Low-Carbon Campus: Exploring Universiti Malaysia Sarawak's Pedestrian Walkways as Tools for Sustainable Mobility

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ABSTRACT

The development of university campuses presents a valuable opportunity to create sustainable and inclusive spaces that support low-carbon initiatives and encourage active mobility. This study focuses on the thoughtful planning and intentional incorporation of pedestrian infrastructure, with UNIMAS West Campus serving as a case study. The research adopts a mixed-methods approach, combining a survey of 107 respondents with site observations at UNIMAS West Campus. It examines students' perceptions and the current design of pedestrian walkways, aiming to identify improvements for promoting sustainable mobility. Positioned within a horseshoe-shaped elevated area, the campus exemplifies a commitment to blending with the natural landscape while enhancing connectivity and accessibility. Despite the successful establishment of pedestrian walkways, recent studies reveal ongoing challenges, including vehicular emissions and the heavy reliance on motorized transportation by students and staff. The lack of covered walkways and insufficient lighting further diminishes the pedestrian experience, affecting comfort and safety, particularly during adverse weather and nighttime hours. To address these issues, the study proposes key improvements such as the installation of covered walkways, better lighting systems, wider pathways, and regular maintenance of pedestrian routes. Additionally, it emphasizes the need to address diverse user needs, including wheelchair accessibility and tactile guidance, to promote inclusivity. By implementing these recommendations, UNIMAS can foster sustainable mobility and move closer to its goal of becoming a low-carbon campus. This research highlights the need for holistic pedestrian infrastructure and showcases university campuses as models for sustainability and inclusive urban development.

Keywords: Environmental, Low-Carbon Campus, Pedestrian Design & Planning, Pedestrian Walkway, Students' Mobility, Sustainable Development

INTRODUCTION

Over the past two decades, concerns about climate change have grown significantly. According to the 2020 report by the International Energy Agency (IEA), the Paris Agreement's Nationally Determined Contribution (NDC) aims to reduce greenhouse gas emissions intensity by 35% by 2030, or 45% with international support. Global warming, largely driven by human-induced CO2 emissions, is one of the most pressing environmental challenges.

In response, the concept of a low-carbon city has emerged as a solution to sustainability challenges, particularly in green knowledge-based industries and socioeconomic development (Mustaffa et al., 2022). Universities, due to their large populations and diverse activities, serve as microcosms of cities and can promote low-carbon development. By fostering sustainable habits, universities play a vital role in educating students and advocating policies that protect biodiversity from climate change (Gomez et al., 2016).

Walkability on campuses is crucial for reducing air and noise pollution by decreasing car usage, leading to better respiratory health. Walkability, defined by the ease of pedestrian mobility in the built environment, can significantly impact a community's environmental footprint (Baobeid et al., 2021).

Universiti Malaysia Sarawak (UNIMAS) developed the UNIMAS Low-Carbon Campus Roadmap 2030, a sustainable blueprint aimed at encouraging staff, lecturers, and students to actively lower their carbon emissions. Through the roadmap's strategic actions, UNIMAS seeks to significantly reduce greenhouse gas emissions, particularly carbon dioxide, from key operations such as transportation, waste management, and energy consumption (*UNIMAS Low-Carbon Roadmap 2030*, 2023).

According to recent research findings by Kabit et al. (2022), there is a significant issue with vehicle emissions on the UNIMAS campus. It was determined that there were 1,330.3 kg of $CO2$ emissions from vehicles on UNIMAS's campus overall which much higher than the maximum value set by European Commission in 2009 which is 0.130 kg per km. Designing a campus to be more pedestrian-friendly increases the likelihood that students will use fewer vehicles, which will lower carbon emissions. This research aims to evaluate student mobility at UNIMAS in relation to pedestrian walkway design, promoting low-carbon practices on campus.

LITERATURE REVIEW

Low Carbon Campus

Global efforts to promote long-term sustainable development have led to the establishment of the Sustainable Development Goals (SDGs). Increasing populations, globalization, and industrialization are contributing to rising global temperatures, making environmentally sustainable development critical. In Malaysia, rapid growth, social stability, and economic expansion have led to rising carbon emissions.

Malaysia's low-carbon development strategy for green campuses includes building a structure for eco-friendly programs (Hooi et al., 2012; Mohaiyadin et al., 2018; Isa et al., 2021). Key components of a low-carbon campus include reducing emissions, improving air quality, and fostering effective governance (Liu et al., 2017). Universities, as energy-intensive institutions, play a significant role in advancing sustainability by promoting energy conservation and renewable technologies (Eagan, 2008). Higher Education Institutions (HEIs) are pivotal in shaping future leaders and advancing decarbonization efforts (Leon et al., 2018).

Campus walkability

Southworth (2005) defined walkability as the ability of a built environment to enable secure, comfortable, and timely pedestrian movement, while offering visual stimulation. Battista & Manaugh (2019) defined walkability as the user-friendliness of an environment regarding walking, active mobility, exercise, leisure, and service access.

For college students, walkability is crucial, as walking is their primary mode of transport. Unlike neighbourhoods, campuses have defined perimeters, secured entrances, and services for specific groups (King et al., 2020). Campus walkability is influenced by both physical infrastructure and students' perceptions of their surroundings (King et al., 2020; Horacek et al., 2012; Asadi-Shekari et al., 2014). High-quality connectivity can reduce the reliance on motorized vehicles by enabling efficient movement, especially during emergencies (Marshall & Garrick, 2011).

Relationship between walkability with low carbon footprint and sustainability

Improving pedestrian-friendly areas reduces carbon dioxide ($CO2$) and nitrogen oxide (NO) emissions (Frank et al., 2006; Marshall et al., 2009). Walkable areas promote sustainable mobility, which supports environmentally friendly transport systems and enhances community health and safety (Christian et al., 2010). Pedestrian-focused neighbourhoods reduce dependence on motorized vehicles, lowering the demand for non-renewable resources and decreasing pollution levels (Handy et al., 2005; Howell et al., 2019; Smith et al., 2017). Creating a walkable campus that provides easy access to amenities is a key challenge for campus sustainability (Amaral et al., 2015).

Pedestrian design and planning that promote walkability

Nasution et al. (2021) identify key factors for successful pedestrian facility development. Pedestrian safety depends on the strategic design of structures, textures, and dimensions such as free space and slope. Security can be enhanced with proper lighting, well-designed structures, and open landscapes. Comfort involves convenient access, weather protection, and inclusive designs accommodating individuals with disabilities. Walkway enjoyment is influenced by distance, width, terrain, and proximity to facilities, alongside aesthetic appeal.

Similarly, Abdullah & Al-Qemaqchi (2020) emphasize that university campuses are designed environments where components like walkways, routes, and buildings shape pedestrian behaviour. Walkway features such as length, width, and intersections significantly affect how people move, highlighting the importance of thoughtful design in these spaces.

Socioeconomic and Cultural Influences on Mobility Choices

While physical infrastructure is a critical determinant of walkability, mobility choices on university campuses are also shaped by a complex interplay of social and environmental factors. Research by Delmelle & Delmelle (2012) highlights that socioeconomic status, including access to personal vehicles and the cost of alternative transport, significantly influences commuting behaviour. Students from lower-income backgrounds may be more reliant on walking or public transit, while those with greater financial resources may opt for the convenience of private cars, irrespective of walkway quality.

Furthermore, cultural attitudes and habitual behaviours play a significant role. In the Malaysian context, where car ownership is often associated with status and independence (Barter, 2004), students may perceive walking as less desirable, even for short distances. Weather perceptions, such as the discomfort of heat and humidity, can also culturally normalize the use of motorized transport for trips that would otherwise be walkable. Afsar et al. (2016) found that in Malaysian public universities, students identified canopy cover as the top priority for pedestrian facility improvement, underscoring how tropical climate conditions directly influence mobility preferences. Similarly, Ramakreshnan et al. (2024) reported that among 504 campus community respondents at the University of Malaya, pedestrian infrastructure and street furniture ranked among the top five needs, with institutional support and connectivity also identified as critical factors for encouraging walking. Therefore, a successful low-carbon campus strategy must not only improve infrastructure but also address these underlying social and cultural norms through targeted engagement and incentive programmes.

METHODOLOGY

This study employs a mixed-methods approach, combining quantitative and qualitative methods. A total of 107 students participated in a questionnaire survey, complemented by site observations conducted at the UNIMAS West Campus. While this sample provides valuable insights into student perspectives, the authors acknowledge that a more comprehensive understanding of campus walkability would benefit from including other key campus user groups. Future iterations of this research should aim to incorporate perspectives from faculty, staff, and alumni to create a more holistic view of pedestrian infrastructure needs across the entire campus community.

By combining qualitative and quantitative data from site observations, the study provides a comprehensive understanding of students' mobility patterns and satisfaction with the pedestrian walkways. This method supports planning and design improvements for campus walkways, contributing to a low-carbon campus environment.

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Questionnaire

This research employed questionnaires to collect quantitative data on students' mobility preferences, perceptions of pedestrian walkways, and carbon footprint awareness. The questionnaires were distributed using the Simple Random Sampling method, ensuring each UNIMAS student had an equal chance of selection, providing an unbiased representation of the student population.

The questions were designed based on key walkability criteria, including safety and security, comfort, built environment quality, visual interest, and connectivity. Students evaluated whether these criteria were met, allowing the assessment of pedestrian walkways based on user experience.

Site observation and survey

This research utilized structured site observations with a checklist method at three locations within the UNIMAS West Campus: the pedestrian walkway between Central Teaching Facilities 2 (CTF2) building and Tun Abdul Rahman Ya'kub Library (PeTary), the pedestrian bridge, and the sidewalk near the UNIMAS lake.

The checklist criteria were based on the Basic Guidelines on Pedestrian Facilities: *Nota Teknik Jalan 18/97* by the Malaysian Public Works Department and indicators from Makki et al. (2012) for creating a walkable university campus. The four key criteria include accessibility, safety/security, comfort, and connectivity.

Case Study

University Malaysia Sarawak (UNIMAS) is a public university located in Kota Samarahan, Sarawak, Malaysia. The UNIMAS campus is spread across around 2000 acres in the Kota Samarahan district. The campus is principally located within a horseshoe-shaped area of 30-meter-high terrain, which naturally forms a basin at its center. The campus plan is intentionally designed to blend in with the site's natural features.

This research emphasis on the identification of areas where pedestrian walkway design and planning can be improved to support sustainable mobility that focusing at UNIMAS West Campus area, insights into students' perspectives and preferences related to sustainable transportation and recommendations for UNIMAS to enhance its efforts in promoting a low carbon campus.

Three types of pedestrian walkways were identified at the UNIMAS West Campus: (1) walkways between buildings, (2) pedestrian bridges, and (3) walkways adjacent to roads and next to UNIMAS lake. Students were asked to share their opinions on these walkway types to inform future improvements. Table 1 shows the justification for the chosen site.

Table 1: Justification on chosen site

Site	Justification
1. Pedestrian walkway in between buildings from Central Teaching Facilities 2 (CTF 2) to Tun Abdul Rahman Ya'kub Library (PeTARY)	To understand the characteristic and the design needs in pedestrian walkway that surrounded by buildings.
2. Pedestrian bridge	To understand the characteristic and the design needs in bridge type of pedestrian walkway.
3. Pedestrian walkway (sidewalk) near road and next to UNIMAS lake.	To understand the characteristic and the design needs in pedestrian walkway near road and lake.

Figure 1: Pedestrian walkway in between buildings from Central Teaching Facilities 2 (CTF 2) to Tun Abdul Rahman Ya'kub Library (PeTary) (Source: Author and Google Earth)

Figure 2: Pedestrian bridge (Source: Author and Google Earth)

Figure 3: Pedestrian walkway (sidewalk) near road and next to UNIMAS lake

(Source: Author and Google Earth)

RESULT AND DISCUSSION

Questionnaire Result

The total number respondents are 107 and between male and female respondents, 36 (33.6%) of them are male and 71 (66.4%) are female. These students are majority are on-campus residents which is 104 (97.2%) while only 3 (2.8%) students are campus non-residents. Most of these students are using the campus facilities more frequent as they are living in campus. In term of their year of study, the highest participation came from the first-year students which is 100 (93.5%), who based on university's rule, are not eligible to bring cars in campus in their first year of study. Hence, the choice of their main mode of mobility in campus is by walking which shown in Figure 4 with 98 (91.6%) of them choosing this mode of mobility compared to the rest.

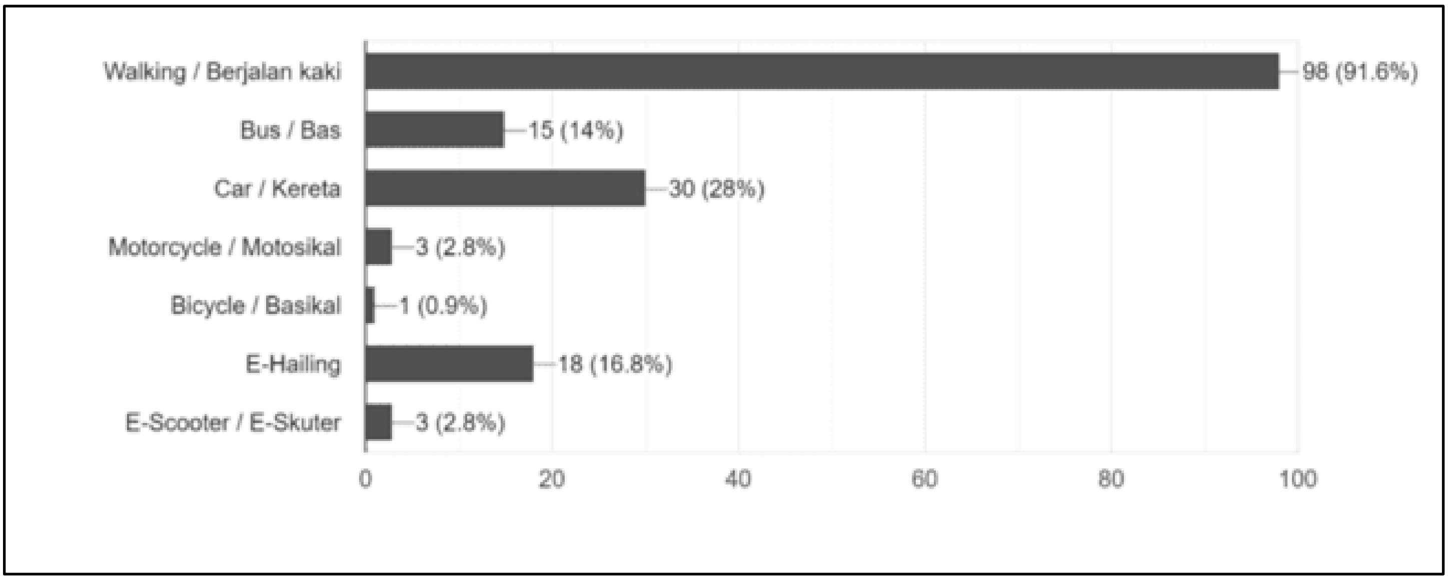

Figure 4: Students' main mobility mode in campus (Source: Author)

Table 2, 3 and 4 shows the students responses and perceptions on the three types of pedestrian walkways in UNIMAS respectively. There are three sections in the questionnaire which are Section A covers on walking experience and Section B covers on walking facilities. The final component which is Section C discusses on students' awareness of the low carbon campus.

Table 2: Result of survey questionnaire on campus walkability among students of UNIMAS for Pedestrian Type 1 (Source: Author)

Pedestrian Type 1: Pedestrian walkway in between buildings from CTF2 to PeTary					
Scope of Study	**Strongly Agree**				**Strongly Disagree**
Section A: Walking Experience	**5**	**4**	**3**	**2**	**1**
a) Safety & Security	43 (43.9%)	28 (28.6%)	15 (15.3%)	8 (8.2%)	4(4.1%)
b) Overall Comfortability	45 (45.9%)	26 (26.5%)	14 (4.3%)	8 (8.2%)	5 (5.1%)
c) Comfortability of sharing same pathway with other mode of mobility	25 (25.5%)	29 (29.6%)	26 (26.5%)	12 (12.2%)	6 (6.1%)
d) Visual Quality	27 (27.6%)	29 (29.6%)	25 (25.5%)	13 (13.3%)	4 (4.1%)
Section B: Walking Facilities	**5**	**4**	**3**	**2**	**1**
e) Walkway width adequacy	48 (49.1%)	29 (29.6%)	10 (10.2%)	8 (8.2%)	3 (3.1%)
f) Pathway material suitability	31(31.6%)	33 (33.7%)	20 (20.4%)	13 (13.3%)	1 (1%)
g) Maintenance	25 (25.5%)	30 (30.6%)	30 (30.6%)	11 (11.2%)	2 (2%)
h) Connectivity	39 (39.8%)	34 (34.7%)	16 (16.3%)	5 (5.1%)	4 (4.1%)

Table 2 indicates that most students believe Universiti Malaysia Sarawak offers adequate walking facilities and a pleasant walking experience. This is likely due to the walkway's placement between buildings, reducing risks from traffic. The 3.5-meter-wide pedestrian lane, which accommodates both pedestrians and mobility users, may also contribute to this perception. According to the Basic Guidelines on Pedestrian Facilities: *Nota Teknik Jalan 18/97*, the current width meets the minimum requirements, even in high pedestrian activity areas. However, some students report feeling unsafe due to inadequate lighting at night and occasional vehicle use of the walkway, which doubles as a service road. Additionally, the lack of cover from weather, uneven surfaces, and stony patches every 13 meters detract from the experience. Despite these concerns, students appreciate the walkway's connectivity, as it links directly to most faculties. Many suggest adding roofs for shade, more landscaping, benches, improved lighting, fixing potholes, better drainage to prevent flooding, and replacing uneven surfaces to enhance the walking experience.

Table 3: Result of survey questionnaire on campus walkability among students of UNIMAS for Pedestrian Type 2 (Source: Author)

Pedestrian Type 2: Pedestrian Bridge					
Scope of Study	**Strongly Agree**				**Strongly Disagree**
Section A: Walking Experience	**5**	**4**	**3**	**2**	**1**
a) Safety & Security	56 (55.4%)	20 (19.8%)	14 (13.9%)	5 (5%)	(5.9%)
b) Overall Comfortability	48 (47.5%)	24 (23.8%)	18 (17.8%)	5 (5%)	6 (5.9%)
c) Comfortability of sharing same pathway with other mode of mobility	31 (30.7%)	22 (21.8%)	27 (26.7%)	14 (13.9%)	7 (6.9%)
d) Visual Quality	51 (51%)	23 (23.1%)	18 (18%)	3 (3%)	5 (5%)
Section B: Walking Facilities	**5**	**4**	**3**	**2**	**1**
e) Walkway width adequacy	38 (38%)	29 (29%)	21 (21%)	8 (8%)	4 (4%)

f) Pathway material suitability	49 (49%)	29 (29%)	15 (15%)	5 (5%)	2 (2%)
g) Maintenance	43 (43.4%)	32 (32.3%)	13 (13.1%)	8 (8.1%)	3 (3%)
h) Connectivity	49 (49%)	29 (29.1%)	14 (14%)	6 (6%)	2 (2%)

Overall, students are satisfied with the pedestrian bridge and its facilities, as shown in Table 3. Safety features, such as guardrails, help prevent falls, though some students feel insecure due to the bridge's height of 4.2 meters above the ground and its crossing over the campus's main road. Concerns about darkness and quietness at night also contribute to feelings of insecurity. To improve safety, many students recommend better lighting along the bridge.

While the bridge's 3.8-meter width is adequate for pedestrians, it becomes cramped when shared with bicycles or e-scooters, which are currently allowed on the same path. Although most students feel comfortable sharing the space, some suggest expanding the pedestrian area to reduce congestion. The lack of a roof to protect users from rain and sun is a key source of discomfort. Many students recommend adding a covering to improve the experience.

The bridge's location, connecting key areas like the Chancellery building and the lake amphitheatre, is considered well-connected, and students appreciate the scenic views of the UNIMAS lake and surrounding landscape.

Table 4: Result of survey questionnaire on campus walkability among students of UNIMAS for Pedestrian Type 3 (Source: Author)

Pedestrian Type 3: Pedestrian Walkway (Sidewalk) near road next to UNIMAS lake					
Scope of Study	**Strongly Agree**				**Strongly Disagree**
Section A: Walking Experience	**5**	**4**	**3**	**2**	**1**
a) Safety & Security	25 (24.3%)	28 (27.2%)	32 (31.1%)	13 (12.6%)	5 (4.9%)
b) Overall Comfortability	12 (11.8%)	22 (21.6%)	30 (29.4%)	24 (23.5%)	14 (13.7%)
c) Comfortability of sharing same pathway with other mode of mobility	12 (11.8%)	22 (21.6%)	30 (29.4%)	24 (23.5%)	14 (13.7%)
d) Visual Quality	30 (29.1%)	29 (28.2%)	27 (26.2%)	12 (11.7%)	5 (4.9%)
Section B: Walking Facilities	**5**	**4**	**3**	**2**	**1**
e) Walkway width adequacy	18 (17.6%)	31 (30.4%)	22 (21.6%)	28 (27.5%)	3 (2.9%)
f) Pathway material suitability	20 (19.4%)	40 (38.8%)	31 (30.1%)	10 (9.7%)	2 (1.9%)
g) Maintenance	10 (9.8%)	28 (27.5%)	35 (34.3%)	20 (19.6%)	9 (8.8%)
h) Connectivity	19 (18.4%)	31 (30.1%)	32 (31.1%)	17(16.5%)	4 (3.9%)

Table 4 highlights safety concerns along the pathway. Students report feeling unsafe due to limited lighting at night and the narrow 1.5-meter width of the path, which forces them to walk on the street when crowded. Unlike other walkways, this path lacks a dedicated lane for bicycles or e-scooters, which can lead to congestion. Proximity to UNIMAS Lake raises concerns about potential encounters with snakes and lizards, while nearby traffic, despite a 2-meter buffer, contributes to feelings of insecurity. The absence of a roof to shield from rain and sun is a major discomfort, with students resorting to umbrellas for protection. Additionally, the uneven surface due to wear and tear makes walking less pleasant.

Most students are uncomfortable sharing the path with other modes of mobility due to the walkway's limited width, which is insufficient for both pedestrians and e-scooters or bicycles. While the 1.5-meter width is adequate for one person, it is too narrow for two, affecting comfort. The walkway's surface, made of Exposed Aggregate Concrete, is sturdy and non-slip, which most students find suitable for walking. However, the path is not well-maintained, with signs of damage, such as sinkholes and overgrown grass, leading to negative feedback about its upkeep. Despite these issues, many students appreciate the views of UNIMAS Lake, the Suspended Bridge, and the surrounding landscape.

Section C: Low Carbon Campus awareness among students

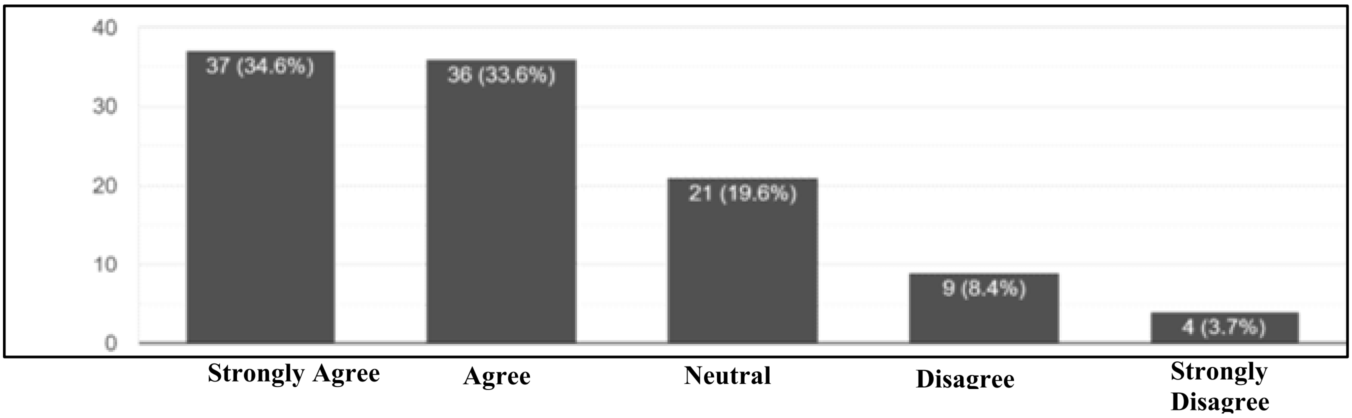

Figure 5: The survey's findings indicate whether the students understand the concept of low carbon campus (Source: Author)

Based on Figure 5, the results of this study indicate that the majority of students are aware of and understand the idea of a low-carbon campus.

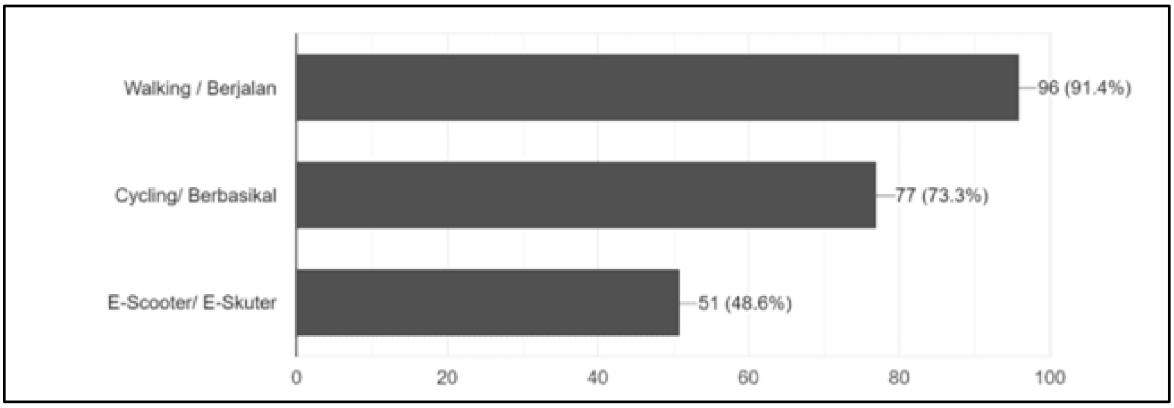

Figure 6: The type of mobility chosen by students that can contribute to low carbon campus (Source: Author)

Figure 6 shows that the students' awareness on types of mobility and its relationship with low carbon campus. Based on the survey, most students choose walking as the type of mobility that can contribute to low carbon campus with 96 (91.4%), followed by cycling with 77 (73.3%) and e-scooter with 51 (48.6%).

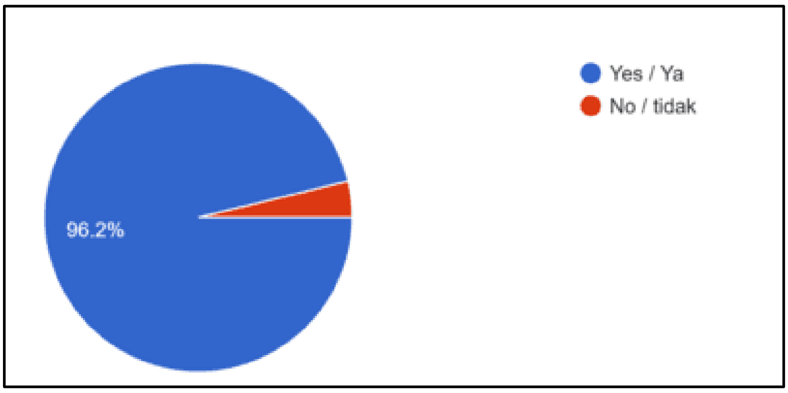

Figure 7: Students' opinion whether the pedestrian condition is important/ crucial for using this kind of mobility (Source: Author)

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Students were asked if the condition of pedestrian pathways was important for using the mentioned types of mobility. The survey revealed that 102 respondents (96.2%) agreed that well-maintained pedestrian pathways are essential for effective mobility. The findings highlight that whether walking, cycling, or using e-scooters, good pathway conditions are crucial to encouraging students to adopt these low-carbon transportation options.

Social and Environmental Factors Influencing Mobility

While the survey results (Figure 4) confirm that walking is the primary mode of mobility for most respondents, largely due to on-campus residency and first-year vehicle restrictions, the data also reveal underlying factors that could challenge long-term walkability. The high percentage of students who rely on walking is not solely a reflection of infrastructure quality but is also influenced by a university policy that mandates it. This finding aligns with the literature suggesting that institutional rules can temporarily override personal mobility preferences (Delmelle & Delmelle, 2012).

Furthermore, the survey's identification of discomfort due to weather (sun and rain) as a major issue (Tables 2-4) points to a cultural and environmental barrier. In Malaysia's tropical climate, the lack of shaded or covered walkways can make walking an unappealing choice, normalizing the use of cars or e-hailing services for short trips when they become available. To foster a lasting shift towards sustainable mobility, UNIMAS must not only install physical structures like covered walkways but also actively work to reshape cultural perceptions. This could involve awareness campaigns that frame walking as a convenient, healthy, and socially responsible choice, thereby addressing the socio-cultural preference for motorized transport identified in the literature (Barter, 2004; Afsar et al. ,2016).

Site observations and analysis

The site observations have been conducted to three sites mentioned in the case study. During the site observation, four criteria were observed which are Accessibility, Safety/security, Comfort and Connectivity. Table 5, 6 and 7 shows the characteristics of each pedestrian based on the criteria.

Table 5: Pedestrian Type 1- Pedestrian walkway in between buildings from CTF2 to PeTary (Source: Author)

Criteria	Characteristic	Pictures
Accessibility	• The pathway is designated for pedestrians, as well as bicycles and e-scooters. • It features a 3.5-meter-wide walking lane and a 2.5-meter-wide lane for bicycles and e-scooters. • The pathway is highly accessible, directly connecting to faculties located along the campus spine. • However, it lacks tactile surfaces to assist individuals with visual impairments. • The stony surface presents challenges for wheelchair users due to its unevenness.	  
Safety and Security	• No major obstacle on the pathway except for one manhole that is position upright (manhole cover not flush with pedestrian surface). • some manhole has uneven surfaces surrounding them. • There is roughly one lamp post for every 15 meters on each side of the pedestrian area. However, significant number of these lamp posts are not functioning properly, resulting in a poorly illuminated pedestrian pathway at night.	 

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Comfortability	• The footpath surface is made of exposed aggregate concrete, which is firm and skid resistant. • Every 13 meters interval of the pedestrian, there is strip of stony surface with 1-meter width. This stony surface is not comfortable to step on. • A paving drainage channel, 100 mm wide, is placed every 6 meters, but uncovered sections create gaps that disrupt the walking experience. Currently many debris and dry leaves accumulated in the channel which not let the water flow out smoothly. • The pedestrian walkway has areas with cracked surfaces and holes, further impacting usability. • The walkway lacks a roof, and while trees are planted along the spine, they are not large enough to provide adequate shade.	  
Connectivity	• Pedestrian walkway connects to other walkways that lead to different areas of UNIMAS, not only to the faculties and institution along the spine, but also to the pedestrian towards a residential college and other institution building near to it.	 

Table 6: Pedestrian Type 2- Pedestrian Bridge (Source: Author)

Criteria	**Characteristic**	**Pictures**
Accessibility	• This bridge connects the northern and southern sections of UNIMAS West Campus. • The walkway is relatively narrow, making it challenging to share with bicycles and e-scooters, with the design appearing more dedicated for bicycles and e-scooters than pedestrians. • The pathway lacks tactile surfaces to guide visually impaired individuals.	
Safety and Security	• The pathway is generally clear, except for three dustbins placed at certain points on the pedestrian bridge, requiring pedestrians and cyclists/e-scooter users to navigate around them. • The bridge lacks dedicated lighting, relying solely on streetlights for illumination. • Pedestrians share the narrow pathway with bicycles and e-scooters, exposing them to potential hazards due to the close proximity of these users.	

Comfortability	• The footpath surface is constructed from firm, even, and skid-resistant material. • The pedestrian bridge lacks a roof, leaving users exposed to hot weather and rain. • The bridge offers pedestrians a scenic view of the UNIMAS lake while walking.	 
Connectivity	• In addition to connecting the northern and southern parts of UNIMAS West Campus, the bridge provides access to the Chancellery building and features staircases leading down to the amphitheatre overlooking the lake.	

Table 7: Pedestrian Type 3- Pedestrian Walkway (Sidewalk) near road next to UNIMAS lake (Source: Author)

Criteria	Characteristic	Pictures
Accessibility	• The pedestrian walkway lacks a dedicated lane for bicycles or e-scooters. However, observations indicate that some students occasionally use this pathway for riding, which, given its 1.5-meter width, can lead to congestion with pedestrians. • The walkway does not include tactile surfaces for visually impaired individuals, nor are ramps provided, limiting accessibility.	
Safety and Security	• A manhole cover near the fire hydrant is not flush with the pathway surface, posing a potential tripping hazard. • Certain sections of the walkway run directly alongside an open drain, creating a safety risk if pedestrians were to fall. • Streetlamps are provided for the first 200 meters of the walkway but do not extend to its entire length, resulting in inadequate lighting and a poorly illuminated pathway at night.	 

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Comfortability	• Certain sections of the walkway have unintended changes in level caused by damage, impacting its usability and safety. • The pedestrian walkway is uncovered, leaving users exposed to hot weather and rain, requiring students to use umbrellas for protection.	 
Connectivity	• This pedestrian walkway connects to other walkways that lead to different areas of UNIMAS which is towards the lake Suspended Bridge and Pusat Islam UNIMAS (PITAS).	

The pedestrian walkways at UNIMAS offer good accessibility and connectivity, enabling convenient movement across the campus on foot. Additionally, the scenic surroundings along these paths enhance the walking experience, potentially motivating more students to adopt walking as their main mode of transport.

However, site observations and surveys have highlighted several challenges that need to be resolved to promote walking. These challenges, along with recommended solutions, are outlined in Table 8, 9 and 10, respectively for pedestrian walkway Type 1, 2 and 3.

Table 8: The pedestrian walkway Type 1 issues and the potential improvement

Issues	**Potential improvement**
1. There was no roof over this pedestrian path, so students had to use umbrellas to protect themselves from the rain and hot weather.	This path serves as a service road in addition to a pedestrian promenade, thus building a roof over the service road could be challenging. Therefore, when it becomes necessary to open the area for maintenance and to let a vehicle in, the roof will be retractable and able to be opened. The roof should be at least six meters above the ground.
2. Not enough light. The location has a number of malfunctioning light posts, which makes the pedestrian walkway dimly lit at night.	To improve pedestrian lighting by considering LED and solar power.
3. The walkway surface is made of rocky material that is uncomfortable to walk on and unsuitable for wheelchair users.	To change out the stony surface with more levelled surface.
4. Lack of a tactile surface for those who are visually impaired.	To introduce tactile surface on the current walkway for pedestrians.

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5. Paving Drainage Channel. There is no cover over this drainage channel, and the accumulation of dry leaves and other debris has prevented the water from draining out smoothly. Uncovered drainage channels have created gaps in the pedestrian walkway that make it difficult to walk and make it harder to push a wheelchair.	Since a roof will be built, the drainage will shift alongside the roof. This drainage will be covered and made deeper. It is necessary to level the pathway's surface.
6. The pedestrian walkway has holes and cracks.	To fix the pedestrian walkway cracks and holes.

Table 9: The pedestrian walkway Type 2 issues and the potential improvement

Issues	**Potential improvement**
1. There was no roof over this pedestrian path, so students had to use umbrellas to protect themselves from the rain and hot weather.	To add roof and make it a covered walkway.
2. Not enough light. The location has a number of malfunctioning light posts, which makes the pedestrian walkway dimly lit at night.	To improve pedestrian lighting by considering LED and solar power.
3. This pathway appears to be more devoted to bicycles and e-scooters than to walkers, and it is also too close to one another. The walking lane is very limited when shared with bicycles and e-scooters.	In order to let pedestrians know that there are moving bicycles or e-scooters, the pedestrian lane walkway should be extended to a minimum of 900mm (for one way, 1800mm for two ways) and the flow of the pedestrian and cycling lanes should be rearranged to face one another.
4. Lack of a tactile surface for those who are visually impaired.	To introduce tactile surface on the current walkway for pedestrians.
5. The walkway is quite clear, except for three trash cans positioned at specific spots along the pedestrian bridge. Users of bicycles, e-scooters, and pedestrians must be mindful of this trash can when they are cycling or walking.	To position the dustbin close to bridge railing or incorporated with it.

Table 10: The pedestrian walkway Type 3 issues and the potential improvement

Issues	**Potential improvement**
1. There was no roof over this pedestrian path, so students had to use umbrellas to protect themselves from the rain and hot weather.	To add roof and make it a covered walkway.
2. Only the first 200 meters of the pedestrian walkway have streetlamps installed. Consequently, this pedestrian crossing lacks enough lighting, making it rather dark at night.	To improve pedestrian lighting by considering LED and solar power.
3. There was a manhole cover adjacent to a fire hydrant that did not flush with the walkway's surface.	To flush the manhole grating and levelled it with the pedestrian surface.

4. There is an area of the walkway that is highly unsafe for pedestrians to fall into because it is right near to an exposed drain.	To install a wall barrier or cover the drain between the drainage and the pedestrian walkway.
5. Pedestrian width is 1.5 meters overall. In contrast to the earlier pedestrian walkways previously described, this one does not have own lane for bicycles or e-scooters.	The pathway should be extended to 4.3 meters in order to provide room for a bike/e-scooter lane in addition to a pedestrian lane.
6. The pathway surface is generally even, however in certain places there are unintentional level differences that mostly damage related.	To fix the cracked and unevenness on the pedestrian walkway.
7. Lack of a tactile surface for those who are visually impaired.	To introduce the tactile surface on the current pedestrian walkway.
8. Students are concerned about the possibility of snakes and lizards due to the walkway's proximity to UNIMAS Lake.	Adding a wall barrier to the pedestrian walkways lake-facing side.
9. Students are especially worried about how cars are moving near the pedestrian walkway.	To add steel barrier/ fence on the side of pedestrian walkway that facing the road.

CONCLUSION

The study identifies two key challenges to optimal pedestrian walkway use: the lack of covered walkways and inadequate lighting, which compromise comfort and safety, particularly during bad weather and at night. To address these issues, the research recommends installing covered walkways, improving lighting, and ensuring regular maintenance to fix surface irregularities and maintain adequate pathway width. It also emphasizes the need for inclusive features, such as wheelchair accessibility and tactile guidance for the visually impaired. By implementing these enhancements, UNIMAS can significantly improve walkability, encourage a culture of walking, and reduce reliance on vehicles. These efforts align with the university's commitment to fostering sustainable mobility, advancing its low-carbon campus goals, and creating a vibrant, inclusive campus environment.

Limitations And Future Research

The findings primarily reflect the views of first-year, on-campus residents who, due to university policy, are restricted from bringing vehicles. To develop a truly inclusive and effective low-carbon mobility strategy, UNIMAS must consider the diverse needs of all campus users. Future research should therefore expand the participant pool to include faculty, staff, and postgraduate students who may have different travel patterns and infrastructure requirements. Longitudinal surveys tracking changes in mobility behaviour following infrastructure improvements would also provide more robust evidence for the effectiveness of the proposed interventions.

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