Original Paper

Student perceptions of environmental sustainability.

Insights into green campus innovations and geospatial analysis at Universitas Negeri Malang

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Abstract. *A growing cohort of higher education institutions, including Universitas Negeri Malang (UM), are embracing green campus initiatives as a strategic response to the imperative of environmental sustainability. This study scrutinizes the extent of student awareness regarding UM's Green Campus strategies and employs a specified Universitas Indonesia (UI) Greenmetric indicator to map environmental features. A comprehensive survey capturing responses from 322 students across various faculties and academic levels was orchestrated to evaluate perceptions of environmental sustainability. The methodology integrated direct mapping and observational techniques, with data processing conducted via SPSS for statistical analysis and ArcGIS for polygon geometry calculations. The findings demonstrate a robust positive reception of the university's environmental initiatives, with numerous elements achieving ratings surpassing 4.0. This research highlights significant student engagement and acknowledges the university's pivotal role in nurturing a sustainable educational environment. Moreover, the study generated intricate maps delineating the spatial distribution and scope of forests, planted, and water absorption areas across UM's tripartite campuses. These cartographic outputs are posited as essential tools for policymakers dedicated to advancing green campus practices informed by the UI Greenmetric criteria. The results not only reinforce the favourable influence of UM's sustainability endeavours on student perceptions but also delineate potential avenues for policy refinement and practical improvements to augment UM's sustainability trajectory.*

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1. Introduction

Environmental issues have become pressing multidimensional concerns that require immediate attention. Global warming, biodiversity loss, and pollution are tangible problems resulting from global environmental degradation (Sadono et al., 2021; Tseng et al., 2022) and must be urgently addressed (Pandya et al., 2022; Singh et al., 2016). The majority of these issues are the result of human activities (Ahmed & Wang, 2019) such as the unsustainable use of natural resources (Fuller

et al., 2022), a lack of environmental consciousness and advocacy, and the increasing demands of human needs (Manisalidis et al., 2020). If unchecked, these activities will lead to continuous ecological system damage (Grifoni et al., 2022) from the environments that have been exploited and utilized (Rume & Islam, 2020).

Universities, as microcosms of urban systems, host various activities that potentially harm the environment. These activities include the use of various facilities, such as air conditioning, audio-visual learning, and laboratory, energy, vehicle, and material usage (Poluan et al., 2020; Tiyarattanachai & Hollmann, 2016) which significantly contribute to environmental issues (Anwar et al., 2020; Khan et al., 2020) and impact greenhouse gas emissions (Akadiri et al., 2012; Gammie et al., 2023). Furthermore, the construction of buildings and other facilities has led to the reduction of green areas, such as campus planted or forests (Idowu, 2012). A concept that universities must adopt to realize sustainable development is the green campus concept.

The green campus concept prioritizes the protection, management, and preservation of the environment in the long term. It focuses on minimizing negative impacts on the environment (He et al., 2020; Liziane Araújo da Silva et al., 2023) through the efficient use of resources, waste management, eco-friendly transportation, and the integration of environmental aspects into campus life (Fachrudin et atl., 2021; Partino et al., 2021). The implementation of the green campus plays a crucial role in fostering environmentally conscious campuses (Muhiddin et al., 2023; Rajalakshmi et al., 2022) and can serve as a basic reference in creating a healthy environment (Tu & Hu, 2018). The Green Campus Award is obtained based on the evaluation of categories and indicators of the UI GreenMetric (Lourrinx et al., 2019).

UI GreenMetric is a platform that assesses the sustainability programs and policies of universities worldwide. The UI GreenMetric ranking also provides insights into the strengths and weaknesses of implementing green campus and sustainable development (Tabucanon et al., 2021). Since its inception, the UI GreenMetric World University Ranking has garnered significant attention and has been improving annually (Boiocchi et al., 2023; Sari et al., 2021). The UI GreenMetric categories include setting and infrastructure (SI), energy and climate change (EC), waste (WS), water (WR), transportation (TR), and education and research (ED) (Alawneh et al., 2021; Fatriansyah et al., 2021). The Green Campus concept based on UI GreenMetric has been implemented by various universities in Indonesia (Farhan et al., 2020; Kusumaningtyas et al., 2019), including Universitas Negeri Malang (Gandasari et al., 2020).

Universitas Negeri Malang has committed to enhancing environmental management through the implementation of Green Campus. This commitment is realized in policies, management, infrastructure, and higher education activities, such as waste management strategies, smart building development, and the application of renewable energy (Puspitasari et al., 2022). Additionally, Universitas Negeri Malang also conducts outreach on sustainable campus waste management, integrates environmental knowledge and learning into specific courses across all faculties, and implements sustainable environmental programs and activities to foster green behaviours (Novianti et al., 2019). As a result, the total UI GreenMetric score of Universitas Negeri Malang has continuously increased, reaching 5900 in 2020, 6375 in 2021, and 7025 with a ranking of 32nd as a green campus in Indonesia in 2022.

However, many aspects of sustainability still need enhancement, such as evaluating policies, management, infrastructure, and environmental activities. This evaluation is not only to improve the UI GreenMetric score but also to create a sustainable and environmentally conscious campus environment (Fortes et al., 2019; Yusliza et al., 2020; Zamora-Polo & Sánchez-Martín, 2019). The implementation of a sustainable campus will have a positive impact on its community, including students who will become future policymakers. This study employs a quantitative descriptive research design to assess student perceptions of environmental sustainability at Universitas Negeri Malang (UM). The design integrates survey methodology and spatial mapping to provide a comprehensive understanding of student awareness and the spatial distribution of green campus initiatives. The study aims to address the following research questions:

1. How do students at Universitas Negeri Malang perceive and engage with the university's Green Campus initiatives, particularly in terms of their environmental concerns, participation in sustainability activities, and their satisfaction with the university's efforts in promoting a sustainable campus environment?
2. What are the spatial distributions and size of green areas (forest vegetation, planted vegetation, and water absorption) on UM campuses?

2. Methodology

2.1. *Research design*

This study utilizes a quantitative descriptive research design. The quantitative research design was conducted through surveys administered to students using

forms and mapping the green areas at Universitas Negeri Malang using numerical data, particularly the spatial dimensions of green areas with the assistance of ArcGIS software. The quantitative data generated will be descriptively explained as supporting data for the implementation of the green campus concept. This quantitative approach allows the study to produce data that is not only empirical but also measurable and analysable statistically, thus providing more objective and comprehensive insights.

2.2. *Survey*

The forest vegetation, planted vegetation, and water absorption regions are critical physical aspects of the green campus. Besides physical conditions, the knowledge and implementation of the green campus concept by students are also paramount. Therefore, we conducted a survey based on: (1) concern for the environment in the present or future, (2) the role of students in supporting the environment and campus sustainability, (3) the role of the campus in supporting the environment and sustainable campus, and (4) student opinions on the environment and campus sustainability. All survey items were sourced from similar research and have been modified by the researchers according to the needs of the study. The survey utilized the Google Forms platform and involved the active participation of students from various faculties. A comprehensive survey was conducted, capturing responses from 322 students across various faculties and academic levels. The survey included both open-ended and closed-ended questions. Closed-ended questions used a five-point Likert scale to gauge perceptions on various aspects of environmental sustainability. The survey questions are presented in Appendix 1.

2.3. *Mapping*

The mapping process was methodically arranged into four stages: initial preparation, which includes the study area, Unmanned Aerial Vehicle (UAV) flight preparation, and control point design; data collection, which encompasses literature study, small-format aerial photography, and control point data; data processing, which involves stitching, georeferencing, land classification and cover, and geometry calculation; and the results, which are the outcome of the research in the form of green area maps at Universitas Negeri Malang, including forest vegetation, planted vegetation, and water absorption. The flow diagram of this research methodology is presented in Figure 1.

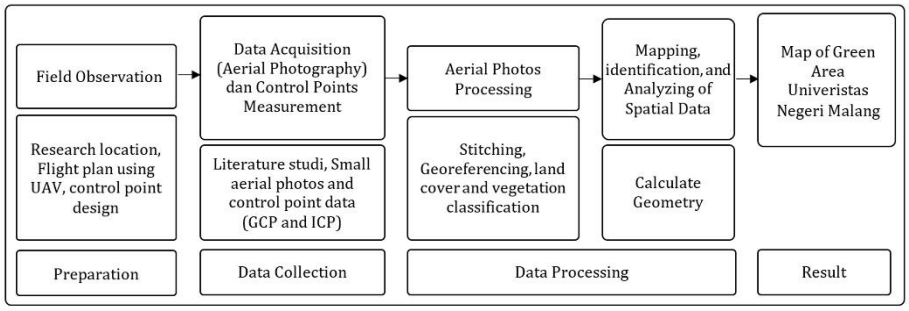

Figure 1. Research flow of Green Area Mapping Universitas Negeri Malang

1. Forest vegetation. These are defined as areas densely covered with trees and other vegetation, providing critical ecological functions such as carbon sequestration, biodiversity habitats, and microclimate regulation. The criteria for classifying an area as a forest include a minimum tree density, canopy cover percentage, and presence of native plant species.
2. Planted vegetation. These areas are characterized by landscaped spaces primarily designed for aesthetic and recreational purposes. They include lawns, flower beds, and shrubs. The criteria for planted vegetation involve the extent of cultivated land, the diversity of plant species, and the presence of recreational facilities like benches, walkways, and sports areas.
3. Water absorption. These areas are strategically placed to optimize water management on campus. These areas include vegetated swales, retention ponds, and permeable surfaces that facilitate water infiltration and reduce runoff. The catchment areas are crucial for mitigating flood risks, conserving water resources, and supporting the campus's overall sustainability goals. They also serve as practical examples for students studying sustainable urban planning and water management.

The mapping process involved capturing aerial photos using photogrammetry techniques (creating digital maps from physical objects by recording, measuring, and interpreting photos to obtain measurements and information) using UAV, due to its various advantages as shown in **Figure 2.** In this study, the UAV used was the DJI Phantom 4 Pro V2.0. The aerial photography process produced small aerial photo format images based on predetermined coordinates. The UAV

photos then underwent a stitching process to produce a comprehensive map of the study area.

Figure 2. The aerial photographs taken using the UAV (a) and the images from Google Maps (a) were compared. The UAV photographs demonstrate superior quality in aspects of detail, resolution, and colour (Sadono et al., 2021).

2.4. *Study area description*

To provide a comprehensive understanding of the study area, a geographical map of Universitas Negeri Malang has been included. This map highlights the university's location within the city of Malang, East Java, Indonesia, and its spatial context relative to significant urban and environmental features. The map serves as a visual aid to illustrate the geographic scope of the research, facilitating a better grasp of the environmental and infrastructural layout of the campuses involved in the study.

The geographical location of Universitas Negeri Malang is strategically important for the implementation of green campus initiatives. The university's campuses are situated in urban areas that present both challenges and opportunities for sustainability practices. The map below delineates the specific locations of Campus 1, Campus 2, and Campus 3, providing a clear view of their spatial distribution and proximity to key urban features.

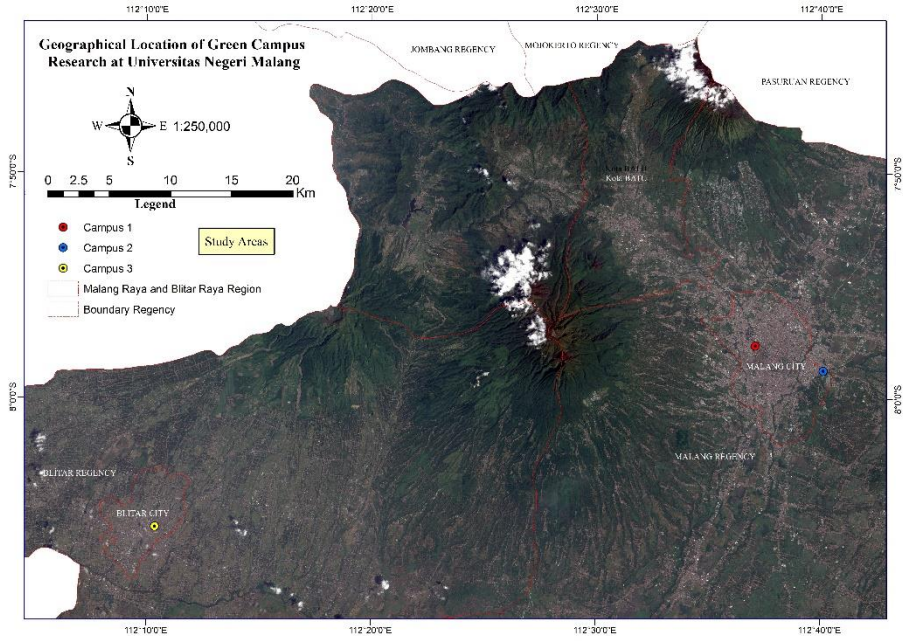

Figure 3. Geographical location of Universitas Negeri Malang Campus 1, Campus 2, and Campus 3, at East Java, Indonesia

2.5. *Types and collection of data*

The types of data used in this research include primary and secondary data. Primary data were obtained through mapping in the study area and surveys with students, and secondary data were gathered through literature studies related to and supporting the research study and documents on green campus policies at Universitas Negeri Malang.

2.6. *Data Analysis*

The mapping results will be analysed using Geographic Information System (GIS) software, specifically ArcGIS, to produce detailed visualizations of the distribution of green areas at Universitas Negeri Malang. Based on the analysis, the resulting maps are categorized into three classifications: (1) distribution and size of forest vegetation, (2) distribution and size of planted vegetation, and (3) distribution and size of water absorption. The method adopted to determine the

size of each area is the calculate geometry technique using a polygonal approach. Additionally, in the data analysis process, official documents issued by Universitas Negeri Malang serve as a primary data source. Furthermore, field observations also significantly contribute to presenting descriptive data that reflects the actual field conditions. In survey data, the data analysis will employ simple statistical analysis techniques such as frequency, percentage, and ANOVA using SPSS 25.

3. Result and Discussion

3.1. *Survey*

3.1.1. Respondent information

The survey was conducted over a period of 14 days and garnered a total of 322 respondents, comprising 146 males and 176 females from various faculties and levels of study. The survey results were predominantly female, primarily at the undergraduate level (bachelor's degree), from the Faculty of Social Sciences (FIS), and the class of 2023. The frequency of respondents living on campus and those with previous experience of living on campus was shown to be very low. The survey results concerning respondent information are displayed in **Table 1.**

3.1.2. Student insight about campus sustainability and UM Green Campus

Student insights on sustainable campus practices and the UM Green Campus are categorized as in **Table 1**. The results for each category and their explanations are detailed in **Table 2**:

According to the survey results, UM students demonstrate a high level of concern for environmental issues, reflecting a deep conviction about the vulnerability of the environment and the negative consequences of human behaviour on the ecosystem. A total of 57.5% of respondents acknowledged their concerns regarding the wastage of natural resources and its impact on pollution or environmental degradation. Additionally, 34.8% of students agreed, and 29.8% strongly agreed, that current development contradicts deteriorating environmental conditions. This indicates a strong belief among students about ecological vulnerability, where the natural environment is a system that can be damaged by human activities (Amoah & Addoah, 2021; Liu et al., 2020). Human activities that prioritize economic and development factors without considering ecological implications result in various negative consequences for both current and future generations (Wang et al., 2024).

Table 1. Respondent information (N=322)

Categories	Items	Frequency (N)	Percentage (%)
Gender	Male	146	45.3
	Female	176	54.7
Level of study	Bachelor's Degree (S1)	273	84.8
	Master's Degree (S2)	4	1.2
	Doctoral Degree (S3)	36	11.2
	Teacher Professional Education (PPG)	9	2.8
Faculty	Faculty of Education	45	14.2
	Faculty of Economics	10	3.3
	Faculty of Letters	8	2.4
	Faculty of Mathematics and Natural Sciences	41	12.5
	Faculty of Engineering	20	6.6
	Faculty of Social Sciences	89	27.6
	Faculty of Sports Sciences	8	2.7
	Faculty of Vocational Studies	88	27.8
	Faculty of Medicine	1	0.3
	Graduate School Faculty	8	2.6
Class year	2019	4	1.2
	2020	11	3.4
	2021	21	6.5
	2022	105	32.7
	2023	181	56.2
Living on campus	Yes	27	8.4
	No	295	91.6
Previous experience of living on campus	Yes	26	8
	No	296	92
I know that UM adopts the Green Campus Concept	1	5	1.6
	2	11	3.4
	3	53	16.5
	4	117	36.3
	5	136	42.2
Have participated in activities with the theme "sustainability" (seminars, public lectures, etc.)	Yes	180	55.9
	No	142	44.1
Have participated in environmental action activities within the UM Campus	Yes	97	30.1
	No	225	69.9

These survey results align well with the Ecological Belief Model (EBM), which emphasizes the importance of personal responsibility and self-efficacy towards the environment (Baier et al., 2013). The EBM posits that individuals' beliefs about their ability to influence environmental outcomes play a crucial role in motivating pro-environmental behaviours (Shafiei et al., 2017). By fostering a sense of self-efficacy, individuals are more likely to engage in actions that benefit the environment, thereby contributing to broader sustainability goals (Baldwin et al., 2022; Hamann et al., 2024). This model is further supported by 43.8% of

students stating that environmental factors are often overlooked due to a focus on economic factors. These results suggest that students recognize their responsibility in making sustainable decisions that enhance not only the economy but also infrastructure development for future generations (Foroozesh et al., 2022).

Table 2. Concern for the environment in the present or future

Survey Question	Answer					Average
	(1)	(2)	(3)	(4)	(5)	
I am quite concerned about the waste of natural resources and the destruction or pollution of the environment that is happening today.	8 (2.5%)	5 (1.5%)	26 (8.1%)	98 (30.4%)	185 (57.5%)	4.3 (100%)
I believe that the current economy is based on practices that will have a negative impact on future generations	19 (3.7%)	35 (6.8%)	126 (24.9%)	84 (34.8%)	58 (29.8%)	3.4 (100%)
I see that the current development is contrary to the deteriorating environmental conditions.	12 (3.7%)	22 (6.8%)	80 (24.9%)	112 (34.8%)	96 (29.8%)	3.8 (100%)
Environmental factors are often overlooked due to a focus on economic factors	7 (2.2%)	14 (4.3%)	40 (12.4%)	120 (37.3%)	141 (43.8%)	4.1 (100%)

Answers: (1) Strongly Disagree; (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree.

This awareness encourages students to engage in pro-environmental actions or support green policies at Universitas Negeri Malang (Null & Asirvatham, 2023). Such support is a form of self-efficacy and an expression by students that humans can make positive changes to the environment, starting from their personal surroundings (Akhtar et al., 2022). According to the Ecological Belief Model, interventions are directed to enhance knowledge and awareness about the ecological impacts of everyday human behaviours through self-efficacy (Baldwin et al., 2022; Hamann et al., 2024). This approach is highly effective in building student character towards pro-environmental actions by understanding various negative impacts that could occur (Saulick et al., 2024). Various programs and initiatives to support the UM Green Campus, such as campaigns, workshops, and sustainability projects on campus, can encourage and strengthen sustainable behaviours (Mohamed et al., 2020). These activities not only form pro-environmental attitudes but also aid in implementing consistent behaviours that maintain a sustainable ecological environment (Castellanos & Queiruga-Dios, 2022; Ibáñez et al., 2020).

Table 3. The role of students in supporting a sustainable environment and campus

Survey Question	Answer					Average
	(1)	(2)	(3)	(4)	(5)	
Reduce the use of private vehicles and use public transportation	45 (14%)	41 (12.7%)	122 (37.9%)	62 (19.3%)	52 (16.1%)	3.1 (100%)
Car Free Day (CFD) at UM makes the campus atmosphere more comfortable	8 (2.5%)	12 (3.7%)	68 (21.1%)	83 (25.8%)	151 (46.9%)	4.1 (100%)
Car Free Day (CFD) at UM as a strategic step to support Zero Carbon Emissions in the UM campus environment	4 (1.3%)	3 (0.9%)	59 (18.3%)	82 (25.5%)	174 (54.0%)	4.3 (100%)
Using durable (non-disposable) equipment	3 (1%)	9 (2.8%)	67 (20.9%)	128 (39.6%)	115 (35.7%)	4.1 (100%)
Avoiding foods with a lot of disposable packaging	4 (1.2%)	20 (6.2%)	138 (42.9%)	91 (28.3%)	69 (21.4%)	3.6 (100%)
Turn off lights and other electronic equipment when not in use	1 (0.3%)	1 (0.3%)	26 (8.1%)	75 (23.3%)	219 (68.0%)	4.5 (100%)
Use natural light (sunlight) by adjusting the curtains instead of turning on the lights	5 (1.5%)	6 (1.9%)	59 (18.3%)	101 (31.4%)	151 (46.9%)	4.2 (100%)
Reduce the use of air conditioning by opening windows	18 (5.6%)	23 (7.1%)	91 (28.3%)	76 (23.6%)	114 (35.4%)	3.8 (100%)
Using water wisely (not leaving taps running, reporting drips and leaks, etc)	2 (0.6%)	2 (0.6%)	30 (9.3%)	80 (24.9%)	208 (64.6%)	4.5 (100%)
Save paper when printing (printing double-sided or on the back of scrap paper) or going paperless (sharing, reading, and storing documents electronically)	2 (0.6%)	12 (3.7%)	85 (26.4%)	122 (37.9%)	101 (31.4%)	4.0 (100%)
Utilize food waste into compost	60 (18.6%)	69 (21.5%)	99 (30.7%)	48 (14.9%)	46 (14.3%)	2.8 (100%)

Answers: (1) Never; (2) Seldom; (3) Sometime; (4) Often; (5) Always

The survey results illustrate an understanding and active role of students in supporting a sustainable environment. A total of 46.9% of respondents strongly

agree that the Car Free Day (CFD) program enhances the campus atmosphere's comfort, improves quality of life, and contributes positively to the environment (Glazener et al., 2022). This indicates that the CFD program strengthens community and student engagement in supporting the UM Green Campus (Prasad, 2022).

Furthermore, 54% strongly agree that CFD is a strategic step in supporting Zero Carbon Emissions on campus. This shows a high level of student awareness about the relationship between campus activities, namely CFD, and the reduction of carbon emissions in the campus environment and its impact on climate change (Chandra et al., 2022). The success of CFD in motivating students to reduce reliance on personal vehicles by using environmentally friendly transportation or walking is notable (Pazhuhan et al., 2022).

Car Free Day is one of the simple programs to achieve a sustainable campus. Previous research has found that CFD is effective in reducing carbon emissions and increasing environmental awareness among students (Cirrincione et al., 2022; Perez-Lopez et al., 2021). This program restricts vehicle access to the outer ring of the campus area and requires university community members to walk. Besides having a positive impact on the environment, this program also positively affects physical activity levels (Junior et al., 2022).

Given the significant potential and strong student support for the UM Green Campus, the university can expand and enhance the effectiveness of similar programs (Ribeiro et al., 2021). Possible measures include improving infrastructure for pedestrians and cyclists, providing information and resources about sustainability benefits, and integrating sustainability education into the curriculum of each study program (Dawodu et al., 2022). This can encourage pro-environmental behaviour not just during specific events, but as part of everyday conduct (Liu et al., 2020).

On other aspects, such as durable equipment, electricity savings, and water conservation, significant results were achieved, with 35.7%, 68.0%, and 64.6% respectively. These results demonstrate a commitment to sustainable environments through waste reduction and the conservation of electricity and water (Fissi et al., 2021). These survey findings illustrate how environmentally friendly behaviours have been integrated into daily life. Additionally, the survey results reflect the level of awareness and individual responsibility towards the environment.

Although the outcomes are commendable, there remains considerable scope for improvement, especially in the consumption of single-use food packaging and

the conversion of household waste into compost, which are relatively low at 21.4% and 14.3%, respectively. This indicates significant challenges for sustainable practices, influenced by lifestyle and the prevalence of hard-to-avoid plastic packaging (Dey et al., 2021).

Reducing single-use food packaging is a major issue in decreasing the amount of plastic waste. This is because most products sold are synonymous with disposable plastic packaging, from food needs to hygiene products and more (Dey et al., 2021). Programs like ecobrick production have not been maximally implemented, leading to plastic waste ultimately ending up in landfills (Mihai et al., 2022). Additionally, the use of household waste for composting has not been optimized due to various factors, such as the availability of land (Tarashkar et al., 2023).

Student awareness about the importance of using durable equipment and saving electricity reflects sustainability education. Students tend to utilize natural energy, such as sunlight or air circulation from windows, rather than using lights or air conditioners (Álvarez, 2020). According to previous research, the use of durable equipment and energy-saving activities are essential in promoting sustainable lifestyles (Al-Obaidi et al., 2022; Harun et al., 2022; Yoo et al., 2020).

Overall, the survey results are consistent with the theory of Ecological Justice, which highlights the distributive aspects of responsibility and benefits from sustainable practices at Universitas Negeri Malang. This theory emphasizes that all individuals should have equal access to maintaining and utilizing a sustainable environment (Svarstad & Benjaminsen, 2020). Survey data indicate that students support and contribute to achieving a sustainable environment, such as through the CFD program, even though there are imbalances in other practices, such as reducing disposable packaging materials and using waste for compost (Sousa, 2023).

Applying the theory of Ecological Justice in campus policy can address disparities, issues, and enhance the quality and capacity of students in achieving a sustainable environment (Martin et al., 2020). Universitas Negeri Malang can enhance awareness and infrastructure that support the reduction of plastic use and the processing of organic waste into compost (Phrophayak et al., 2024). This can provide opportunities for students, regardless of their field of study, to contribute to maintaining and enhancing environmental quality (Silva et al., 2023). This approach can also strengthen the campus community, as every individual plays a role in creating a sustainable environment (Qazi et al., 2020).

Table 4. The role of the campus in supporting the environment and a sustainable campus

Survey Question	Answer					Average
	(1)	(2)	(3)	(4)	(5)	
Environmental studies as a compulsory subject	6 (1.9%)	21 (6.5%)	99 (30.7%)	94 (29.2%)	102 (31.7%)	3.8 (100%)
Green campus seminar held by students	1 (0.3%)	4 (1.2%)	81 (25.2%)	106 (32.9%)	130 (40.4%)	4.1 (100%)
Student organizations active in the environmental field	1 (0.3%)	2 (0.6%)	59 (18.3%)	101 (31.4%)	159 (49.4%)	4.3 (100%)
Encourage the use of public and environmentally friendly transportation	0 (0%)	8 (2.5%)	58 (18.0%)	107 (33.2%)	149 (46.3%)	4.2 (100%)
Owning and using non-disposable products	2 (0.6%)	5 (1.6%)	60 (18.6%)	93 (28.9%)	162 (50.3%)	4.3 (100%)
Seminars and training or practice in recycling, energy conservation, and resources	1 (0.3%)	2 (0.6%)	50 (15.5%)	109 (33.9%)	160 (49.7%)	4.3 (100%)
Green campus campaign in the form of banners, posters, and stickers	9 (2.8%)	19 (5.9%)	67 (20.8%)	95 (29.5%)	132 (41.0%)	4 (100%)
The university has a website about the green campus	0 (0%)	4 (1.2%)	47 (14.6%)	82 (25.5%)	173 (58.7%)	4.3 (100%)
University reduces paper consumption (paperless)	1 (0.3%)	5 (1.6%)	56 (17.4%)	87 (27.0%)	173 (53.7%)	4.3 (100%)

Answers: (1) Strongly Disagree; (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree.

Universitas Negeri Malang as a Green Campus University demonstrates a significant role in supporting a sustainable environment. The environmental awareness is reflected in the survey results regarding the importance of environmental study subjects (31.7%), conducting green campus seminars (40.4%), and student organization activities in the environmental field (49.4%). Additionally, UM has a UM Green Campus website that contains information about sustainable campus initiatives, from programs to annual reports. This website positively impacts students' knowledge about the green campus (58.7%), which is presented in various formats such as banners, posters, stickers, etc. (41.0%).

Integrating environmental education into the university curriculum is crucial and serves as a flagship program to achieve a sustainable campus. According to prior research, courses integrated with environmental content can enhance student awareness and engagement in environmental issues (Handoyo et al., 2021; Marpa, 2020). Moreover, the university can also provide opportunities for students to engage in environmental activities, such as organizations or seminars (Mamurov

et al., 2020). This can increase environmental awareness among students through peer tutoring.

Based on Human Ecology theory, human behaviour is influenced not only by internal factors but also by external or environmental factors where individuals reside (Bubolz & Sontag, 1993). Human Ecology examines the interactions between humans and their environments, emphasizing how these interactions shape behaviours and societal norms (Nguyen et al., 2023). This theory posits that the environment, including physical, social, and cultural elements, plays a crucial role in shaping human behaviour (Michelson, 1970).

In the context of UM Green Campus, understanding campus environmental policies can influence students' sustainable behaviours (Jnr, 2021; Mohammadi et al., 2023). The Human Ecology theory complements the Ecological Belief Model (EBM) by providing a broader framework for understanding how environmental settings and social contexts contribute to the development of pro-environmental behaviours. While EBM focuses on individual beliefs and self-efficacy in driving environmental actions, Human Ecology highlights the importance of the broader environmental context and social dynamics in shaping these behaviours.

1. Campus Design and Infrastructure: Universitas Negeri Malang has implemented the green campus concept in aspects of campus design and infrastructure that support a sustainable environment and encourage environmentally friendly behaviours. Providing facilities such as waste management places, green areas, and specific pedestrian paths are examples of how UM supports the green campus program. These facilities are efforts by UM to reduce carbon emissions from motor vehicles.
2. Education and Environmental Awareness: Universitas Negeri Malang has mandated academic programs to develop curricula that include environmental studies, covering ecological issues and sustainable development. According to Human Ecology theory, an environmental education curriculum is vital in shaping social norms and individual behaviours. Moreover, environmental education can also encourage students to apply knowledge in daily life, thus having a positive impact on sustainable practices in the surrounding community and campus environment.
3. Participation in Sustainable Activities: Active student involvement, such as environmental organizations, environmental seminars, or green campus campaigns, is an important indicator in Human Ecology theory. Students

not only enhance their own awareness of the importance of a sustainable environment but can also strengthen community norms. According to Human Ecology theory, this social dynamic is crucial in shaping student identities as agents of change in a sustainable environmental context.

4. Influence of Social Environment: Human Ecology theory acknowledges the importance of the influence of other students or the social environment as shapers of behaviour. At the university level, group norms and collective attitudes towards sustainability have a significant impact in promoting environmentally friendly behaviours.

Table 5. Students' opinions on the environment and sustainable campus

Survey Question	Answer					Average
	(1)	(2)	(3)	(4)	(5)	
Environmental stewardship is important for the campus and its community	1 (0.3%)	2 (0.6%)	40 (12.4%)	88 (27.4%)	191 (59.3%)	4.4 (100%)
You are satisfied with the environmental management at Universitas Negeri Malang	5 (1.6%)	14 (4.3%)	107 (33.2%)	134 (41.6%)	62 (19.3%)	3.7 (100%)
The green spaces available at Universitas Negeri Malang are important to you	0 (0%)	1 (0.3%)	33 (10.3%)	88 (27.3%)	200 (62.1%)	4.5 (100%)
Universitas Negeri Malang provides sufficient green space to support a better quality of life	1 (0.3%)	9 (2.8%)	74 (23.0%)	110 (34.2%)	128 (39.8%)	4.1 (100%)
The energy-saving practices carried out by the Universitas Negeri Malang do support a better quality of life.	0 (0%)	1 (0.3%)	64 (19.9%)	118 (36.6%)	139 (43.2%)	4.2 (100%)
Climate change mitigation programs (greenhouse gas emission reduction) support a better quality of life	0 (0%)	1 (0.3%)	37 (11.5%)	101 (31.4%)	138 (56.8%)	4.4 (100%)
Waste management at Universitas Negeri Malang (e.g. waste segregation, waste reduction) supports a better quality of life	1 (0.3%)	4 (1.2%)	43 (13.4%)	98 (30.4%)	176 (54.7%)	4.4 (100%)
Water management (water saving) carried out by the Universitas Negeri Malang supports a better quality of life	1 (0.3%)	3 (1.0%)	42 (13.0%)	101 (31.4%)	175 (54.3%)	4.4 (100%)
Universitas Negeri Malang transportation conditions (amount of traffic, availability of public transportation, etc.) support a better quality of life	5 (1.5%)	13 (4.0%)	86 (26.7%)	100 (31.1%)	118 (36.7%)	4.0 (100%)
Environmental education at Universitas Negeri Malang (courses and academic activities related to the environment) supports a better quality of life.	1 (0.3%)	7 (2.2%)	64 (19.8%)	115 (35.7%)	135 (42.0%)	4.2 (100%)
You are satisfied with your overall quality of life at Universitas Negeri Malang	3 (1.0%)	6 (1.9%)	82 (25.4%)	142 (44.1%)	89 (27.6%)	4.0 (100%)

The survey results above demonstrate a high level of student opinion regarding campus sustainability. The majority of respondents believe that energy management practices (43.2%), climate change mitigation programs (56.8%), waste management (54.7%), and water management (54.3%) can improve the quality of life on campus. This is also supported by various environmental education activities aimed at enhancing the quality of life (42.0%). This indicates that all respondents are satisfied with the quality of the Universitas Negeri Malang campus (average rating of 4.0), reflecting their understanding of the importance of the campus environment in creating a sustainable environment.

Student perceptions of environmental sustainability at Universitas Negeri Malang show that practices and programs such as energy management, climate change mitigation, and waste management have a positive impact on improving quality of life. This is closely related to the Theory of Quality of Life, which associates individual satisfaction with various aspects of life, emphasizing the importance of sustainable environmental conditions (Fuchs et al., 2020). According to the Theory of Quality of Life, a healthy and sustainable environment not only meets basic human needs but also provides space for personal growth and well-being (Mouratidis, 2021).

The Theory of Quality of Life posits that an individual's overall satisfaction and happiness are determined by multiple factors, including physical health, psychological state, level of independence, social relationships, personal beliefs, and their relationship to salient features of their environment (Mouratidis, 2021). This theory emphasizes that quality of life is a broad, multidimensional concept that usually includes subjective evaluations of both positive and negative aspects of life. A sustainable environment significantly contributes to better physical health by reducing pollution and providing clean air and water, which is reflected in the positive feedback from UM students regarding energy management and waste management practices. These responses indicate students' recognition of the direct impact these initiatives have on their health and well-being (McCabe et al., 2010; Mouratidis, 2021). Furthermore, sustainable practices on campus, such as green spaces and eco-friendly initiatives, contribute to students' psychological well-being by creating a sense of harmony with nature and reducing stress levels. The survey results show that students are satisfied with climate change mitigation programs, which can alleviate anxiety related to environmental degradation (Fuchs et al., 2020).

The positive survey responses from UM students reflect the effective implementation of sustainability initiatives that enhance their quality of life. This alignment with the Theory of Quality of Life underscores the multifaceted

benefits of a sustainable campus environment. Students' satisfaction with energy management, climate change mitigation, and waste management practices suggests that these initiatives are meeting their basic needs and contributing to a healthier, more fulfilling campus experience.

1. Energy management practices. Efficient energy use not only reduces operational costs but also minimizes the campus's carbon footprint, contributing to a cleaner, healthier environment. Students' satisfaction with these practices indicates their awareness of the long-term benefits of energy efficiency on their health and well-being (Latif et al., 2021).
2. Climate change mitigation programs. Programs aimed at reducing greenhouse gas emissions and promoting renewable energy sources play a critical role in combating climate change. The high level of student approval for these programs demonstrates their understanding of the importance of such initiatives in ensuring a sustainable future (Alhamad et al., 2024).
3. Waste management. Effective waste management practices, such as recycling and composting, reduce pollution and promote a cleaner campus environment. Students' positive feedback on waste management practices highlights their recognition of the environmental and health benefits of reducing waste and conserving resources (Zhang & Tu, 2021).
4. Water management. Sustainable water management practices, including the use of rainwater harvesting and water-efficient fixtures, ensure the conservation of this vital resource. The survey results show that students appreciate these efforts, recognizing the importance of water sustainability for their quality of life and the environment (Guo et al., 2020).

3.2. *Mapping*

3.2.1. Distribution and size of covered in forest vegetation

The distribution and size of covered in forest vegetation at Universitas Negeri Malang, encompassing campuses 1, 2, and 3, are represented in **Figure 4**. This mapping result is also supplemented with information on the size of forest vegetation (Ha) and the percentage (%) at each campus in **Table 6**. According to the mapping analysis results, the total forest vegetation at Universitas Negeri Malang is 11,618 Ha, which constitutes 22,971%. In the UI GreenMetric evaluation under the settings and infrastructure (SI) category, the indicator "total area on campus covered in forest vegetation" scored 75 and is classified in category "4".

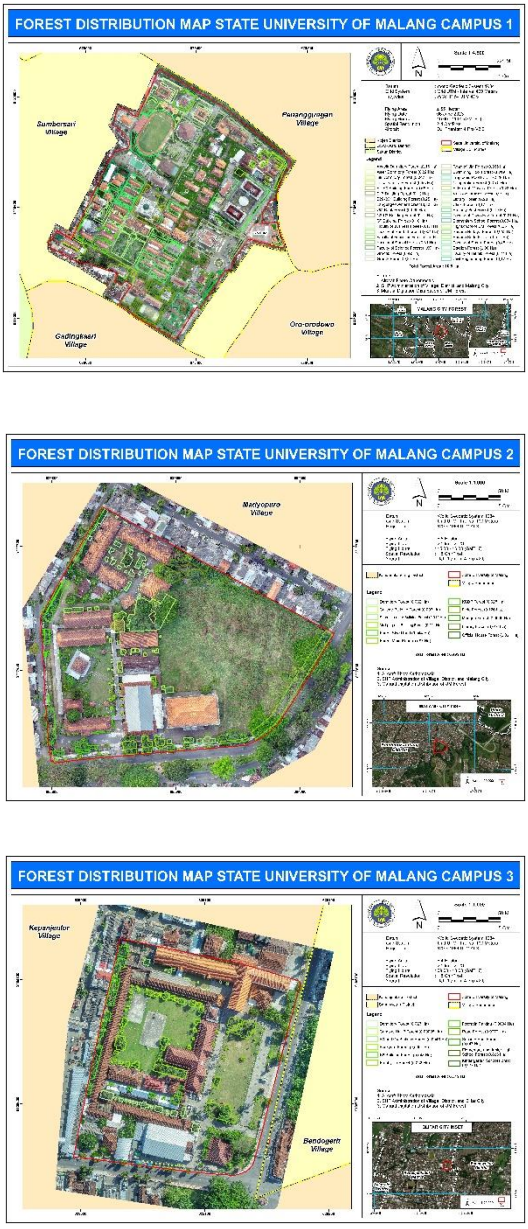

Figure 4. Map of the distribution and size of covered in forest vegetation at Universitas Negeri Malang, Campus 1 (a), Campus 2 (b), and Campus 3 (c) in 2023

The campus areas covered with forest vegetation provide various implications. Forests around the campus deliver clean and comfortable air for the campus community (Susilowati et al., 2021). Clean and fresh air can enhance the physical and mental well-being of the surrounding community (Baur, 2022). Furthermore, the presence of forests also creates green open spaces that can be utilized for various activities, such as recreation, sports, and other events (Tudorie et al., 2020). This not only provides a comfortable learning and campus life experience but also promotes a sustainable lifestyle (Menon & Suresh, 2020).

In addition to positively impacting the campus community life, the existence of forests also contributes to climate change mitigation and biodiversity conservation (Muluneh & Worku, 2022). Forests function as carbon sinks, addressing global warming and producing oxygen for other living beings (Nunes et al., 2020). Forests also serve as natural habitats and support biodiversity through the conservation of plant and animal species (Basavarajaiah et al., 2020). This is crucial for maintaining ecosystem stability and as a supportive means for conducting education and research at the university.

Table 6. Forest vegetation size (Ha) and percentage (%) based on data analysis using the calculate geometry method in ArcGIS Software

Location	Area Size (Ha)	Forest Vegetation Size (Ha)	Percentage (%)
Campus 1	45,182	10,800	23,93
Campus 2	2,937	0,499	16,99
Campus 3	2,457	0,319	12,98
Number and ratio (%)	50,576	11,618	22,97

3.2.2. Distribution and size of planted vegetation

The distribution and size of planted vegetation at Universitas Negeri Malang, encompassing campuses 1, 2, and 3, are represented in **Figure 5**.

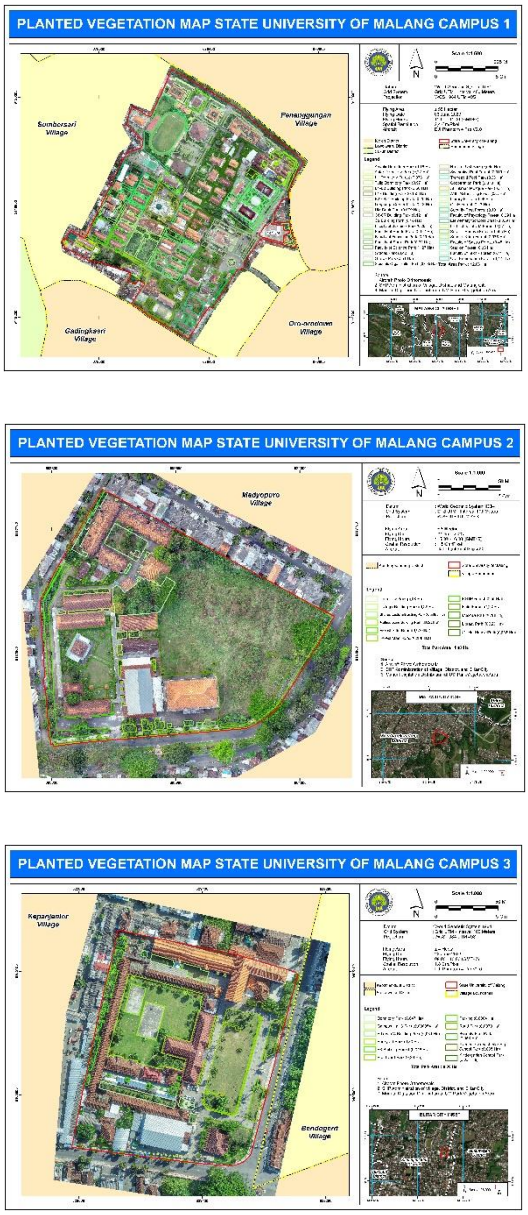

Figure 5. Map of the distribution and size of planted vegetation at Universitas Negeri Malang, Campus 1 (a), Campus 2 (b), and Campus 3 (c) in the Year 2023.

This mapping is also supplemented with information on the size of planted vegetation (Ha) and their corresponding percentages (%) at each campus in **Table 7**. According to the mapping analysis, the total planted vegetation at Universitas Negeri Malang amounts to 15,400 Ha, or 30,449%. In the UI GreenMetric evaluation under the settings and infrastructure (SI) category, the indicator "total area on campus covered in planted vegetation" scored 150 and is classified in category "4".

Table 7. Planted vegetation size (Ha) and percentage (%) based on data analysis using the calculate geometry method in ArcGIS Software

Location	Area Size (Ha)	Planted Vegetatation Size (Ha)	Percentage (%)
Campus 1	45,182	12,660	28,020
Campus 2	2,937	1,880	64,010
Campus 3	2,457	0,860	35,002
Number and ratio (%)	50,576	15,400	30,449

The implications of having planted vegetation represent and support the previous indicator, namely the presence of forests, which are interconnected. Planted vegetation provides important green open spaces for creating activity areas for the community, such as sports facilities for students, staff, and campus visitors (Tudorie et al., 2020). Besides positively impacting mental health, planted vegetation also strengthens social bonds and builds a sense of comfort and safety within the campus environment (Baur, 2022).

As areas planted with vegetation, planted vegetation also benefits the surrounding environment. Planted vegetation produces oxygen and absorb carbon dioxide, making the area around them feel cooler and helping to prevent global warming, especially in campus areas (Muluneh & Worku, 2022). This is a crucial step in maintaining environmental sustainability and protecting local biodiversity (Basavarajaiah et al., 2020).

In educational aspects, planted vegetation can create a cooling and inspiring learning atmosphere for creativity. Planted vegetation can be utilized by faculty and students as locations for outdoor learning, group discussions, and personal reflection (Dring et al., 2020). The planted vegetation at Universitas Negeri Malang positively impacts the productivity of the community through the provision of comfortable and cool green open spaces (Alnusairat et al., 2021).

Planted vegetation not only promotes community well-being but also contributes to the preservation of the environment sustainably.

3.2.3. Distribution and size of water absorption

The distribution and size of forest vegetation at Universitas Negeri Malang, which includes campuses 1, 2, and 3, are represented in **Figure 6**. This mapping is also supplemented with information on the size of forest vegetation (Ha) and their corresponding percentages (%) at each campus in **Table 8**. According to the mapping analysis, the total forest vegetation at Universitas Negeri Malang is 11,319 Ha, which constitutes 22,380%. In the UI GreenMetric evaluation under the settings and infrastructure (SI) category, the indicator "total area on campus for water absorption besides the forest and planted vegetation" scored 75 and is classified in category "4".

The presence of water absorption is closely linked with the goals of a green campus. The green campus concept is not only about greening and environmental preservation but also involves the effective and efficient management of water resources (Amanina & Ilham, 2024). Water absorptions serve as indicators that synergize with the two previous indicators, as they involve land areas that support the development of forest and planted vegetation (Pille & Säumel, 2021).

Water absorptions are capable of naturally absorbing and storing rainwater through vegetation growing on the soil. The presence of forests and planted vegetation serves not only as aesthetic features but as green infrastructure in water management (Monteiro et al., 2020). Moreover, water absorptions reduce the dependence on artificial water sources, such as clean water from wells or pipelines (Geetha Varma, 2022). These areas also positively impact the balance of the local ecosystem, including plants, animals, and microorganisms (Tolossa et al., 2020).

3.3. *Green area in UM green campus according to UI GreenMetric*

Green areas play a crucial role in enhancing the environmental quality and sustainability of the campus environment. Based on the mapping conducted at Universitas Negeri Malang, forest vegetation contributes 11,618 Ha, or about 22.971%, planted vegetation contributes 15,400 Ha or 30.449%, and water absorption contributes 11,319 Ha or 22.380%. According to the UI GreenMetric evaluation, these percentages fall within category 4, with respective weights of 75 for forest vegetation and water absorption, and 150 for planted vegetation. While these results are commendable, efforts are needed to increase the extent of green

Figure 6. Map of the distribution and size of water absorption at Universitas Negeri Malang, Campus 1 (a), Campus 2 (b), and Campus 3 (c) in 2023.

areas, not only to enhance ratings and rankings but also to reap benefits and support environmentally friendly sustainable development (Abakumov & Beresten, 2023).

Table 8. Water absorption Size (Ha) and percentage (%) based on data analysis using the calculate geometry method in ArcGIS Software.

Location	Area Size (Ha)	Water Absorption Size (Ha)	Percentage (%)
Campus 1	45,182	10,720	23,726
Campus 2	2,937	0,499	16,990
Campus 3	2,457	0,319	12,983
Number and ratio (%)	50,576	11,319	22,380

Green areas have significant importance, both on small and large scales. They act as carbon sinks, reducing the adverse effects of greenhouse gases and thereby mitigating global warming (López-Pacheco et al., 2021). Green areas support air quality by absorbing pollutants and producing oxygen, creating a healthier learning environment. As educational spaces, green areas enable field studies and environmental research for both faculty and students. Green areas also help reduce stress and enhance the mental well-being of students and staff, providing spaces for relaxation, reflection, and social interaction. Furthermore, green areas enrich campus biodiversity, supporting a variety of flora and fauna by providing habitats and food (Imbar et al., 2020).

4. Conclusions

Based on the survey results, it can be concluded that students' perceptions of the UM Green Campus are rated as very good. Various points presented have an average above 4.0, while only a few points are below 4.0. In the mapping results, the green areas as per the UI GreenMetric indicators are divided into three categories: forest vegetation, planted vegetation, and water absorption, each with different criteria and evaluation weights. As a university implementing the green campus concept, it is crucial for Universitas Negeri Malang to perform mapping on the distribution and size of green areas across the entire campus. According to the mapping and calculate geometry analysis in ArcGIS, forest vegetation comprises 22.971%, planted vegetation 30.449%, and water absorption 22.380%. These results meet category 4 criteria and are considered good. However, further

efforts are necessary to enhance these outcomes, not only to improve ratings but also to create an increasingly environmentally friendly campus environment.

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