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Promoting Active Transportation in Egyptian University Campuses: Assiut University as a Case Study

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Abstract

To create sustainable cities, mitigating challenges such as traffic congestion, air pollution, energy depletion, and environmental degradation is imperative. A pivotal aspect of achieving this goal is the adoption of sustainable transportation modes, such as active transportation which relies on human physical power. The present study explores the incorporation of active transport as a sustainable approach to transportation issues prevalent within Assiut University, which currently faces significant deficiencies in this regard. The study explores the principles and indicators of active transport and proposes their implementation on the university campus. Using an analytical and descriptive methodology, the study conducts data collection through two primary methods: questionnaires and on-site visits. The questionnaires are designed to gather quantitative data on current transportation practices, preferences, and challenges among students and staff. Complementing this data, on-site visits offer additional clarity of the university's transportation infrastructure, providing valuable context and identify specific areas for improvement. The findings aim to generate interventions for enhancing transportation at Assiut University. Moreover, they potentially serve as a model for similar universities, thereby facilitating the creation of more sustainable environments on a broader scale.

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Keywords: Active transportation; Indicators; Assuit University; Convenience; Amenities, Maintenance.

1. INTRODUCTION

Urban transport activities are a significant source of air pollution and noise emissions [1–4]. The negative effects of transport activities primarily impact the population's health and quality of life [5–8]. These effects include road safety issues, environmental impacts, and reduced physical activity due to the excessive use of private cars [4,8–11]. According to the World Health Organization (WHO), nine out of ten people globally breathe air with pollutant levels exceeding WHO guidelines [12,13]. The transportation sector is a major source of greenhouse gas emissions, accounting for around 25% of global CO2 carbon dioxide emissions [14–17], and is projected to constitute 40% of total global emissions by 2030 [4]. In the U.S. for example, transportation methods are responsible for 47% of the net increase in total emissions since 1990. This influence is enormous to the extent that, in the WHO European region alone, an estimated 500,000 premature annual deaths are linked to exposure to ambient air pollution [4]. It worth noting that transport-related air pollution ranks fourth among global health risk factors [18]. Additionally, traditional transportation infrastructure such as roads and highways can violate natural habitats and agricultural lands. This contributes

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to urban sprawl and habitat fragmentation, in addition to being a significant source of noise pollution and contaminating water bodies, which can also have adverse effects on both human health and wildlife. [14–17].

Accordingly, countries have begun strengthening their climate plans to urgently cut carbon emissions and achieve net zero by 2050 [19,20]. Similarly, the United Nations' (UN) goals aim to limit the mentioned negative effects. For example, Goal 11 of the UN aims to: *"Make cities inclusive, safe, resilient and sustainable"*, while target no.2 attempts to: *"By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons"* [21]. The level of global attention to this matter, combined with the adverse effects of transportation activities, has prompted the current study to investigate sustainable and eco-friendly transportation methods.

1.1. Active transport (AT)

The previously mentioned issues underscore the necessity of ensuring the safety and sustainability of urban roads and transportation systems, accessible to all demographic groups. Thus, it highlights the importance of promoting AT as a key component of sustainable transport strategies. AT can be defined as *"a mode of transportation that is powered by human movement and does not rely on an engine"* [22] and can also be defined as *"any means of getting from A to B that involves being physically active"* [23]. Walking and cycling are widely recognized as the most utilized modes of AT [22]. However, it is important to note that other activities such as skateboarding, roller-skating, and numerous others also fall under this umbrella [23]. Nonetheless, the concept of AT goes beyond these specific examples, emphasizing the importance of engaging in any mode of transportation that involves physical exertion. As explained in section 1.2, AT boosts local economies by creating jobs, enhancing commercial growth, and raising real estate values, while promoting community health, environmental sustainability, and transportation equity. [23].

1.2. Benefits of AT

AT, which encompasses human-powered activities such as walking and cycling, is increasingly recognized for its comprehensive benefits. It presents a unique set potential gain, offering advantages that extend beyond the personal level to the communal level. The following highlights the diverse benefits of AT:

1.2.1. Economy

AT plays a crucial role in stimulating the growth of the local economy [1,24–26]; Creating walkable and bike-friendly neighborhoods promotes residents' interaction with their surroundings, thereby encouraging the growth of local businesses. Furthermore, accessible, appealing neighborhoods for AT can attract visitors, contributing to the local economy. AT also maintains a city's competitiveness, especially for lower-income, youth, and senior citizens who rely on transportation [27,28]. Well-integrated AT has much to offer in terms of reducing the financial burden of vehicle ownership, maintenance, and insurance [1,25–27,29]. Hence, the residents can allocate larger portions of their income towards local amenities such as groceries, restaurants, and clothing.

1.2.2. Health

Research has established a correlation between AT and enhanced physical activity, leading to improved health outcomes [30–32]. Engaging in regular physical activity, even of moderate intensity such as brisk walking or cycling has been shown to decrease the risk of premature mortality and various chronic diseases [33,34]. Physical activity also contributes to

psychological well-being and serves as a preventive measure against weight gain and obesity, thereby promoting overall health [35–37]. For instance, according to the studies, individuals who commute to work by cycling have lower overall mortality risk compared to those who commute by car or public transport [38]; In fact, cyclists reportedly have lower risk of developing heart disease and cancer [39–43].

1.2.3. The environment

AT, as a non-motorized mode of transportation, offers many environmental advantages. These include a reduced dependency on vehicular transport, the alleviation of traffic congestion, and a reduction in air pollution and greenhouse gas (GHG) emissions [44–47,26]. Figure 1 demonstrates the emissions from different vehicle types in comparison to AT modes of travel. Hence, AT is not only a sustainable alternative to traditional transport but also a strategic tool for cities aiming to achieve environmental improvement. Furthermore, it contributes to the reduction of the city's ecological footprint, the preservation of the natural environment, and mitigating climate change [44,47].

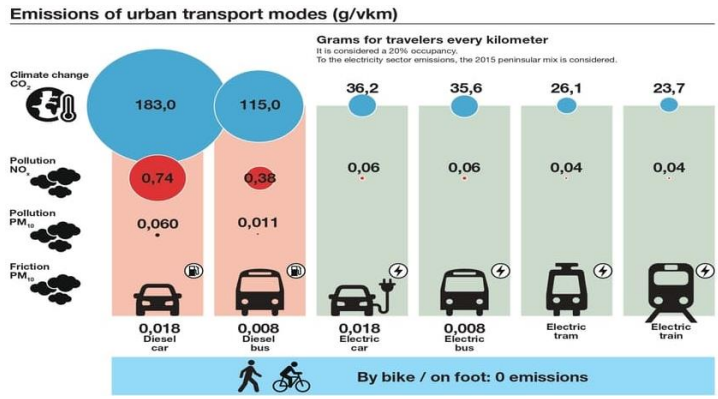

Figure 1: Emission from different vehicle types in comparison to AT, from [48].

1.2.4. Social benefits

Research has highlighted that AT can reinforce community cohesion and connectivity, as residents who regularly walk or cycle within their community tend to experience increased social interactions [49,50]. For younger demographics, AT promotes the adoption of sustainable travel habits from an early age, potentially influencing transportation choices in adulthood. Furthermore, the frequency of AT within a community is often perceived as an indication of sustainability and livability; A high occurrence of AT highlights the community's commitment to promoting environmentally friendly transportation, reflecting its sustainability goals. Additionally, it signals a high degree of livability, as communities that support AT typically offer safe, accessible, and enjoyable environments for their residents to navigate [47,49].

1.2.5. Equity

AT induces an equitable and accessible transportation system for individuals who may lack access to private transportation such as with low-income individuals, and youth. Consequently, promoting AT options is necessary to address the requirements of these marginalized groups. This can potentially have a good impact on social aspects of the society and introduce more humanized atmospheres [51–54].

1.2.6. Safety

Studies show that as AT adoption increases, possible accidents between vulnerable road users and motor vehicles are decreased [25]. This is commonly referred to as the 'safety-in-

numbers' principle, which implies that areas with high levels of pedestrian and cyclist activity are also the safest for individuals [55–58]. Furthermore, research has also demonstrated that reducing allowed vehicle speeds significantly increases road users' safety and imparts a sense of security. Accordingly, promoting AT as a more visible and viable mode of travel leads to a safer environment for all road users [31,59].

1.2.7. Traffic congestion

AT considerably reduces traffic congestion by reducing the number of cars on the road. This is especially critical for easing traffic congestion in cities, where heavy traffic volumes can have detrimental effects on the environment and cause major delays. Studies show that a 5% increase in neighborhood walkability is associated with 6.5% fewer vehicle miles travelled per capita [60,61]. Similarly, promoting cycling through providing separated bicycle lanes encourages more individuals to choose cycling for transportation, thereby reducing the number of vehicles on the road, and improving traffic flow [62–65].

Despite the numerous benefits of AT, there are several widely recognized issues that impede its widespread adoption. The car-centric development of cities prioritizes private vehicles over pedestrians and cyclists, creating a strong dependence on automobiles and making it difficult to shift towards AT. Additionally, there's a lack of coordination among various government agencies and departments, leading to inconsistent and fragmented approaches to promoting AT. Many cities also lack comprehensive infrastructure for safe walking and cycling, leading to concerns about safety and perceived risks, which hinders increased AT adoption. In car-dependent societies, walking and cycling are often viewed as inferior transport options, making cultural change challenging and securing funding for active transportation infrastructure difficult due to prioritization for automobile-oriented projects [66–70]. Addressing these multifaceted barriers is crucial for promoting more sustainable and livable cities.

2. SCOPE

Universities serve as vital hubs for many diverse user groups, thus necessitating a high standard of interaction and environmental consciousness. Hence, supporting transportation modes that address the mentioned requirements is imperative in this context. Accordingly, this study examines the concept of AT and its implementation potential within Assiut University (AUN). The outcomes of this investigation can be replicated on a broader scale to suit the size of neighborhoods or cities. It is also important to note that the study focused on the physical AT indicators, thus eliminating non-physical element.

3. RESEARCH PROBLEM

The research problem pertains to the common issue of elevated pollution levels within university, mainly associated with the widespread reliance on private transportation modes. The range of this pollution extends beyond environmental concerns to also encompass acoustic and aesthetic issues. Accordingly, this negatively affects several environmental, health, and societal aspects of society, thereby requiring the formulation of a comprehensive approach to mitigate such negative impacts.

4. RESEARCH AIM

The study aims to employ AT indicators as a method for evaluating and enhancing the condition of pedestrian pathways within AUN, with the overall goal of creating a user-friendly environment. Through this approach, the study integrates diverse measures aimed at promoting and facilitating AT modes, thereby encouraging a more sustainable, accessible, and

user-centered university campuses. Ultimately, this initiative aims to enhance the overall quality of life within the university community.

5. RESEARCH OBJECTIVES

While the aims of the study are achieved through the main goal of enhancing the condition of AUN's pathways, several pertaining sub-objectives can be identified as follows:

- Examining the benefits of AT.
- Identifying indicators of successful AT implementation.
- Examining AT indicators along AUN's pathways.
- Developing recommendations for further development of AUN's paths based on the condition of AT indicators.
- Identifying and prioritizing recommendations for the implementation of AT in universities.

6. METHODOLOGY

The current research uses both a descriptive and analytical approach. Literature is used to identify indicators that describe the extent of AT's implementation in a specific setting. As a case study, users of AUN's campus were asked to share their opinions on the presence of these indicators along the university's pathways. The acquired responses, combined with on-site visits, provided a detailed account of the condition of AUN's pathways and identified existing deficiencies. Logical analysis, informed by insights from the literature, was then employed to recommend suitable enhancements to address the deficiencies and align the pathways with AT principles. Further examination of the results also allowed the authors to propose generic steps for the application of AT and highlight specific priorities. Figure 2 highlights the mentioned methodology.

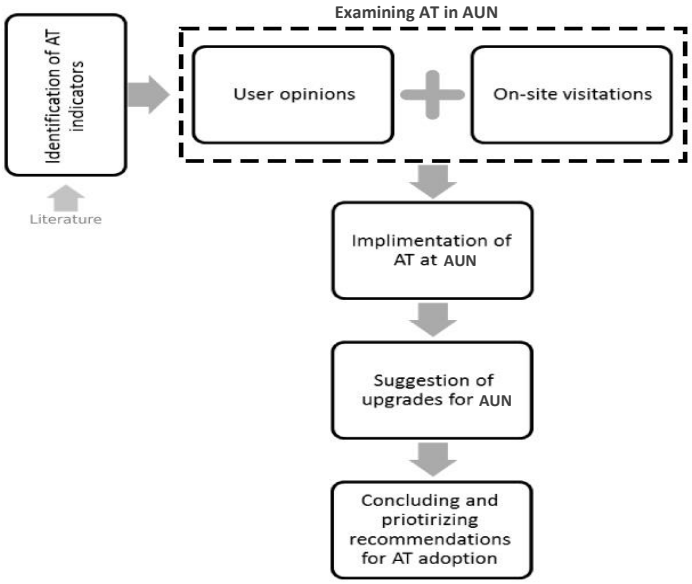

Figure 2: The study's methodology.

7. ACHIEVING AT

The presented earlier literature, in addition to other studies, have pointed out the presence of several indicators the show the degree of application of AT in a setting. Through analysis of this work, the authors have been able to deduce the most critical AT indicators as follows:

7.1. Road quality

When discussing the quality of pathways in the context of AT and infrastructure development, various factors come into play to ensure the efficient, healthy, and safe movement of pedestrians [71–73]. The quality of materials used in constructing pathways is crucial. Durable and weather-resistant materials, such as concrete or asphalt, ensure longevity, reduced maintenance costs, and cleaner environments [74]. Properly maintained surfaces also contribute to a smoother and more comfortable experience for users. Moreover, the appropriate widths of pathways are essential to accommodate different types of users and activities [75,76]. Wide pathways allow for comfortable passing of pedestrians and cyclists going in opposite directions and provide space for activities such as jogging and strolling. In addition, separating lanes reduces the risk of accidents and ensures a more organized flow of traffic along the road [77,78].

7.2. Convenience

Incorporating climatic considerations is essential for creating sustainable and resilient environments [79]. Climatic factors, such as sun exposure, wind patterns, and rain levels, inform decisions about shading, ventilation, and drainage systems [80–83]. Visually, the landscape can be enhanced, both aesthetically and functionally, by integrating green spaces, trees, and water features [84]. Moreover, the visual image plays a crucial role in shaping the identity and attractiveness to users, which can be manipulated through certain design elements, such as architectural styles, colors, and public art installations [85–87].

7.3. Amenities

Providing essential services like seating areas, public toilets, and commercial kiosks holds significant importance [88,89]. Such elements offer individuals a place to rest, socialize, or enjoy the surroundings, thus promoting a sense of community, belonging and relaxation [90]. In addition, certain elements are crucial for addressing basic human needs, such as well-maintained public toilets and commercial kiosks, thus must not be considered redundant [90].

7.4. Safety and security

The integration of assistive devices and elements such as traffic lights, pedestrian crossings, and night lighting plays a pivotal role in ensuring safety, accessibility, and functionality [89,91,92]; Traffic lights control the flow of vehicles, reducing traffic and improving pedestrian and motorist safety. Carefully positioned pedestrian crossings offer secure routes for users, encouraging walkability and reducing the risk of accidents [93,94]. Similarly, night-lighting is essential for illuminating pathways and roads, improving visibility and security, and enhancing the aesthetics of urban spaces [95,96].

7.5. Maintenance

Ensuring the longevity and usability of pathways in urban areas requires constant periodic maintenance [97]. Regular inspections for wear and tear, cracks, or other damage are essential

to identify issues at an early stage and prevent potential safety hazards [92,98]. Additionally, routine cleaning to remove debris, litter, and overgrown vegetation facilitates maintaining a clean and inviting environment for pedestrians and cyclists.

7.6. Promoting AT Culture

This revolves around encouraging sustainable means of commuting such as walking, cycling, and using public transportation. By encouraging individuals to adopt AT, communities are able to reduce traffic congestion, lower carbon emissions, and improve public health [99–101]. Accordingly, positive initiatives like creating bike lanes, pedestrian-friendly pathways, and efficient public transit systems play a vital role in this regard. While the promotion of AT is a broad topic that requires considerable effort. Some major initiatives that can be taken in this regard [102–104] that include: a) Developing targeted marketing and awareness campaigns to showcase walking, cycling, and public transit as easy, fun, and essential parts of everyday life. b) Organizing community events such as open street days, group bike rides, and walking challenges to generate excitement and normalize AT. c) Providing financial incentives such as bike share programs or employer benefits. d) Implementing supportive policies like car-free zones to promote walking, cycling, and public transit use. e) Offering courses on AT ethics, rules, and precautions. It is also crucial to establish indicators and targets to measure the performance and effectiveness of AT initiatives in local communities. This involves collecting data from surveys, sensors, and reports to assess outcomes. Additionally, creating feedback loops capable of refining AT-related strategies and continuously improving them is equally important [103–106].

7.7. Governmental policies

Governmental policies play a significant role in promoting and supporting the adoption of AT, whether at a national or municipal level [107–109]. Therefore, governmental and administrative policies typically focus on aspects such as infrastructure development, funding, and promoting modes of AT with the aim of enhancing public health, reducing emissions, and creating more sustainable and connected communities [107,110,111].

It is worthy to note that the physical indicators of AT are the primary focus of the present study as they correspond to the descriptive methodology of the study. Therefore, factors 7.5, 7.6, and 7.7 are excluded from the questionnaire. Yet, such indicators are mentioned as part of the analytical process of the study leading to related recommendations.

8. CASE STUDY

AUN, situated in Assiut, Egypt, was founded in October 1957, and holds the distinction of being the inaugural university in Upper Egypt, marking a pivotal moment in the advancement of higher education accessibility in the area. The university boasts a diverse academic landscape, comprising 20 colleges, catering to the educational needs of approximately 75 thousand students. Complementing its robust student body, AUN is home to a dedicated faculty comprising 4450 members [112]. Figure 3 displays the university's campus and the location of several elements that are relevant to the study.

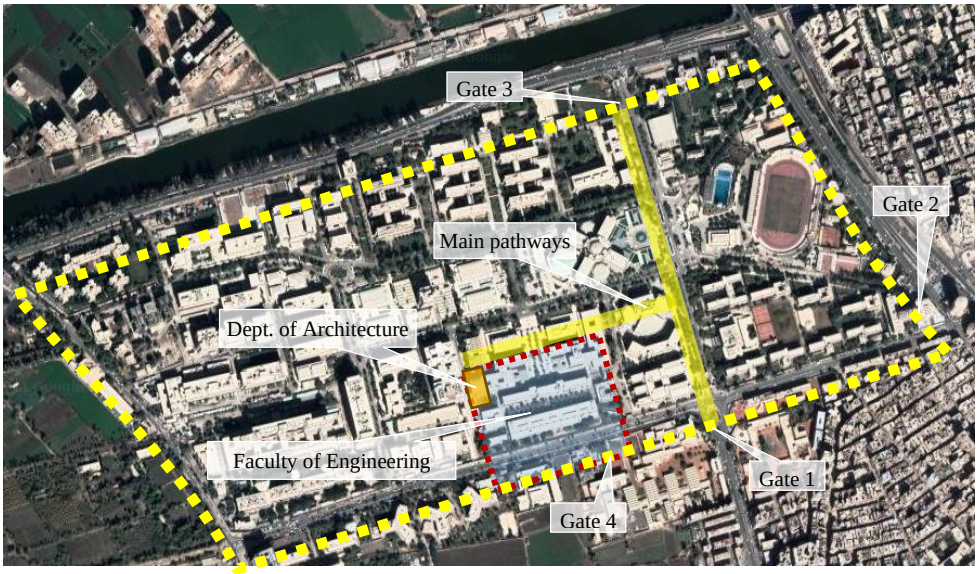

Figure 3: The layout of Assuit university, showing the department of architecture, main pathways, and location of the main campus gates (Image from Google Earth™, edited by the authors).

8.1. AUN's Campus

On-site visitations reveal that AUN's campus boasts a well-defined layout comprising buildings, roads, open spaces, and various essential services. Figure 4 shows examples of AUN's pathways and highlights their relatively good condition. Yet, despite this robust infrastructure, certain deficiencies are reported, which hinder the usability for pedestrians; examples of this are issues relating to the quality of sidewalks, availability of shading structures, and deficiencies in certain services.

Figure 4: The relatively good condition of AUN's pathways (taken by the authors).

8.2. AT condition at AUN's campus

The authors used AT indicators to create a questionnaire, which was distributed to university users to evaluate the advantages and disadvantages associated with movement within the campus's pathways. The goal was to assess the current state of mobility at AUN and identify areas for improvement. The effort aims to optimize the university's transportation infrastructure and create a more favorable environment for active modes of travel on campus. The questionnaire was formulated in light of AT indicators, sub-indicators, and variables

inferred from literature relevant to the current study, thus accordingly it concentrated on critical elements pertaining to AT, such as the quality of lanes and sidewalks, the efficiency of road crossing points, adequacy of lighting, safety measures, convenience factors, amenities availability, and climatic considerations. Each question was designed to examine a specific indicator of AT. Appendix A shows several examples of the questions that the respondents were asked to address. The study focused on the architectural engineering department's users, limiting the study's scope, due to the university's large student and staff number. Also, the study focused on the physical indicators of AT, excluding any non-physical indicators. The questionnaire targeted 30 respondents, including 16 architects and planning experts, and 14 students from the Department of Architecture. The sample included equal numbers of males and females, aged 21 to 69, representing a wide range of the university's users.

8.3. Questionnaire results and analysis

The questionnaire's results have revealed that there are many advantageous aspects related to the studied pathways, yet several components are either inadequately addressed or completely absent. Figure 5 shows the degree of satisfaction/availability or dissatisfaction/unavailability for each element of the pathways based on the respondents' replies.

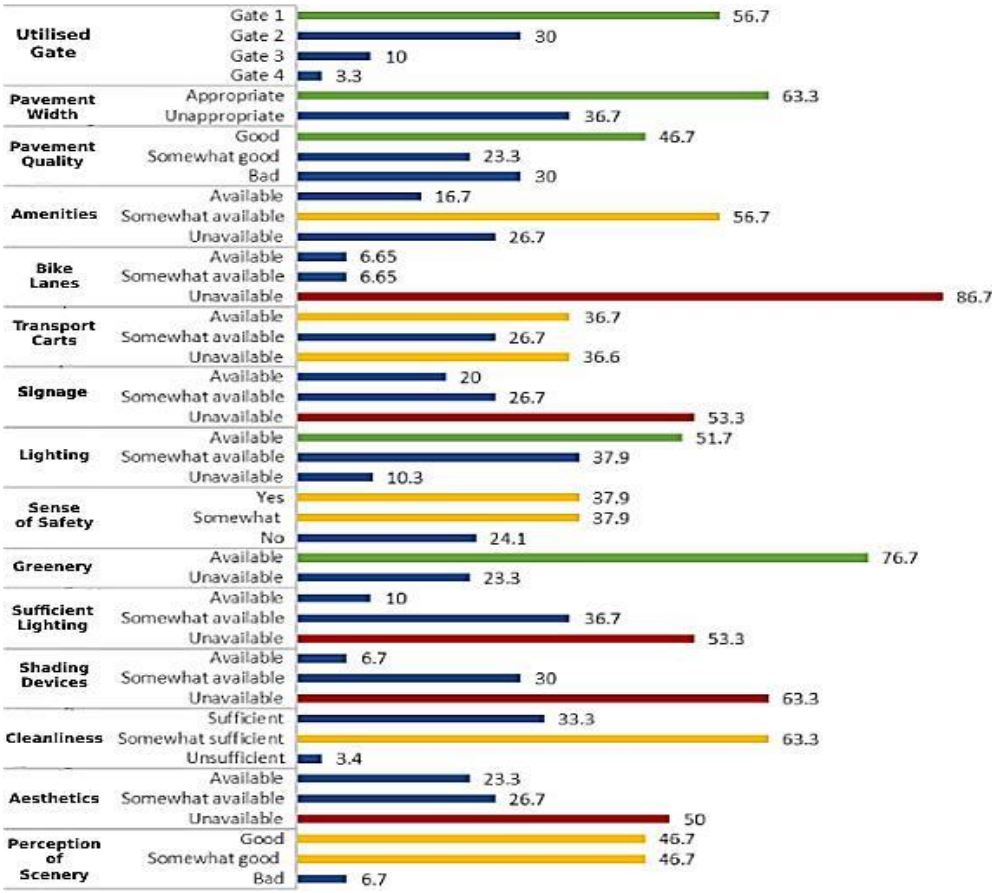

Figure 5: Summery of the questionnaire results, showing satisfactory and unsatisfactory indicators of the studied pathways.

The acquired responses suggest that the pathways have not been designed with AT in mind, thus, the concept of AT is not fully achieved. It is important to point out that, in a preliminary

inquiry of opinions, 50% of the respondents expressed that they do not tend to fully utilize AT due to owning a private vehicle. Also, 57% of respondents stated that issues related to tardiness can hinder AT. These opinions indicate that AT is lacking as popular culture among the respondents and highlight the importance of cultural awareness and community engagement in this regard. Additionally, 60% of respondents underlined the inappropriate distance from the university's gates to the investigated department, 86.7% emphasized the issue of harsh weather, and 10% highlighted the unsuitability of the university's pathways. This result suggests that little or no appropriate AT design features were integrated into the pathways' designs, hence indicating the lack of AT-pertaining design knowledge among designers and planners.

For further clarity on the condition of the investigated campus, a thorough analysis of the responses combined with logical reasoning is conducted. To commence, the acquired responses are summarized and categorized into four groups as shown in Table 1, to facilitate further analysis. Then, on-site visits were conducted to assess and validate the state of the aforementioned indicators as reported by respondents. These field visits are also useful in informing the recommended improvements, ensuring their practicality and suitability for the specific investigated site. It is worth noting that, in certain cases, the respondents were inconsistent in their replies. For instance, 36.7% of respondents expressed their satisfaction with the availability of transport carts while the same percentage of respondents mentioned their dissatisfaction. Such conflict in opinions may be due to a variety of reason, such as subjective views or personal circumstantial experiences. In such cases, the authors further relied on the on-site visits coupled with the numerical averages of responses to conclude the actual condition of the indicators. These indicators are marked with (*) in the table. The proposed improvements are as follows:

TABLE 1: SUMMERY OF QUESTIONNAIRE RESPONSES CATEGORIZED BASED ON AT INDICATORS.

Category	Element	Adequate/ Appropriate	Requires Minor Improvement	Requires Major Intervention
Road Quality	Pavement Width	✓		
	Pavement Quality	✓		
Convenience	Gates			✓
	Bike lanes			✓
	Transport Carts*		✓	
	Signage			✓
	Shading Devices			✓
	Cleanliness		✓	
	Seating			✓
	Greenery	✓		
	Aesthetics			✓
	Scenery*		✓	
Amenities	Amenities		✓	
Safety and Security	Lighting	✓		
	Sense of Safety*		✓	

* Denotes conflicting responses.

8.3.1. Road quality

In terms of road quality, the questionnaire results shown in Figure 5, indicate that no significant modifications are required as the current condition is suitable. The existing pavements allow for all modes of walking with ease, as seen in Figure 6(A). However, on-site visits conflict with this finding; the visits show several detrimental issues that affect the quality of the road such as the uneven walking surfaces, misplaced utility entrances, and the poor condition of flooring tiles, as seen in Figure 6(B). Furthermore, the lack of regular

maintenance has led to several issues, including poor cleanliness, which pose potential safety hazards and detract from the aesthetic quality of the campus. Given the extensive area of AUN, such deficiencies might not be immediately noticeable to all users, which explains the conflict between user responses and on-site visits. However, it is imperative to highlight that regular maintenance processes are crucial for sustaining these favorable conditions and preventing the escalation of these currently limited deficiencies.

(A)

(B)

Figure 6: (A) The good condition and width of most pathways; (B) Maintenance issues (taken by the authors).

8.3.2. Convenience

The responses, presented in Figure 5, reveal this category is particularly deficient in comparison to the other examined categories. A possible explanation for this is due to the prevailing culture that may overlook the importance of convenience and comfort in an outdoor urban setting. On site visits further confirm this and reveal many deficient issues relating to convenience. In terms of convenience when walking, the visit show that despite the good condition of most pathways, many obstacles are present that can hinder AT's full potential. Examples of these are the misplaced decorative plantations, utilities, unsuitable seating areas, uneven walking surfaces, improper parking areas, and the poor condition of flooring tiles as shown in Figure 7. Furthermore, as literature affirms, that pathways must ensure the incorporation of features such as medians, pavement ramps, detectable warnings, appropriately elevated pavements, comfortable walking distances, sufficient lighting, disabled facilities, and crosswalk markings which can significantly enhance pedestrian safety and accessibility [113–117]. These features also seem to be lacking within the investigated pathways. The on-site visits further substantiate the absence of shading devices, as depicted in Figure 6(A), which hold critical significance in mitigating the effects of the region's harsh weather conditions. Similarly, the lack of designated bike lanes necessitates bicycles to share

the roadway with vehicular traffic, consequently posing risks to both cyclists and motorists alike.

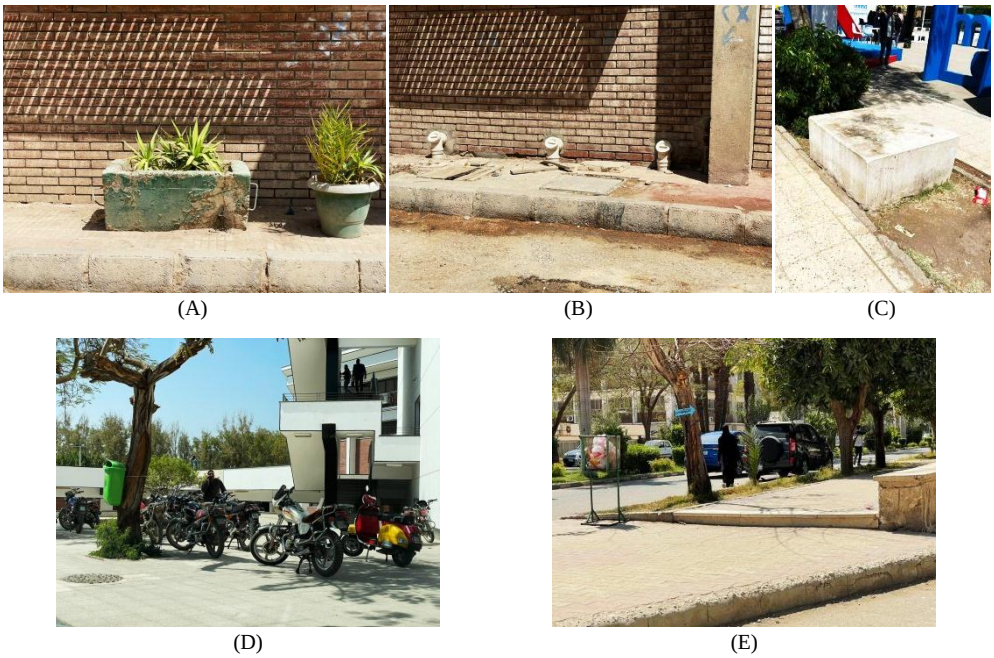

Figure 7: Inconvenient pathway obstacles: (A) Misplaced plantation; (B) Poorly managed utilities; (C) Unsuitable seating areas; (D) Improper parking areas; (E) Uneven walking surfaces.

With regard to aesthetic convenience, there appears to be a degree of dissatisfaction despite the presence of considerable greenery and visually appealing scenery. A logical reason for this is due to the previously mentioned indicators being overshadowed by other detrimental factors such as poor maintenance, architectural absurdities, or cluttered surroundings. This is to say that the advantageous aesthetical elements in the campus are not strategically incorporated. Additionally, individual preferences and cultural norms regarding aesthetics could also influence perceptions of beauty and convenience, thereby contributing to the observed discontent despite the apparent visual attractiveness of the surroundings. Convenience also encompasses the proximity of entrance gates in relation to the targeted buildings. This parameter significantly influences walking distances, thereby impacting factors such as fatigue levels, walking duration, and various other considerations that may influence the adoption of AT as a lifestyle choice.

8.3.3. Amenities

It is apparent that a good level of amenities is available for users; nonetheless, the responses, shown in Figure 5, suggest that these provisions are not sufficient. This inadequacy can likely be attributed to the expansive nature of the university campus, which leads to distant areas being underserved or lacking in coverage. Additionally, the commercial nature of amenity providers drives them to select relatively crowded sites located on main pathways to setup their shops. This inclination inherently exacerbates the challenge of accessibility for more remote regions within the campus environment. As presented in Figure 8, a good example of this is the investigated building (presented by the yellow dot); While the building lies directly on main serviced paths (presented by red lines), another secondary path is much shorter (presented by the green line). This results in users favoring the shorter path despite its insufficient amenities. Hence, it is logical then to design most buildings as close as possible

to the main pathways that will contain sufficient amenities. Furthermore, it is the responsibility of the university's administration to provide sufficient amenities in remote campus locations regardless of its economic efficiency.

Figure 8: The location of the department of architecture in relation to main and secondary paths (Image from Google Earth™, edited by the authors).

8.3.4. Safety and security

The safety of pedestrians and cyclists within the university environment can be attributed to various factors, including lighting, suitability of pathways and the availability of bike lanes. Consequently, the evaluation of safety is not confined only to the feedback garnered from this category; rather, it is a combination of the other inquired categories. The collective responses, presented in **Error! Reference source not found.**, indicate a prevailing feeling among users of a slight sense of insecurity while in the campus.

8.4. Proposed improvements

Building upon the previously mentioned outcomes, the authors are able to propose suggestions that are aligned with AT principles, to effectively modify the pathways and enhance their support for AT. Such suggestions are not only limited to upgrading the current status of the university's pathways but are able to serve as a strategy for similar future projects. Table 2 shows the mentioned suggestions and presents the affected category of AT indicators presented earlier in section 8.3. The table highlights the expected challenges that may face the use of each suggestion, based on logical analysis and reasoning. In the current case, it categorizes these challenges into three primary groups: technical, financial, and administrative; The technical challenges refer to obstacles in practical implementation and technological aspects, including compatibility with existing infrastructure, complexity, and the need for specialized expertise or equipment. Financial challenges refer to the monetary resources needed for executing the suggestions, including funding availability, budget constraints, cost-effectiveness, and potential sources of investment. Administrative challenges include obstacles in managerial aspects, such as decision-making processes, stakeholder coordination, regulatory compliance, and bureaucratic procedures. Given the logical correlation between the UN's sustainable development goals and AT, the authors identified relevant goals as #3, 7-9, and 11-13 [118]. Appendix B depicts the definition of the mentioned goals as proposed by the UN [118]. Accordingly, the table highlights the specific goals addressed by each AT indicator. This is important as it highlights the connection between AT and future sustainability efforts.

TABLE 2: SUGGESTED IMPROVEMENTS RELATED TO AT AND POSSIBLE CHALLENGES.

Recommendation	Affected AT indicators				Challenge			Affected UN goal						
	Quality	Convenience	Amenities	Safety	Technical	Financial	Admin.	Goal #3	Goal #7	Goal #8	Goal #9	Goal #11	Goal #12	Goal #13
Regular Maintenance Schedule: Establish a strategic maintenance plan that includes periodic inspections and rapid repairs to identify and address minor damages before escalating into major issues.	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓
Improve Cleaning Protocols: Increase the frequency and scope of cleaning activities to ensure the pathways remain free from debris, litter, and other forms of pollution.	✓	✓				✓	✓	✓			✓	✓	✓	✓
Upgrade Utilities: Assess and redesign utility entrances to ensure they are safely integrated into the pathway including leveling uneven surfaces, securing loose fixtures, and providing adequate signage to prevent accidents.	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Community Involvement Programs: Encourage local community involvement in maintaining the pathways through awareness campaigns and volunteer programs to create sense of ownership and responsibility among users.	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓
Utilize Durable Materials: use high-quality, durable materials that require less frequent maintenance and withstand environmental impacts, especially during retrofitting and maintenance upgrades.	✓			✓	✓	✓					✓	✓	✓	✓
Remove Obstacles: Identify and relocate misplaced decorative plantations and utilities. Also, ensure seating areas are strategically placed to avoid hindrance to pedestrian flow.		✓		✓	✓	✓					✓		✓	✓
Repair Walking Surfaces: Address uneven walking surfaces and replace damaged flooring tiles.	✓	✓		✓	✓	✓		✓			✓	✓	✓	✓
Improve Pavements: Incorporate medians for safer pedestrian crossing and pavement ramps to accommodate wheelchairs. In addition, ensure pavements are at a comfortable height for pedestrians and comply with accessibility standards.	✓	✓		✓	✓	✓					✓	✓	✓	✓
Shading Devices: Add shading devices along pathways to protect pedestrians from harsh weather conditions.		✓		✓		✓		✓				✓		✓
Sufficient Lighting: Ensure pathways are well-lit to enhance visibility and safety during evening and night hours.		✓		✓		✓						✓		✓
Designate Bicycle Lanes: Allocate dedicated lanes for bicycles to separate them from vehicular traffic.		✓		✓				✓				✓		✓
Provide signage and markings: Ensure crosswalks are clearly marked and include signals or signage to guide pedestrians safely across roads. This also includes signage and digital tools for real-time information regarding the location and status of amenities.	✓	✓	✓	✓		✓						✓		✓
Place Buildings Strategically: Design and place buildings in close proximity to main pathways, which are well-serviced with amenities to ensure that users have convenient access to necessary facilities and services.		✓	✓		✓		✓					✓		✓
Enhance Accessibility to Remote Areas: Improve secondary paths to make them more accessible and appealing, thus encouraging their use and ensuring that better service.		✓	✓		✓		✓					✓		✓
Equitable Distribution of Amenities: The university's administration should prioritize the equitable distribution of amenities across the entire campus including deliberate placement of essential services in remote or areas.		✓	✓			✓	✓		✓	✓		✓	✓	✓
Incentivizing Amenity Providers: The university could explore offering subsidies, reducing rent, or other financial incentives to providers in remote areas, so as to ensure a more balanced distribution of amenities.		✓	✓			✓	✓	✓	✓	✓		✓	✓	✓
Regular Assessment of Needs: Conduct regular assessments of the evolving needs of the campus to inform decisions on where to locate new amenities and how to improve existing ones.		✓	✓		✓		✓			✓	✓	✓	✓	✓

As presented in the table, it is evident that each suggestion will impact various aspect of AT, which emphasizes the intertwined nature of AT. Based on impact, it is also clear that upgrading current utilities, creating community programs, and providing signage and markings are of most highest priority as the will result in the most influence. Creating a regular maintenance schedule seems also to be of a relatively high impact, thus should be prioritized. While the other suggestions are important, their expected impact is slightly lower, hence, are of a lower priority.

In terms of challenges, the financial challenge is most crucial. This is to be expected as most of the construction, upgrading, and monitoring processes will require a form of payment or funding. This highlights the importance of allocating governmental and private funds towards AT, possibly though innovative community-driven initiatives. Furthermore, it can be expected that financial savings overtime from AT in the form of reduced vehicle operating, reduced congestion, and reduced reliance on infrastructure could exceed these initial costs [119,120]. In fact, studies show that the financial benefits of AT exceeds its costs by a ratio from 8:1 to 38:1, depending on the specific project and methodology [121–123]. It is noteworthy that both the technical and administrative challenges appear to hold comparable significance, yet inferior to financial challenges. The relation between AT indicators and UN goals also sheds light on many aspects of AT; It is clear that Goals #9 and 13 are greatly influence by AT. These goals relate directly to the suitability and sustainability of the surrounding environment. Hence, it can be further affirmed that AT provides a robust approach to positively impact the built environment and mitigate its detrimental effect.

9. CONCLUSIONS AND RECOMMENDATIONS

The current study was able to shed light on the importance and expected benefits of AT in a large setting such as university campuses. The findings further confirm that AT holds great potential; In addition to promoting physical and mental well-being, AT emerges as a pivotal instrument in advancing environmental initiatives by mitigating carbon emissions, alleviating traffic congestion, and reducing dependence on fossil fuels. Moreover, the inclusive nature of AT promotes social equity by providing transportation options for diverse demographics, while also offering significant economic advantages through reduced healthcare expenses, infrastructure maintenance costs, and societal productivity gains.

To investigate the feasibility of AT, the indicators that form AT were identified through literature and compared with the status of pathways in the AUN as a case study. User opinions and on-site visits identified AT-related deficiencies in the pathways. Accordingly, the authors suggested improvements to enhance AT in the university, creating guidelines suitable for adoption in similar settings and aiding upgrading and retrofitting processes. Based on this, it can be inferred that while certain indicators of AT exhibit greater significance than others, there exists a profound correlation between them.

It is also evident that financial constraints pose a significant barrier to the successful implementation of AT. Nevertheless, it is important to note that the anticipated financial benefits far surpass the initial investment by a substantial margin. This highlights the pivotal role of financial considerations in the adoption and utilization of AT. The study further highlights that the technological and administrative aspects of AT are of nearly equal significance, yet they do not present substantial obstacles to its implementation. This is expected, as AT neither requires sophisticated technology nor involves complex administrative procedures. Additionally, the findings impart a particular emphasis the role of constant upgrading of utilities and cultural awareness in enhancing the condition of AT in university campuses and other similar settings. Such aspects evidently seem to be of higher significance compared to other indicators. Similarly, on a more detailed level, the findings also emphasize the significance of repairing walking surface, improving pavements, and providing sufficient signage and markings. Such measures are essential for creating an

environment conducive to the successful implementation and utilization of AT, thereby promoting accessibility and inclusivity for all users.

Based on the study's findings, several recommendations can be made to upgrade the condition of AT at AUN, and possibly similar universities or settings as follows:

- Creating dedicated bike lanes to encourage cycling as a prominent form of AT.
- Providing suitable robust shading devices along pathways and seating areas.
- Enhancing the quality of seating areas and increasing their number.
- Exercising caution in the fabrication, provision, and placement of signals and markings along pathways.
- Thoroughly re-considering the aesthetic aspects of pathways and seating areas.

On a broader scale, the authors also offer several recommendations for the adoption of AT, most significant of which is as follows:

a) The widespread adoption of AT initiatives relies on securing substantial financial resources. Therefore, it is crucial to prioritize allocating governmental and private funds towards AT, which highlights the critical role of adopting community-driven initiatives aimed at garnering support for AT projects.
b) Effective awareness campaigns are essential for integrating AT into daily life and achieving broader sustainability goals. Therefore, the study recommends establishing suitable programs to promote awareness of the health, environmental, and economic benefits of AT to normalize walking, cycling, and other non-motorized travel modes.
c) The study supports implementing regular maintenance schedules for public areas to ensure safety and usability. This includes regular upkeep of pathways, cycling lanes, and associated infrastructure to prevent deterioration, reduce hazards, and enhance the overall user experience.
d) While all indicators of AT are influential to users, the findings support prioritizing upgrading current utilities and providing signage and markings due to their elevated significant.
e) The study recommends a radical shift in views in terms of governmental policies, to include AT as a nationwide goal rather than solely relying on individual initiatives.
f) The study findings advocate for a more robust adoption of AT by the UN, highlighting substantial correlations between AT indicators and the UN's goals.

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APPENDIX A

- *When walking, which gate do you usually use?*
- *Why do you feel that many prefer not to walk within the university's pathways?*
- *Are the width of the pavements suitable for walking?*
- *How would you describe the quality of the payment (in terms of evenness, height, and finishing)?*
- *Are there sufficient amenities for pedestrian along your route?*
- *Are there dedicated bike/cycling lanes?*
- *Do you feel that the availability of electric carts facilitate movement within the university campus?*
- *Are there sufficient signage and crossing markings along your route?*
- *Do the universities pedestrian pathways have sufficient night lighting?*
- *Do you feel safe when walking within the university, especially during late hours?*
- *Are there sufficient vegetation and plants along the pedestrian pathways?*
- *Are there sufficient seating areas along pedestrian pathway?*
- *Are there sufficient shading devices?*
- *Are the pedestrian pathways sufficiently clean?*
- *Do pedestrian pathways entail of good aesthetic and visual aspects?*
- *During walking, do you perceive a degree of good scenery?*

APPENDIX B

Related UN sustainable development goals [118].

Goal	UN's Definition
Goal 3	*"Ensure healthy lives and promote well-being for all at all ages."*
Goal 7	*"Ensure access to affordable, reliable, sustainable and modern energy for all".*
Goal 8	*"Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all".*
Goal 9	*"Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation."*
Goal 11	*"Make cities and human settlements inclusive, safe, resilient and sustainable."*
Goal 12	*"Ensure sustainable consumption and production patterns."*
Goal 13	*"Take urgent action to combat climate change and its impacts."*