs that focus on reducing the use of motorized vehicles, providing emission-free vehicle infrastructure, and building pedestrians for pedestrians, which is presented in Figure 5. UM also organizes the Car Free Day (CFD) program which is held every Friday of each week as an effort to increase awareness and involvement of the academic community in tackling increased carbon emissions. These various efforts are strengthened by the green campus program which aims to increase understanding and awareness in using environmentally friendly transportation. UM facilitates the use of environmentally friendly transportation by implementing regulations through rector regulations and circular letters for each faculty on transportation management within UM.

Figure 5. Car Free Day program, disability-friendly pedestrians, and bicycle parking lot at State University of Malang (UM)

4.2.4 Airlangga University

UNAIR has built separate and safe bicycle lanes, thus encouraging academicians to cycle to campus. In addition, UNAIR also provides wide sidewalks for pedestrians, ensuring the comfort and safety of the academic community who choose to walk around campus. UNAIR has provided Flash Shuttle Bus service, which is a campus transportation that uses regularly and free of charge connecting Campus A, B, and C Universitas Airlangga. UNAIR also adopted several policies to encourage the use of environmentally friendly vehicles on campus. In addition, UNAIR also eases charging for electric vehicles using a charging station helped by a cell phone application, namely BANGGA (Barata-Airlangga Electric Vehicle Charging Station), which is presented in Figure 6.

Figure 6. Availability of bicycle lanes and vehicle charging station at Airlangga University (UNAIR)

4.2.5 University of Indonesia

Transportation within the UI campus area assists the UI community in selecting EFT options that contribute to enhancing local air quality, health, and the comfort of mobility in the UI region. Limiting motorized vehicle access to campus areas, one of the efforts implemented by UI is to provide EFT transportation such as buses, bicycles, and scooters that can be used for free by the academic community, which is presented in Figure 7. UI created pedestrian paths, designed the BORR (Bikers Outer Ring Road) facility for cyclists, and implemented a gate parking system at each campus access to reduce and limit private vehicles. In addition, UI also implemented various policies such as reducing parking areas and prohibiting first and second semester students from bringing private vehicles into the campus area. This step was taken by UI to reduce the number of vehicles entering the campus area.

Figure 7. Availability of electric bicycle shelters for University of Indonesia (UI) academics

4.2.6 Muhammadiyah University of Malang

The implementation of innovative strategies in the field of transportation management at UMM includes limiting the use of motorized vehicles within the UMM area, by replacing them with the operation of electric cars for public transportation within the campus area. UMM applies rules for all motorized vehicles belonging to students, lecturers, staff, and guests to be parked outside the campus area. The existence of these rules, UMM helps by providing pedestrian paths for pedestrians equipped with guiding blocks for disabilities, lighting, and surveillance cameras, which is presented in Figure 8.

Figure 8. Bicycle lanes at Muhammadiyah University of Malang (UMM)

4.3 Barriers and Opportunities for Eco-Friendly Transportation Implementation

Several universities in Indonesia such as UI, IPB, UNAIR, UGM, UM, and UMM have a vision of creating a sustainable environment that is in line with the implementation of EFT. Universities as higher education institutions have the responsibility to accelerate a sustainable environment by involving all academicians in reducing carbon emissions [56, 68, 69]. This research analyzes the challenges and opportunities in the implementation of EFT on several campuses in Indonesia by exploring aspects that contribute to opportunities and shortcomings in the implementation of environmentally friendly transportation technology in campus areas. Therefore, EFT are believed to reduce air pollution and support sustainable environmental policies.

The implementation of EFT in the campus environment faces various complex barriers. One of the main barriers is the limited supporting infrastructure such as charging stations and dedicated lanes for electric vehicles. Without these facilities, the use of EFT becomes less practical and discourages the campus community from switching from fossil fuel vehicles. In addition, the initial investment cost for infrastructure development is also a significant obstacle, especially for educational institutions that have limited budgets [58, 64].

Another dominant obstacle is the cultural and behavioral resistance of the campus community. Many students, lecturers, and staff still have a strong preference for conventional vehicles due to convenience, habit, or ignorance of the benefits of EFT. Environmental behavior change requires a continuous educational approach to internalize the value of sustainability in the community [70–72]. Lack of socialization on the long-term benefits of using EFT also reinforces the resistance. Technical aspects related to the performance and reliability of EFT are also a challenge. Limited battery capacity, relatively long charging times, and limited mileage are factors that reduce the attractiveness of EFT among academics [4, 53, 73]. In addition, the limited choice of electric vehicle models suitable for mobility needs in campus areas, such as small vehicles or electric scooters, also narrows the opportunity for wider adoption.

Based on the observations made, despite structural, cultural, and technical barriers, the opportunity to implement EFT on campus remains significant. Strategic efforts that combine infrastructure development, campus community empowerment, strengthening environmental literacy, and multi-stakeholder collaboration are key to overcoming these obstacles. Thus, the implementation of EFT can be an integral part of campus transformation towards a greener, more sustainable, and innovative ecosystem.

5 Discussion

The new paradigm of campus environmental management encourages higher education institutions to develop innovative strategies and an environmentally friendly culture. Higher education institutions not only develop science, but also emphasize the importance of environmental awareness for their academics [74, 75]. Universities have a strategic role in sustainable development efforts and preventing environmental damage in the campus area. The transformation of higher education towards a sustainable environment should encourage inter and transdisciplinary approaches, integration of theory and practice, individual and group commitment, discussion, and critical thinking [76–78]. Therefore, the effectiveness and feasibility of implementing such programs depend on various structural, cultural, and technical factors that need to be analyzed in depth.

Based on a structural perspective, campus infrastructure readiness is a major factor in accelerating the adoption of EFT. Without the best infrastructure support, the use of EFT cannot be improved. Some universities still face limitations in obtaining EFT infrastructure due to cost constraints and development priorities that are not in line with the principle of environmental sustainability. From a cultural perspective, the use of EFT among students, lecturers and education staff is strongly influenced by the level of environmental awareness and readiness to change habits. This requires the optimization of participatory environmental education through socialization programs, environmental awareness campaigns, and the involvement of the entire academic community in the transition to environmentally friendly modes of transportation. Thus, the implementation of EFT strategies on campus is not an impossible necessity. On the contrary, with integrated planning, participatory approaches, and the right infrastructure and policy support, the use of EFT can be an integral part of campus transformation towards a more sustainable environment [54, 61, 79].

Campuses in Indonesia continue to strive through various innovative strategies in providing EFT modes in the campus area [57]. This aims to accelerate a sustainable environment, reduce carbon emissions, and realize a young generation that is aware of its environment. These innovative strategies are designed according to the characteristics of students and the culture of each university. Universities conduct educational activities, design lessons, practicum activities, research, and community service related to the implementation of EFT [77, 80–82]. Universities provide environmentally friendly transportation facilities, such as pedal bicycles, electric motors, buggy cars, electric buses, provision of decent pedestrians for disabilities, campus rules governing the use of EFT, and providing incentives for academicians who use EFT [83, 84].

Several campuses in Indonesia have implemented and promoted EFT as an effort to accelerate a sustainable university environment. UM is one of the environmentally friendly campuses that provides EFT infrastructure that is used by the academic community, ranging from pedal bicycles, electric bicycles, buggy cars, to disabled-friendly pedestrians. However, UM still does not have a shuttle service because the area and distance between buildings are not too far and can be reached on foot. UGM has an educational program that involves students in research and innovation projects in the field of sustainable environment, this can be seen from UGM research, and community service programs with the theme of sustainable transportation management implementing environmentally friendly transportation solutions. UNAIR and UMM are also working to improve transportation efficiency and convenience in the campus area. UNAIR and UMM's efforts in improving transportation management are not only focused on infrastructure and technology, but also on environmental awareness education, cooperation, and participation. UNAIR also collaborates with various parties such as local governments, transportation operators, and related organizations to improve the transportation system around the campus.

Despite these obstacles, there are opportunities for the implementation of EFT on campus. Opportunities that can be used by higher education institutions are government support through policies and transportation electrification. In addition, collaboration with partners can be implemented in accelerating the provision of environmentally friendly transportation facilities for the academic community. Each higher education institution conducts education, designs activities, research, and community service related to the use of EFT [57].

Another opportunity to capitalize on is the increasing environmental awareness among the younger generation. Today's students tend to be more concerned about climate change and sustainability issues, and thus more open to the use of EFT than previous generations [52]. With an effective environmental education approach, campuses can build a strong culture of sustainability through programs based on student participation, such as green campaigns, providing incentives for the use of EFT, and involvement in green policy formulation [85].

6 Study Highlights

(1) The results of measuring student perceptions of climate change awareness on the use of EFT on campus get particularly satisfactory results.

(2) The environmental attitudes indicator gets the highest average score; this shows that students have an environmental attitude that can be the basis for improving sustainable habits and lifestyles on campus.

(3) The environmental knowledge indicator gets the lowest average score, this is a challenge for universities in increasing student understanding in the form of learning activities, seminars, and so on.

(4) Based on the results of measuring student awareness of climate change, students already have environmentally friendly attitudes, intentions, and behaviors, but universities need to increase student understanding and involvement in real action to mitigate climate change.

(5) In promoting a sustainable campus environment, most campuses in Indonesia are implementing innovative strategies in EFT management.

(6) The implementation of EFT on campus has its own opportunities and challenges, requiring innovative strategies to maximize resources to increase the use of EFT in the local wisdom of each campus.

(7) Based on observation, most campuses in Indonesia are very possible to develop an ecosystem of EFT as an effort to accelerate sustainable lifestyles on campus.

7 Limitations and Future Research Directions

The study may have focused on a limited number of universities within Indonesia, making it difficult to generalize the findings to all Indonesian campuses. Cultural, geographical, and infrastructural differences across regions might influence awareness and transportation choices differently. This study captures a snapshot in time and may not account for seasonal or policy-related changes in transportation behavior or awareness. Longitudinal data is needed to assess trends and the impact of awareness campaigns over time. Factors such as transportation infrastructure, availability of public transport, economic constraints, or government policies may not have been deeply explored. A sole focus on transportation may limit understanding of students' overall sustainability practices.

Future studies should include a more diverse sample across different Indonesian islands and demographic groups, including vocational schools, rural students, and working youth, to better reflect national trends and challenges. Conducting research over an extended period would help track changes in awareness and behavior, as well as evaluate the long-term effects of educational or governmental interventions aimed at promoting sustainable transportation.

8 Conclusions

Higher education institutions can develop EFT ecosystems as an effort to accelerate climate change mitigation awareness on campus. Based on the results of measuring climate change mitigation awareness in students, it is necessary to increase their understanding and involvement in various activities related to environmental sustainability issues. Various innovative strategies that have been conducted by universities can improve air conditions and ecosystems that are environmentally friendly. The development of EFT facilities and infrastructure, such as pedal bicycles, shuttle buses, electric bicycles, and pedestrian-friendly pedestrians, has an impact on increasing environmental awareness in the academic community. Based on the research results, the implementation of EFT on campus has a significant opportunity to be successfully implemented, if it is supported by strategic planning, consistent policies, and cultural changes in the behavior of the academic community. In addition, there are barriers found, such as limited infrastructure to low awareness of the academic community so that a holistic and collaborative approach is needed.

The findings of this study indicate that climate change awareness among university students functions as an educated subject and depends on the choice of environmentally friendly transportation. Furthermore, by conducting the study on Indonesian campuses, this research introduces a local perspective that expands the application of behavioral theory and value-belief-norms to underrepresented socio-cultural settings. The integration of institutional and psychosocial factors offers a more holistic understanding of sustainable mobility behavior, advancing current theoretical models by emphasizing the role of environmental identity, campus culture, and perceptions of behavioral

control in shaping students' transportation decisions. This study underscores the importance of combining an understanding of climate change mitigation with campus-based sustainability initiatives to accelerate long-term behavioral change among students.

Author Contributions

Conceptualization, R.H.R., S., and S.U.; methodology, R.H.R. and S.U.; software, R.H.R.; validation, S., S.U.; formal analysis, R.H.R and S.; investigation, R.H.R.; resources, R.H.R.; data curation, S.U.; writing—original draft preparation, R.H.R.; writing—review and editing, S. and S.U.; visualization, R.H.R.; supervision, S. and S.U. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The data used to support the research findings are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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