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Promoting Sustainable Mobility in University Campus: A Case Study of Modibbo Adama University (MAU), Nigeria

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Abstract

Promoting sustainable mobility within university campuses has many benefits. This study aims to examine the mobility pattern and identify challenges related to existing modes of transportation within Modibbo Adama University (MAU) Yola, Adamawa State, Nigeria. Based on inputs from university staff and students through questionnaire surveys and face-to-face interviews, the study ascertains and explains the problems of existing modes of transportation on campus. The survey revealed that 88% of the respondents perceived poor roads and walkways as a major mobility challenge. About 44% rated mobility within the campus as fair, 43% claimed the situation was poor, and 13% rated campus mobility as good. Regarding the desired improvement for campus mobility, 55% of the respondents wanted the provision of walkways, 40% favored the provision of bus stops/terminals, and 5% preferred an increase in the number of Taxis. The study recommended effective implementation of Transportation Demand Management (TDM) strategies within the campus by establishing bus transit services, paved pedestrian walkways to connect bus stops, and encouraging bicycling programs to reduce carbon emissions and enhance non-motorized mobility.

Keywords: sustainable campus, campus mobility, pedestrian walkways, cycling, campus bus

1 Introduction

University campus societies are distinct communities within which various functions concentrate in proximity and where people of different backgrounds, incomes, cultures, lifestyles, and attitudes come together to live, study, work, and recreate. These are self-contained neighborhoods strategically built to provide easy access for students to essential daily necessities with a diversity of land mix usage where students can easily do their banking, grocery shop, eat, work out, and attend classes within walking distance [1]. In recent years, Universities are becoming more sustainable by reducing the increasing population's negative environmental impacts [2]. The trend of the daily movement of the large university population by automobiles presents a great challenge to transportation within the campus and often weakens the drive toward sustainability. Efficient transportation systems on university campuses as a major physical and economic link between 'town and gown' has become entrenched in the broader body of scholarly works; this has rarely dominated the analyses of scholarships in the global south.

The role of other sustainable means of transportation like walking, cycling, and bicycling remains poorly understood in the region. University administrators often fail to consider how to improve mobility based on the campus community's opinions, and campus planners seldom monitor the attributes that make up a pedestrian-friendly environment given the link between bus terminals and walking. The main goal of university mobility is to advance healthy living, lower emissions, and improve sustainable transportation systems [1]. This involves the planning and operation of various traffic modes as a whole [3] as well as the pedestrian walkways and bus stops which remain a key component in achieving a sustainable campus mobility network [4]. Campus mobility planning is an important aspect of a campus master plan [3] that gives users access to a network of connected, direct, and easy-to-follow routes linking the hostels, faculties, green spaces, and other facilities, as well as enhancing campus experience based on safety, functionality, pleasure, and learning [5].

Sustainable mobility is not new within the dynamics of university campus planning. A sustainable transportation system is an important issue for university campus planning and development and rallying around the encouragement of non-motorized (pedestrian and bicyclist) and shared-ride transportation modes instead of car-dependent travels [6]. Planning efforts have struggled to provide access and mobility without destroying campus qualities as distinct communities. However, promoting sustainable campus mobility requires a modal shift from cars to other modes such as bicycling, walking, and local bus shuttle. Hence, the need to introduce strategies to reduce auto-related air pollution, energy consumption, and traffic congestion and minimize these impacts for universities to become more sustainable and to satisfy current transport and mobility needs, without compromising the ability of future generations to meet their own [7].

Sustainable campus initiative is imbued with diverse challenges that many universities must address. Conducive

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living and learning environments for students can be achieved better through a sustainable transportation system that aims to increase accessibility without increasing individual mobility in private modes of transportation in universities [5]. Consequently, promoting sustainable modes of transportation would require a shift from using private automobiles to sustainable modes of transportation. Therefore, encouraging students to walk in the proximity of campus buildings, while public transportation can be used to access locations further away is paramount to achieving sustainable mobility on the university campuses. The need to understand the level of campus mobility and its relationship with the environment inform this study's choice of Modibbo Adama University Yola (MAU). The research was directed to ascertain the extent of challenges and potentials for sustainable transportation, consider existing policies, and aim to propose a pathway as an alternative behavioral approach that will achieve an efficient transport system on the campus.

Although the spatial distribution of buildings allows students to meet the daily requirement for physical activity, it encourages walking between nearby buildings. Public transport systems (Taxis) are used to access further locations within the campus. Also, inadequate and poor quality of campus mobility infrastructure in form of broken paths, unlinked pedestrian ways, and absence of designated bus stops for pick-ups and drop-offs were evident within the campus. Finally, the study reviewed the opinions of respondents and problems associated with achieving sustainable campus mobility and made recommendations to improve the situation. This study would assist other universities in planning sustainable campus mobility and can be emulated in the region towards ameliorating the current transport and mobility challenges for sustainable campus development.

2 Literature Review

Transportation plays an important role in efficient mobility within the campus. College campuses are privileged places to communicate sustainability and help reshape society's transportation patterns. The size of universities infers a high concentration of people and high traffic movement on the campus that requires the use of more automobiles to travel from one place to another. High energy use for transportation and movement of goods and services, to support activities, operations, and circulation within the campus, results in high carbon dioxide emission from fossil fuel combustion [8], a major challenge for global warming.

Transportation within university campuses has always been challenging and calls for approaches to reduce conflicts and manage mobility. University campuses are major traffic generators that greatly impact the quality of campus communities' environment through disturbance to teaching, loss of natural environment and greenery, defacement of the visual environment by parking provision, and health effects on staff and students [7]. The university campus's design allows students to meet the daily recommendations for physical activity due to the spatial distribution of the buildings. However, the existing transport system creates a spatial structure where unsustainable transport modes such as cars are preferred above humans, resulting in accidents, noise, air pollution, congestion, and cost, among others [9].

Universities play a leadership role in promoting environmentally sound programs through research opportunities, teaching, and service-learning on non-motorized travel, hence, sustainable mobility is not new within the dynamics of university campus planning. Meanwhile, the overriding issue is changing the way of thinking, and the need to change routine decisions, behavior, and levels of commitment bounded by creativity and willingness to take risks and improve living conditions. Therefore, promoting sustainable mobility on the campus may include cutting the environmental cost of commuting through the 'Green campus approach' [10], providing access and mobility without destroying campus qualities [7], and considering the impact of cyclists and motorists on physical activities in the university [11].

Transportation systems are among the most important aspects of university Master Plans and involve the planning and operation of various traffic modes, including motor vehicles, bicycles, transit, and pedestrians [3]. The success of sustainable transportation will depend on the encouragement of non-motorized (i.e., pedestrian and bicyclist) and shared-ride transportation modes instead of car-dependent travel with the corresponding carbon footprint value. Encouraging sustainable transportation on the campus and changing the choices students, faculty and staff use for transportation may not be easy. Promotions and campaigning are very essential for students to become active, and may play an integral role in the success of sustainable transportation initiatives in universities [12]. In addition, the main goal of sustainable university mobility should advance healthy living, lower emissions, and improve sustainable transportation [1]. Notwithstanding, pedestrian walkways and bus terminals are distinct components of sustainable campus mobility as it gives users access to a network of connected, direct, and easy-to-follow routes linking the hostels, faculties, green spaces, public transport stops, and other facilities, as well as enhancing campus experience based on safety, functionality, pleasure, and learning [5].

The challenges of university campus transportation are numerous. Transport accounts for nearly a quarter of current energy-related carbon dioxide emissions, with car travel constituting more than three-quarters of all vehicle kilometres travelled. However, a change in transport behavior through effective interventions could reduce car use and CO_2 emissions from road transport [13]. Continued automobile usage causes serious environmental and social problems, such as those associated with high levels of automobility, including traffic accidents, congestion, air, water, and noise pollution, global warming, resource depletion, public health, and suburban sprawl [7]. Car-based transportation is expensive and inefficient over short distances and a major contributor to global warming. In addition, planning law requirements make parking spaces expensive to build, thus resulting in the proliferation of haphazard and inadequate parking spaces on college campuses. Effective interventions could reduce car use and CO_2 emissions from road transport and provide solutions through parking management, car sharing, park-and-ride schemes, mass transit, vehicle technology, and alternative fuels, among others.

Among commonly used strategies to combat transportation problems on university campuses are elements of Transportation Demand Management (TDM) such as public transportation, carpooling and vanpooling, parking management and utilization, encouraging the use of bicycles, and providing a pedestrian-friendly campus. Best practices indicate that creating bicycles and walking-friendly campuses requires efforts to focus on strategies such as TDM, organization, planning, facilities, promotion, education, and enforcement of policies. The development of highly integrated strategies has the potential to improve sustainability; however, it is necessary to customize these measures to local conditions to avoid considerable opposition to their implementation.

TDM is a veritable tool for sustainable campus mobility and an indispensable strategy for altering the transit attitudes and behaviours of movement directed towards providing

alternative travel choices and the motivation to decrease trips using private cars [14]. It is the art of changing transportation behavior [2] and among its numerous benefits are the preservation of natural resources and the environment, efficient use of land, decreased traffic accidents and congestion, a decline in pollution, increased transport options, reduction in consumption of energy resources, and overall improvement in livability and social equity [15].

Providing incentives for walking, and bicycling, discouraging the use of single-occupancy cars and encouraging mass transit, and ridesharing, reviewing parking costs, as well as linking transportation planning to land-use planning are major initiatives toward sustainable transportation planning on university campuses. Generally, sustainable transportation aims to increase accessibility without increasing individual mobility in private modes of transportation [16] resulting in a corresponding reduction of the value of carbon footprint on the campus.

The success of sustainable transportation is prominent in the corresponding reduction of the value of carbon footprint when comparing the shares of different travel modes on the campus. A major characteristic of sustainable campuses is embedded generally in their walkability and bike-friendly nature. This can be achieved by developing a bike-friendly campus network, either along the road network or by creating separate bike paths or bike lanes along the walkways. Though using the bike as a transportation mode is not very popular in the study region, enlightenment programs are required to make a mixed flow of bicycles and vehicles in the same lane safe and symbolic in the long term. More realistic policy development would be achieved through management and specific reduction policies for private car use on campus.

Approaches to sustainable transport development vary according to local challenges. The best alternative is one that suggests realizing the transportation goals within sustained social, economic, and environmental conditions and conforms to intergenerational desire directed towards a progressive, safe, and secured environment for the university community. Such an approach must combat the challenges and secure an environment conducive to health, wealth, and general welfare without injuring the physical environment. The key factor in arresting conflicts from a sustainable environment will require a change in system behaviour.

Sustainable Travel Plan within the university campus is a major sustainable transport initiative since the travelling pattern within the university campus affects sustainability. The objectives of sustainable travel plans are to maximize the opportunities for the movement of goods and services and undertake business using transport modes other than the private car in the University. Sustainable transport initiatives provide reasonable alternatives and discourage the use of private cars by staff, students, and visitors to travel within the University for other work-related Journeys. The pattern of movement must be complementary to the efficient operation of the University and contribute to improving the health and well-being of staff and students by promoting walking and cycling to reduce the overall carbon emissions produced by university-related activities and promote sustainability.

Vehicle ownership is a mark of affluence. The daily trips of staff and students' vehicles commuting from home to work and from residential hostels to academic areas are fossil fuel-based transport systems and among the largest contributor to greenhouse gas. In the absence of a policy to restrict the movement of vehicles, coined with the need for the circulation of goods and services within the campus, a significant level of carbon emission and a high carbon footprint may be imposed on the transport sector of the university [17]. Therefore, commitment to formulate more effective and innovative approaches and make Sustainable Travel Plans a top priority in campus transportation planning is paramount to ensuring sustainable campus mobility.

In addition, pedestrian walkways and bus terminals remain key components in achieving a sustainable campus mobility network. Walking is commonly associated with many benefits ranging from reducing air pollution and traffic congestion, improving fitness and other health benefits, encouraging neighbourly interactions, making the environment more enjoyable and safer [18], and also providing economic stability, and environmental protection [4]. Therefore, the pedestrian walkway identifies the perceived friendliness, aesthetics, and safety of space to travel within the public right of way separated from roadway vehicles [19][20].

Similarly, Bus terminals are a critical component of the transit system and play a vital role in the operation and function of an efficient, convenient, and safe public transport system within the campus [21]. Thus, every transit customer or bus rider desires to get to a bus stop easily and wait to board the bus or alight in comfort within a safe environment, hence the need for well-designed and managed Bus Terminals to avoid significant barriers. Subsequently, the alternative to reduce the extent of emissions in universities will mean adopting a change in movement patterns and mobility behaviour within the campus and introducing policies and actionable strategies in sustainable movement patterns and green transport development. Other strategies such as utilizing Bio-Diesel fuel, prioritizing fuel efficiency, expanding the university bikes program, and supporting and subsidizing the car-sharing program may assist to achieve sustainable transportation.

Sustainable campus transportation has the potential to affect the transportation behavior of the campus population in the present and also the transportation habits and environmental awareness that students can develop in the long term, as they progress to occupy influential roles in government, companies, or other organizations [10]. In this way, innovative transportation approaches will likely diffuse from higher education to other parts of society.

3 Methodology

Modibbo Adama University (MAU) is a third-generation Nigerian public university with a population of about twenty thousand (20,000) people and a land mass of over 1,000 hectares within the Sudan savannah zone with marked dry and wet seasons. The temperature increases gradually from January to April with a seasonal maximum of $42°C$ in April and drops in the rainy season from July to October.

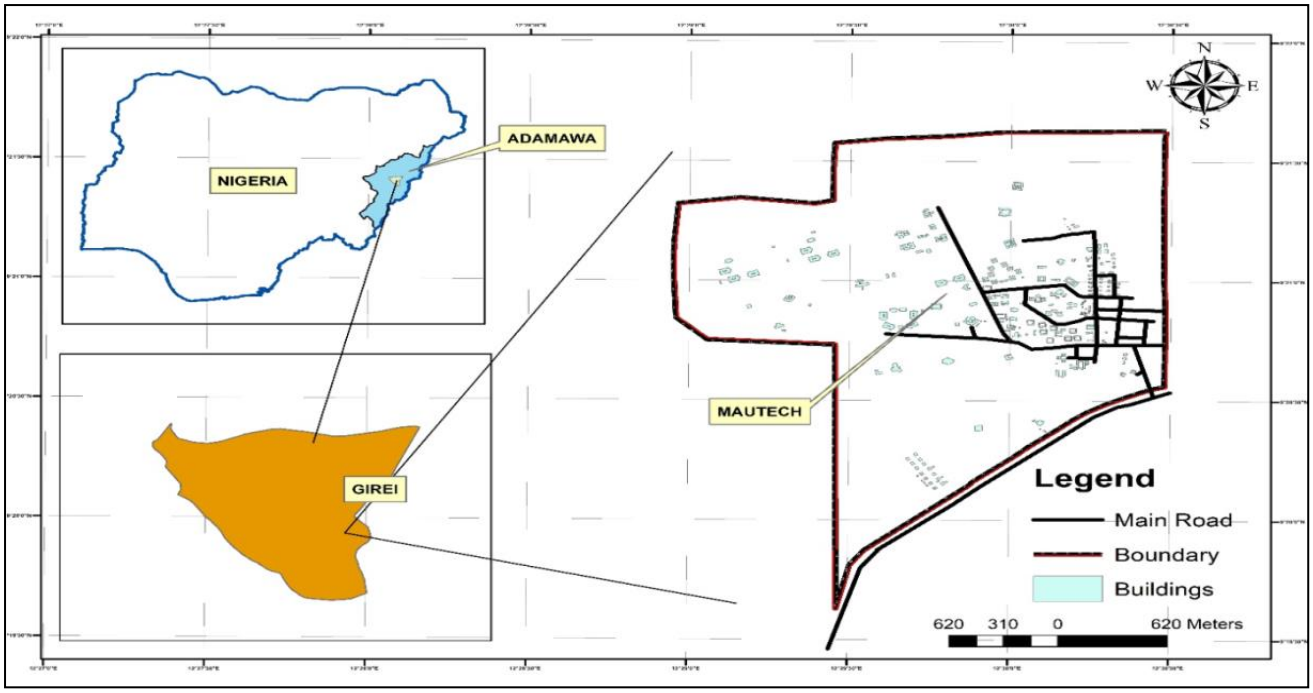

Figure 1: Map of Modibbo Adama University, Yola. Adamawa State Nigeria

In order to determine the character and extent of mobility challenges within MAU and promote walkability and bus services as sustainable modes for transiting and commuting within the university campuses in response to the challenges, it was necessary to carry out investigations to identify the potential for sustainability transportation and decide on comprehensive policies and strategies that may enforce a new Eco-conscious lifestyle, to achieve easier mobility through the location of suitable Bus Terminals and encourage sustainable mobility within the campus of MAU, Yola. About 405 respondents living off and on the campus were interviewed using designed questionnaires distributed to study the travel behavior of staff, students, and visitors to MAU. The average daily trip generation was determined, and primary and preferred modes of mobility were examined. The travel time and average distance traveled to destinations such as Classrooms, hostels, Academic Departments, Commercial Areas, and Sports areas within the University were also investigated. The study identified challenges related to existing active modes of transportation in MAU, Yola, and also collected information from university staff and students to ascertain the problem with the use of existing modes of transportation inside university campuses; and finally, provide a planning framework for achieving sustainable transportation on the campus. Other data required consists of the Physical data, Infrastructure, and Demographic data of the study area collected from primary and secondary sources.

- Physical data considered the nature/pattern of movement within the campus of MAU, Yola.
- Data for Infrastructure considered location and characteristics of existing infrastructures within the campus
- The size of the university population constitutes the Demographic data for the study.

The definition and selection of the study population were based on the interview of a sample of users using a simple random sampling technique method. Participants were selected using the snowball sampling technique to locate informants by identifying individuals or groups with special knowledge of the phenomenon [22]. The study was based on the case study method and materials were gathered using a questionnaire survey and interviews. Collection of information was done through direct interviews of respondents on the campus using the questionnaire as a guide, while data were collected from six (6) thematic areas corresponding to; i) Occupation and Residence; ii) Preferred Mode of Mobility; iii) Safety and Mobility Rating within the Campus iv) Distances and Travel Time between major activity areas; v) Perception on using Public Transport, and vi) Walking Experience. Other areas of information were on the use of Public transportation (taxi) and Walking, assessment of the Pattern of Movement, Locations of Bus Terminals (where applicable), and the Condition of Walkways as well as a Survey of Perceptions of students and faculty.

Analysis of the information was conducted based on the categories defined above. The codification of the data was performed, separating them according to each of the categories, and finally, the interpretation of the data, considering the context in which they were collected. The coding process was done in Excel. Taro Yamane Method (1967) was adopted to determine a reliable sample size for the study as shown below.

$$n = N/(1+N(e)2) \quad (1)$$

where n is the corrected sample size, N is the population size, and e is the margin of error. The known population size of MAU is 22000 (students population of about 20000 and about 2000 members of staff.

Assuming that a 95% confidence interval was used, and the margin error level is 0.05

The minimum sample size was calculated as:

$$n=22000/(1+22000(0.0025)) \quad (2)$$

$$n=22000/(1+55) \quad (3)$$

$$n=22000/56 \quad (4)$$

$$n=392.8571$$

The minimum required size is 393, however, 450

questionnaires were produced and divided into two major parts, for the students and faculty members living both off- and on-campus respectively. Out of 450 questionnaires, only 420 were administered and 30 were invalid.

4 Results and Discussion

University campus usually presents horizontal or vertical connectivity [7]. MAU supports a horizontal campus connectivity system that is more automobile dependent, encouraging commuting by cars (usually occupied by single passengers), while the majority of staff and students without cars either use Taxis or walk across the campus for up to about 3 - 5 kilometers from the University Main Entrance. Despite its large size, the University is serviced by only fifty (50) registered Taxis that convey students and staff to various destinations within the campus. Because of the high percentage of campus residents, the number of taxis on the campus appears inadequate.

Walking in the open within the campus is challenging due to extreme weather conditions characterized by a hot and sunny heat period between March to May, heavy rainy conditions from June to October, and the dry cold, and dusty harmattan wind between November to January. The gentle slope and little depressions along the two seasonal rivers in the North and Western regions connect the site to River Benue, while the relatively flat terrain with few rocky spots could make the site favorable for bicycling.

In view of the challenges of mobility, walking is the popular mode of getting around the campus. However, priority has not been given to the safety of pedestrians as students were observed to walk along the narrow-motorized road, competing with vehicular transport (Figure 2).

Figure 2: Students Walking Along Narrow Motorised Road

The study also observed past attempts to encourage pedestrian movement within the campus such as the ungraded walkways lined with trees as evident in Figure 3. This is presently rendered obsolete due to poor maintenance. Consequently, existing footpaths as shown in Figure 4 could be upgraded into functional walkways to separate pedestrians from vehicular traffic and promote the sense of walking within the campus. Generally, male and female respondents had similar travel patterns. The majority of those interviewed (56%) were students while members of Staff and Faculty constituted 31% and 13% were businessmen (Table 1).

Figure 3: Existing Poorly Maintained Walkway

Many of the students live on the campus where about 65% of the respondents live in hostels within the campus, while 35% reside outside with the majority living in nearby residential districts (University Village). Students with personal cars preferred driving and non-car owners either walk or take Taxis, while others commute to the campus from the city and transit by walking within the campus. However, most members of staff commute to the campus in private cars, and travel more than five kilometres from the University's Main Entrance because of the inadequate public transport system.

Furthermore, the travel patterns and transportation challenges established through the questionnaires showed the lack of adequate infrastructure for campus mobility, especially walkways and Buses services. Also, the marginal role of walking and cycling as well as the longer time involved in using public transport modes constitute the main barriers to shifting travel modes from private vehicles to non-motorized modes. Other data collected from respondents include Occupation and Residence, Preferred Mode of Mobility, Distances and Travel Time between major activity areas, Safety and Mobility Rating within the Campus, and Perception of using Public Transport and Walking Experiences as presented in Table 1.

Figure 4: Existing Pedestrian Paths could be upgraded to functional walkways

Table 1: Respondents and their Residence

Variables	**Types**	**Frequency**	**Percentage %**
Respondents	Students Staff Businessmen / Visitors	395 13 12	56% 31% 13%
Residence	On-Campus Off-Campus	273 147	65% 35%

A. Modes of Mobility and Residence of Respondents

Figure 5 presents the Modes of Mobility of respondents as revealed by the study. About 60% walk to their various places of engagement within the campus, 34% use public transport (Taxis and Commercial Tricycles) as provided within the University**,** and 3% own private cars, while 3% make use of bicycles. From the results majority of the students walk to most places within the campus despite poor infrastructure for walking, suggesting the need to promote walkability (the sense of walking) and improve their walking experience by providing walkways within the campus.

B. Preferred Modes of Mobility

Walking is the most preferred mode of mobility (Figure 5), where about 55% of the respondents preferred walking, probably, because of the inadequacy of the existing public transport system within the campus. The second most popular mode is the use of public transport where about 27% showed a preference for using Campus Taxis / Commercial tricycles. This might be because of the spatial distances of some of the facilities within the campus. Notwithstanding, 9% prefer bicycling, while 9% own private cars and naturally prefer to drive. Therefore, there is a need for improved pedestrian circulation through the functional walkway that is accessible to all and links most activity areas.

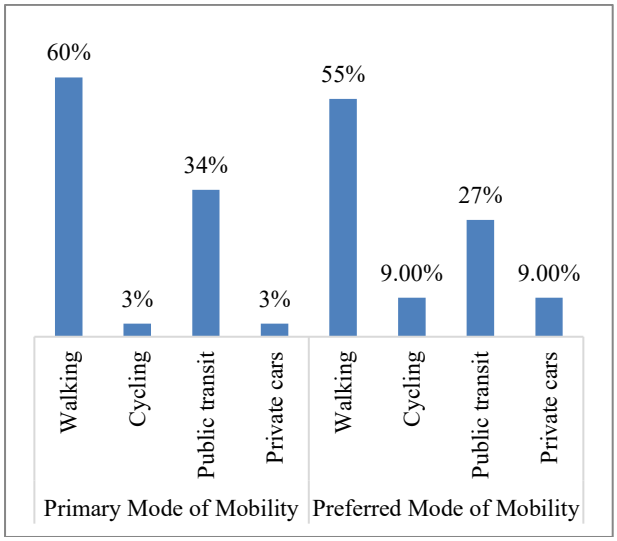

Figure 5: Primary and Preferred Modes of Mobility

C. Distances and Travel Time between Activity Areas within MAU

The average distances and travel time between activity areas within MAU are shown in Table 2. About 32% of the respondents travel a distance between 401- 600m between hostels and classrooms while 31% travel above 600 meters. This means that the majority of the respondents travel between 400 to above 600 meters within 11 to 15 minutes and above between the same facilities respectively. Also, about 58% of those interviewed travel 6 to 15 minutes from the hostels to the classroom, while about 24% travel above 15 minutes. Hostels and Departmental classrooms fall within walking distance in MAU and the travel time can be reduced through the provision of efficient walkways and by locating bus terminals at appropriate sites.

Furthermore, about 61% of respondents travel between Hostel and Commercial areas, covering a distance between 0-200m, 30% cover a distance between 201 – 400m, and only 9% cover a distance between 400-600m. Meanwhile, about 67% of respondents spend less than 5 minutes of travel time between hostel and commercial areas, while only about 9% spend between 11 -15 minutes in such places. This shows that most of the hostels are within walking distance and near commercial areas, which is a potential for the establishment of well-developed walking paths or walkways to encourage walking and make mobility easier. Considering the Travel Time between Hostel and Sports Area, Table 2 also shows that 12% of the respondents travel between 0-5 minutes, while 19% spend between 6-10 minutes, 32% spend between 11-15 minutes, and 33% spent above 15 minutes of travel time. This reveals that the majority of the students spend more time accessing sports centers from their hostels. This problem can be ameliorated by establishing Bus Terminals between major activity areas.

The study also shows that about 57% spend between 0 -5 minutes, 35% spend between 6 and -10 minutes, and 8% spend between 11 – 15 minutes of travel time between classrooms and commercial areas. The result shows that the majority of the respondents spend less than 10 minutes of travel time between their classroom and commercial area. This is within walking distance and can be improved with the provision of a walking path (walkways) to connect the commercial and class area. As a means of fostering a healthy lifestyle and creating a sustainable university, existing dilapidated walkways could be repaired, while an efficient bicycling program should be established to reduce carbon emissions and enhance non-motorized mobility.

Table 2: Distance and Time Traveled

Location	Distance (Meters)	Percentage %	Travel time (minutes)	Frequency	Percentage %
Hostels and Classrooms	0-200 201-400 401-600 Above 600	15% 22.5% 32% 31%	0-5 6-10 11-15 Above 15	71 118 130 100	17% 28% 31% 24%
Hostels and Commercial Area	0-200 201-400 401-600 Above 600	61% 30% 9% 0%	0-5 6-10 11-15 Above 15	285 97 38 ---	68% 23% 9% 0%
Hostel and Sport Area	0-200 201-400 401-600 Above 600	57% 35% 8% 0%	0-5 6-10 11-15 Above 15	50 80 134 155	12% 19% 32% 37%
Classroom and Commercial Area	0-200 201-400 401-600 Above 600	11% 20% 31% 38%	0-5 6-10 11-15 Above 15	240 147 33 ---	57% 35% 8% 0%

D. Mobility Challenge and Perception of Safety

Among the mobility challenges observed within the campus are poor road network and poor walkway pavements, absence of bus stops or terminals, and long travel times and distances. Other findings from the study include the desired improvement suggested by respondents as shown in Figure 6.

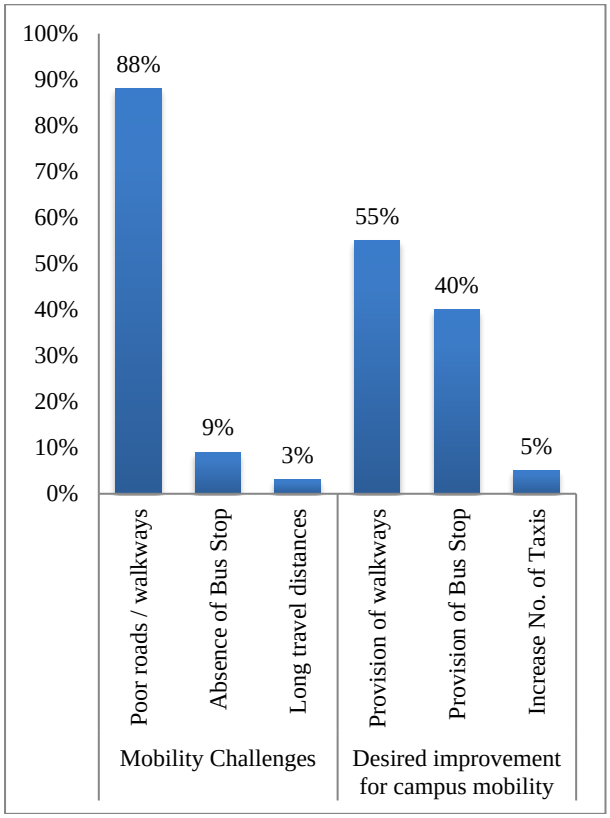

Figure 6: Mobility Challenges and Desired Improvements

About 88% of respondents considered poor roads and poor walkways as impairing mobility within the campus, while the absence of bus terminals constitutes 9% and 3% believed that long-distance travel is a major challenge. Also, 55% of the respondents suggested that improving walkways would promote sustainable mobility, and about 40% claimed that the provision of Bus stops/terminals at designated locations would ease campus mobility while 5% believed that increasing the number of existing Taxis and commercial Tricycles within the campus could ameliorate the challenges experienced in the campus.

Generally, there is a desire for walkability and sustainable transportation in MAU among respondents as reducing car commuting will be of tangible benefit to the University, especially towards being 'green'. Among the suggested locations for the Bus stops/ terminals based on movement patterns and accessibility to functional areas and services to students' needs are the Lecture Theater, Academic Departments, Students' Hostels, and Commercial Areas.

E. Mobility Rating and Perception of Safety

From observation, as shown in Table 3, the campus mobility at MAU can generally be rated as fair. However, about 43% of the respondents claim that mobility within the campus is poor/bad, while 45% said it is fair and 13% rated it as good. Notwithstanding, there is a need to upgrade the transport system through the provision of adequately connected walkways and bus stops at suitable locations to further ease the movement of people. Responding to the perception of the safety of pedestrian movement, about 63% feel unsafe walking within the campus bearing in mind the vehicular traffic, while 37% claimed relative safety as shown in Table 3. Therefore, safety measures such as sidewalks, pedestrian crossings, and bumps need to be put in place to ensure that pedestrians are kept away from motorists as much as possible to provide a safe walking environment.

Table 3: Mobility Rating and Perception of Safety

Variables	Type	Frequency	Percentages
Mobility Rating	Good Fair Bad	54 185 146	13% 45% 43%
Perception of safety	Yes No	155 265	37% 63%

F. Perception of Walking Experience and Using Public Transport

Figure 7 presents respondents' perceptions of walking experience and using public transport. It was observed that 55% rate their walking experience as bad, 37% rate it as fair, and 8% perceived the use of public transport as good. On the use of Public Transport, 74% of the respondents rate their experience as bad and poor, 23% rate it as fair, and only 3% claimed that using public transport within MAU is good. This shows the need to improve the public transport service and enhance pedestrian movement by creating adequate infrastructure, proposing efficient TDM systems, and locating bus terminals at suitable locations to ease movement and improve this perception.

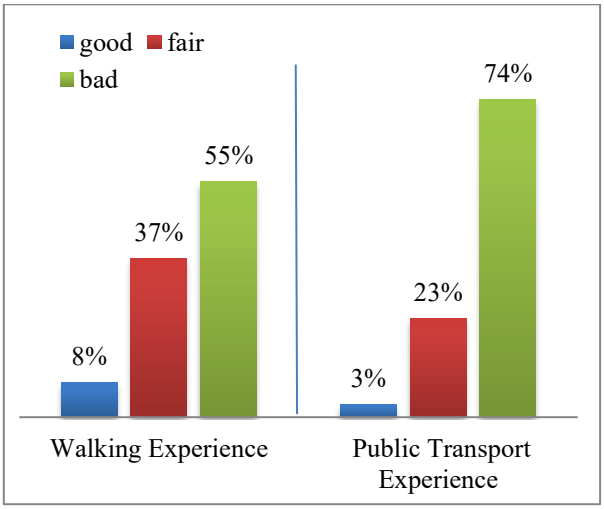

Figure 7: Perception of Using Public Transport and Walking Experience

Furthermore, the survey observed that existing mobility within the University is rather inadequate, while the prospects of sustainable transportation practices remain poorly untapped. About 88% of those interviewed see the bad roads and inadequate walkways as challenging for mobility within MAU. Similarly, the majority of the respondents expressed poor perception experienced in walking and using the public transport systems within the campus. About 64% are in favor of non-motorized modes of transportation, hence, walking, use of public transport, and cycling are considered the preferred modes of transport, while only 8% of the respondents favor private cars. Therefore, upgrading the existing dilapidated and unpaved walkway structure is required to improve walkability within the campus. This could encourage a modal shift from

cars to other modes, such as bicycling, walking, and local bus shuttle to support sustainable transportation within the University. With a population of about 22,000, MAU offers great potential for efficient TDM and can support effective Bus service programs within the university campus. The relatively fair topography of the study area could be an advantage to promoting bicycling as the primary mode of transportation, more so, the introduction of modern bicycles and new technology could surmount the physical/topographical challenges of prevailing weather conditions and encourage a modal shift to nonmotorized travel mode. Furthermore, upgrading the existing dilapidated walkway structure would offer great prospects for sustainable mobility, especially where about 55% of respondents expressed a preference for walking. This will not only promote sound health among students and staff but also increase personal safety, reduce the risks of accidents as well as reduce the carbon footprint of the University.

Efficient implementation of strategies for a sustainable campus may take advantage of the low car ownership, especially when considering along preferred mode of transportation (Table 1) as the potential for the nonmotorized campus environment. The majority of the respondents have a poor perception of using public transport and a poor walking experience, this relatively high rate should be addressed with appropriate strategic programs and policies to make the campus safe for walking and convenient for mobility. Also, the existing car-based parking lots within the campus can be maintained and installed with furniture to complement walkability and recreation. These locations would also be ideal for bicycle-sharing programs and should be effectively linked to the proposed pedestrian network. Considering the characteristics of the in-campus movements the study identified factors discouraging walkability within MAU. Because of the absence of well-defined walkways, hot temperatures, and humid weather, the safety of pedestrians is not given priority, students are exposed to high risk as they are forced to walk on the motorized road (Fig 2). Finally, safety elements like zebra crossing and speed bumps should be provided to protect pedestrians.

5 Conclusion

The goal of this research is to promote sustainable campus mobility. Assessment of existing mobility conditions reveals inadequacies and challenges in patterns of movement. Because of the inadequacy of the existing public transport system, the majority of the respondents walk within the campus, where pedestrians are not safe as they compete with vehicular traffic for space along the existing narrow motorized lanes. Although there is evidence of a few existing walkways, these appear to be in a deplorable state and need repairs/upgrading.

In addition, the Taxi Park is located at the University's Main Entrance which is about 5 kilometers to destinations like the university Library among others, without a definite route and stops assigned for the Taxi service. Also university fleet of buses is lacking and officially designated Bus terminals are absent on the campus leading to random movement and undefined stops by Taxis which results in longer travel time within the campus. Other challenges include freely parked cars without restriction in the few designated parking lots, the absence of an organized public transit system, the absence of well-defined and paved walkways, and poor pedestrian facilities discouraging the choice of walking above other means of mobility and resulting in poor mobility experienced within the campus. The introduction of efficient Transportation Demand Management (TDM) on the campus, would promote sustainable mobility and facilitate the development and location of bus terminals according to land use density and connectivity of walkways, promote bicycling as well as ensure the implementation of other sustainable transportation strategies. It is believed that focusing on the quality of physical infrastructure and the structure of TDM will provide direction for the establishment and implementation of an efficient sustainable mobility system and improve the campus mobility experience at MAU. The study provides a set of recommendations based on existing conditions and the opinions of respondents, as well as the examination of the best practices for sustainable transportation policy, strategy, and plans for achieving sustainable campus mobility in universities. These recommendations are listed below:

- Pedestrians should be given a high priority when it comes to planning the university transport system.
- Adequate provision and maintenance of bus stop facilities and pedestrian walkways should also be made to ease the challenge of mobility experienced within the campus.
- Introduction of efficient Transportation Demand Management in MAU. The University management should create a policy that supports TDM and favor the management and maintenance of transport facilities provided. This will help reduce the maintenance cost and provide a longer life span for the infrastructure.
- The University management should engage the services of professionals in the implementation process to maintain a high level of standard.
- The University management should also provide renewable energy sources such as solar to power the lighting and charging stations at Bus Terminals and along the walkways.
- Due to the high temperature and extreme weather conditions during the rainy seasons, University management should consider covered walkways and prioritize the planting of trees along walking paths. This will help lower the temperature, provide shade, and improve the sustainability goal of the University campus.
- Finally, sustainable transportation promotion campaigns and sensitization is very essential to encourage students to become active in sustainable transportation programs such as the use of bikes and buses to commute within the campus community.

Ethical issue

Authors are aware of and comply with, best practices in publication ethics specifically about authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. Authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language. Also, all procedures performed in studies involving human participants were following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards of the institution or practice at which the studies were conducted.

Competing interests

The authors declare that no conflict of interest would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution to data collection, data analyses, and manuscript writing.

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