JOURNAL OF ENVIRONMENTAL MANAGEMENT & SUSTAINABILITY

REVISTA DE GESTÃO AMBIENTAL E SUSTENTABILIDADE – GeAS

Received: 07 Apr. 2021 - **Approved:** 04 Feb. 2022
Responsible editors: Andreza Portella Ribeiro
Evaluation Process: Double Blind Review
https://doi.org/10.5585/geas.v11i1.19809
e-ISSN: 2316-9834

Assessment of mobility and accessibility at the UPE / Unicap Trip Generation Hub in the city of Recife – PE

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Cite as
American Psychological Association (APA)

Macedo, M. R. O. B. C., Carvalho, L. B. R., Ferreira, B. O., & Kohlman Rabbani, E. R. (2022). Assessment of mobility and accessibility at the UPE / Unicap Trip Generation Hub in the city of Recife – PE. *Rev. Gest. Ambient. e Sust. - GeAS.*, *11*(1), 1-19, e19809. https://doi.org/10.5585/geas.v1i1.19809.

Abstract

Objective: To analyze mobility at the UPE/UNICAP Trip Generation Hub (TGH) based on the observation of travel patterns, the population's input, and the conditions of public transportation access at universities.
Methodology: Application of an online questionnaire that asks about transit characteristics, motivation, and barriers to use. Analysis of the mobility and accessibility of the TGH using the Sustainable Mobility Index for University Campuses (IMSCamp) and Geographic Information Systems (GIS).
Relevance: The traffic department is responsible for many impacts to the urban environment, especially through the promotion of individual motorized transport, which causes degradation of public transportation. From the perspective of sustainability, mobility must be analyzed to identify actions for the proper use and occupation of land in order to mitigate the damage caused to the environment and improve quality-of-life.
Results: The average time for a student who lives 10 km away from the TGH is 2.8 times greater than that for students who live 5 km away from the TGH. Undergraduate students are more likely to use active modes of transport and to follow awareness campaigns.
Contributions: Based on the diagnosis of the current mobility situation and the identification of its principal problems, it will be possible to propose improvements and adjustments that enable sustainable urban mobility in the TGH.
Conclusion: Familiarity with the discussion about active means of transportation and the prioritization of pedestrians makes users more likely to reconsider their use of a private car.

Keywords: Trip generation hub. Sustainable urban mobility. Active modes of transport.

Avaliação da mobilidade e acessibilidade no Pólo Gerador de Viagens UPE/Unicap na cidade de Recife – PE

Resumo

Objetivo: Analisar a mobilidade no Polo Gerador de Viagens (PGV) UPE/UNICAP a partir da observação dos padrões de viagem, da opinião da população e as condições dos meios de transportes no acesso as universidades.
Metodologia: Questionário online com perguntas sobre as características dos deslocamentos, as motivações e barreiras para utilizá-los. Análise da mobilidade e acessibilidade do PGV utilizando o Índice de Mobilidade Sustentável para Campus Universitários (IMSCamp) e Sistemas de Informações Geográficas (SIG).
Relevância: Responsável por muitos impactos no meio urbano, principalmente pela promoção do transporte individual motorizado, o setor de transportes ocasiona a degradação da mobilidade da população. Sob a ótica da sustentabilidade, a mobilidade deve ser analisada para identificar ações para o uso e ocupação do solo de forma a mitigar os danos causados ao meio ambiente e a melhoria da qualidade de vida da população.

Resultados: O tempo médio do estudante que mora a 10 km de distância do PGV é 2,8 vezes superior ao dos estudantes que moram até 5 km de distância do mesmo. Os estudantes de graduação são mais adeptos aos modos ativos de transporte e campanhas de conscientização.
Contribuições: A partir do diagnóstico do quadro atual de mobilidade e a identificação das suas principais problemáticas, será possível auxiliar na proposição de melhorias e adequações que possibilitem a mobilidade urbana sustentável no PGV.
Conclusão: O contato com a discussão acerca de modos ativos de transporte e priorização do pedestre deixa os usuários mais propícios a reconsiderar o uso do automóvel particular.

Palavras-chave: Polo gerador de viagem. Mobilidade urbana sustentável. Modos ativos de transporte.

Evaluación de movilidad y accesibilidad en el Polo Generador de Viajes UPE/Unicap en la ciudad de Recife – PE

Resumen
Objetivo: Analizar la movilidad en el Polo Gerador de Viagens (PGV) UPE/UNICAP a partir de la observación de los patrones de viaje, la opinión de la población y las condiciones de los medios de transporte en el acceso a las universidades.
Metodología: Cuestionario online con preguntas sobre las características de los desplazamientos, motivaciones y barreras para utilizarlos. Análisis de la movilidad y accesibilidad del PGV mediante el Índice de Movilidad Sostenible para Campus Universitarios (IMSCamp) y Sistemas de Información Geográfica (SIG).
Relevancia: Responsable de muchos impactos en el medio urbano, principalmente por la promoción del transporte motorizado individual, el sector transporte provoca la degradación de la movilidad de la población. Desde la perspectiva de la sustentabilidad, la movilidad debe ser analizada para identificar acciones de uso y ocupación del suelo con el fin de mitigar los daños causados al medio ambiente y mejorar la calidad de vida de la población.
Resultados: El tiempo medio del alumno que vive a 10 km del PGV es 2,8 veces mayor que el de los alumnos que viven a 5 km del mismo. Los estudiantes de pregrado son más expertos en modos activos de transporte y campañas de concientización.
Aportes: A partir del diagnóstico del marco de movilidad actual y la identificación de sus principales problemas, se podrá colaborar en la propuesta de mejoras y adecuaciones que permitan una movilidad urbana sustentable en el PGV.
Conclusión: El contacto con la discusión sobre modos de transporte activos y la priorización de peatones hace que los usuarios sean más propensos a reconsiderar el uso del automóvil privado.

Palabras clave: Polo generador de viajes. Movilidad urbana sostenible. Modos de transporte activos.

Introduction

Since the beginning of the twentieth century, Brazilian cities have experienced accelerated growth, with an increase in the concentration of population in urban centers, which, coupled with a lack of planning, has resulted in major problems for the cities. Urban development is progressive and necessary in order to meet the current needs of the population, making the debate on environmental and climate issues, demographic changes, and social and health challenges urgent, in order to achieve a better quality of life for the population.

The transportation sector is responsible for many impacts on the urban environment, affecting not only the environment, but also economic and social spheres. For many years, individual motorized transportation was favored as being the most efficient solution for transportation, causing the degradation of the population's mobility due to urban congestion and air pollution (Carvalho and Santos, 2018). Within the paradigm of sustainability, mobility can be achieved by seeking a balance between the adequacy of transport supply in the socioeconomic context and environmental quality (Campos, 2006), promoting actions for land use and occupation that can mitigate environmental damage. To achieve this, supply and demand must be balanced using financially viable models for financing and remuneration and the principle of universal mobility for public and non-motorized transportation must be validated.

To analyze urban mobility, studies can be conducted in cities or proportionally smaller areas, as is the case of Trip Generation Hubs (TGH) (Stein, 2013; Oliveira, 2015, Carvalho and Santos, 2018). For Portugal (2012) and Oliveira (2015), TGHs cause negative impacts on mobility in their surroundings, creating problems in large urban centers, such as air pollution, congestion, noise, and traffic accidents. The Benfica Campus of the University of Pernambuco and the Campus of the Catholic University of Pernambuco (UNICAP) in Recife/PE can be cited as examples. These two campuses are about 2.1km apart and together they are home to approximately 25 thousand people, divided among teachers, students, and outsourced employees. Beyond just acting together as a TGH, they are also located near large hospitals and medical clinics, shopping malls, commercial buildings, and a sports club, confirming the region's high demand for transportation. This demand, together with the absence of policies focused on sustainability, generates an incentive for the use of motorized modes of transit.

In order to observe the travel patterns based on the opinions of the populace and evaluate the conditions of different methods of transport that access the universities, this study makes use of the Index of Sustainable Mobility for University Campuses, the IMSCamp, developed by Oliveira (2015) to assess sustainability in mobility for the UNICAP and UPE/Benfica campuses. Using this diagnosis of the current mobility framework and the identification of its main problems as a base, it will be possible to propose improvements and adjustments that enable sustainable urban mobility in the TGH.

Contextualization

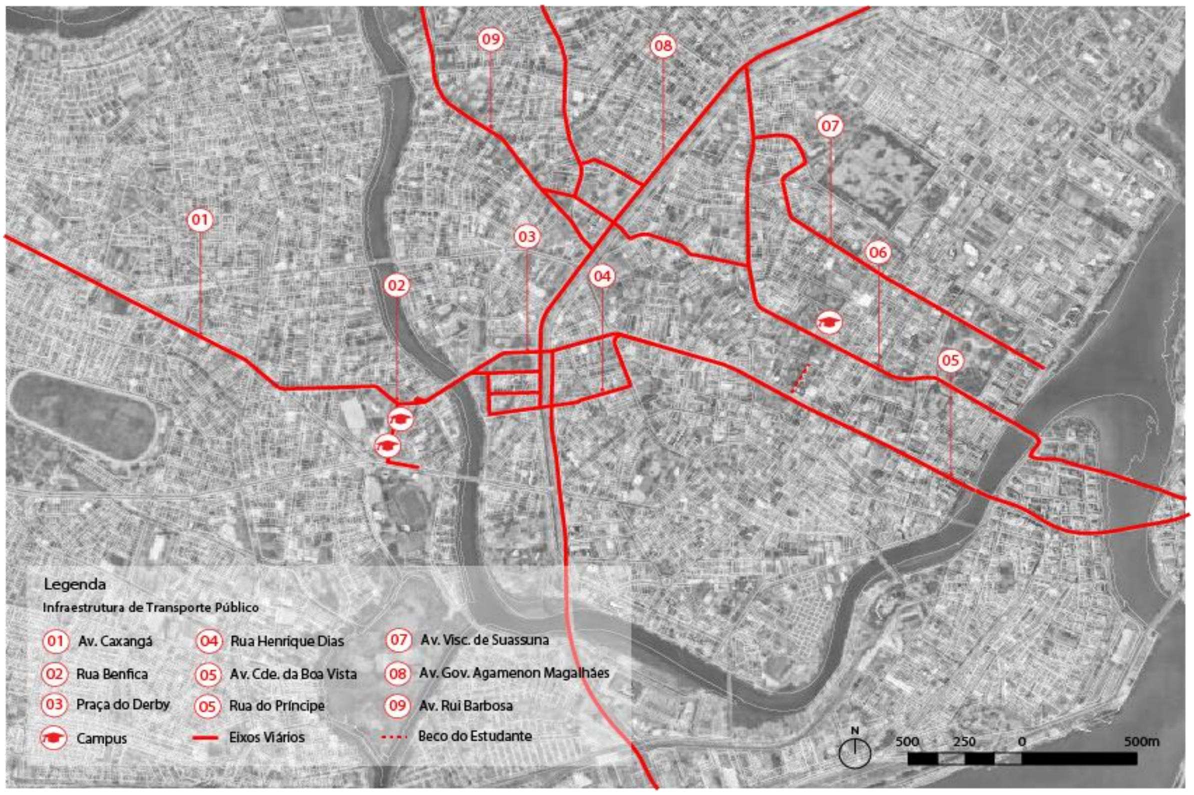
The area in question, referred to as TGH UPE/UNICAP, includes the Benfica campus of the University of Pernambuco (UPE/Benfica) and the campus of the Catholic University of Pernambuco (UNICAP), located in the city of Recife. The UPE/Benfica campus (area 1) has 2 university units, the Polytechnic School of Pernambuco and the School of Administration of Pernambuco, as well as the Application College of Recife, spread over 20,200 m² in the Madalena neighborhood. The UNICAP campus (area 2), with 38,700 m² is located 2.1 km away.

According to the Dean of Graduate and Extension Programs, UNICAP had 15,000 students in 2019 enrolled in various academic modalities and about 5,000 workers, including professors and staff. For UPE/Benfica, according to the Dean of Graduate Programs, the campus had a total of 8,000 students in 2020 and 2,000 workers, including professors, staff, and outsourced workers.

Regarding transportation access, the area includes three principal two-way corridors with two lanes in each direction that are able to transport between two and four thousand vehicles per hour way, as well as a main road, Conde da Boa Vista Avenue (continuation of Benfica Street) that connects the two areas (Figure 1). With regard to public transportation, there are 22 bus lines that serve the UPE/Benfica campus and 34 lines that serve UNICAP.

Figure 1

Study area



Source: Elaborated by the authors.

Methodology

The principal methodological procedures followed are described below.

Selection of indices

To evaluate the sustainability of the local urban mobility of the campuses in question, two methods were considered: IMSCamp, developed by Oliveira (2015), and the Network

Service Area from ArcGis (Ribeiro, 2010), which measures accessibility of the campuses based on spatial analysis using a Geographic Information System.

Development of the questionnaire

The questionnaire was prepared with 42 objective multiple-choice questions, divided between characterization of the sample (10 questions) and calculation of the indicator scores (32 questions). Of the indicator scoring questions, 16 were mandatory for the everyone. Three were exclusively for automobile-related demands and 13 were exclusively for demands related to public transportation and active modes of transportation, and were answered based on the user's profile., The scores ranged from 0.00 (zero) to 1.00 (one), according to the users' degree of agreement with the aspects under analysis. The closer to 1.00, the more sustainable the transportation mobility.

To characterize the sample, questions were selected that addressed the user's position at the university, gender, age, race, address, family income, whether he or she was a person with reduced mobility, and the main mode of transportation used. Then, for those who answered in the affirmative regarding use of public transportation as their main way of getting around, questions about sustainable or active modes (walking and cycling) were also addressed to support the calculation of the indicators.

Each of the indicators had a question associated with it, which made it possible to be evaluated according to the users' point of view. The qualitative questions were also evaluated using the Likert scale.

Application of the research questionnaire

The questionnaire was made available through the free Google Forms platform and disseminated through websites and social networks at the two universities and their academic directories, remaining available to receive user responses for a period of 15 days. The population was defined as professors, students, and technical-administrative and outsourced staff from the two institutions, a total of 25,000 people.

The sample size was calculated from equations 1 and 2, based on the methodology adopted by Barbetta (2001) and the confidence level selected was 95%.

$$n_0 = \frac{1}{E_0^2} = \frac{1}{(0{,}05)^2} = 400 \qquad \text{Equation (1)}$$

$$n = \frac{N\,x\,n_0}{N+n_0} = \frac{25000\,x\,400}{25000+400} = 393 \qquad \text{Equation (2)}$$

Where:

n_0= sample size when the population size is unknown
E_0 = sampling error (in this case, 5% was considered)
N = population (25,000)

Therefore, to guarantee a confidence level of 95% and sampling error of 5% for this study, 393 questionnaires would have needed to be answered. A total of 194 responses were obtained, equating to a 5.1% margin of error.

Data processing

The score for each indicator was collected in order to calculate the total IMSCamp.

To evaluate the users' understanding of urban mobility, questions were applied regarding the prioritization of pedestrians, the creation of new road axes, and actions to raise awareness promoted by educational institutions. The results were subdivided into two categories: perception of urban mobility and educational actions. The scores referring to this domain make it possible to determine adherence to alternative modes of transportation, engagement of users with traffic education actions, and the effectiveness of these actions. To trace the users' profiles, they were divided into the following categories: undergraduate students, graduate students, staff, and professors.

For the stratification of the index, the answers were classified as excellent, good, fair, or poor. In this way, it was possible to determine the principal mode of transportation used by each group of users, whether or not they used alternative means of transportation, their level of contact with educational actions, and how they judge their effectiveness. The qualitative indicators were obtained from their respective scores, through the average of the results obtained. In order to make the quality ranges for the evaluated criteria (from 1 to 5) compatible with the IMSCamp, which ranges from 0 to 1, values between 0 and 1 were assigned correspondingly, based on the methodology used by Oliveira (2015). A value of 0.00 was assigned for 1, 0.25 for 2, 0.50 for 3, 0.75 for 4, and 1.00 for 5. For multiple-choice questions, the value assignment had four levels, which were weighted as follows: excellent/good (1.0), good/good (0.66), fair (0.33), and poor (0.00).

Regarding the distance from a user's residence to the nearest bus stop, distances less than 100 meters or 1 block were considered “excellent,” while distances equal to or greater than 400 meters or 4 blocks were considered “bad.” Regarding frequency of service, intervals equal to or shorter than 15 minutes were considered “excellent,” while intervals equal to or longer than 60 minutes were considered “bad.” For vehicle punctuality, "excellent" never have delays, while "bad" always have delays. When a vehicle takes almost the same amount of time to arrive as a car, it is considered "excellent," and when it takes twice as much time or more as a car, it is considered "bad.” Finally, regarding vehicle capacity, "excellent" is when there are always free seats, and "bad" is when the vehicle is always full. For all of these questions, there are also intermediate levels, good and fair, and it is worth noting that all users, whether from POLI/FCAP or UNICAP, finish their respective trips using public transportation on foot.

In the public transportation infrastructure domain, the public transportation stops near the entrances of the respective campuses were evaluated with regard to distance, lighting, sense of security, coverage, signage, and availability of seats. The distance considered optimal was less than 50 meters between the entrance of the educational institution and the bus stop, with a bad distance being 250 meters or more. Lighting was considered excellent when it was able to guarantee visibility at a distance of over 100 meters, and poor when it was non-existent or precarious, with a visibility of less than 20 meters. Regarding protection from bad weather, excellent protection was a roof able to protect from both sun and rain, while poor protection indicated a complete lack of roof. When signaling and identification of the bus stops was presented clearly and correctly, and was well-maintained, it was considered excellent, while stops lacking signs and without identification were considered poor. Finally, if the bus stop had sufficient seating for peak demand in adequate conditions of use, it was considered excellent, while stops lacking seats were considered poor. For all off these questions, there were also intermediate levels of response.

Spatial analysis of data

In order to analyze accessibility at the Benfica and UNICAP campuses according to their spatial indicators, the road network was modeled with the arc-node topology and the accessibility calculations included minimum costs and more efficient routes, in this case based on time (Pinto, 2011). The Service Area module of the Network Analyst extension of ArcGis was used to perform the calculations. This module allows service areas to be found at any point within the network (for modeled networks only). A service area in a network is a region that encompasses all accessible streets within a specified range (distance or time). In this way it is possible to analyze how accessibility varies with range (Pinto, 2011).

Data obtained from OpenStreetMap (OSM), a collaborative mapping project that has open data, was used to create the network database. The cartographic base was created from street and block data from the Condepe/Fidem Agency, the official mapping agency of the state of Pernambuco. Public equipment data were acquired from the cartographic base of the Recife City Hall for the year 2016 (PDTU, 2016). The bus stops were located based on information available from the Grande Recife Transport Consortium.

Results and discussions

Table 1 shows the indicators used, along with their respective weightings and scores. The UNICAP campus had the highest score, while FCAP had the lowest. The main results of the research are also presented in this section.

Table 1

IMSCamp total

Indicator	Weight	Score			Weight x Score		
		POLI	FCAP	UNICAP	POLI	FCAP	UNICAP
Actions to raise awareness on alternative transport modes	0.098	0.590	0.350	0.560	0.058	0.034	0.055
Traffic awareness actions	0.062	0.450	0.440	0.610	0.028	0.027	0.038
Suitability of transportation mode	0.057	0.807	0.807	0.807	0.046	0.046	0.046
Urban public transportation	0.067	0.387	0.387	0.387	0.026	0.026	0.026
Parking infrastructure	0.048	0.340	0.540	0.740	0.016	0.026	0.036
Building accessibility	0.025	0.474	0.350	0.598	0.012	0.009	0.015
Public safety	0.094	0.327	0.100	0.347	0.031	0.009	0.033
Campus access infrastructure	0.051	0.549	0.600	0.356	0.028	0.031	0.018
Bus stop infrastructure	0.051	0.544	0.544	0.523	0.028	0.028	0.027
Bicycle path infrastructure	0.060	0.312	0.312	0.302	0.019	0.019	0.018
TOTAL	**0.613**	**0.478**	**0.443**	**0.523**	**0.293**	**0.272**	**0.321**

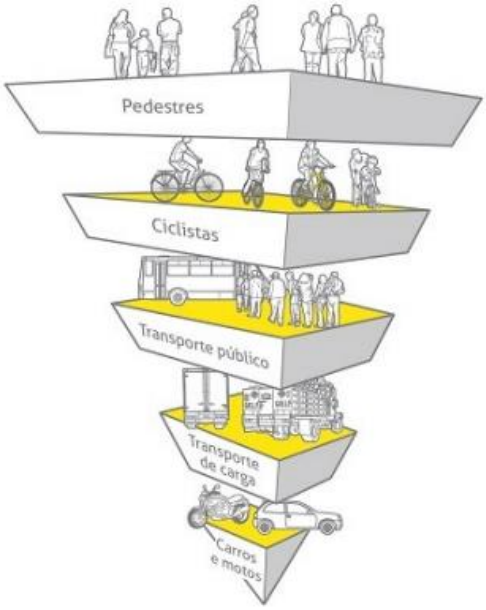
Source: Elaborated by the authors.

Perception regarding sustainable urban mobility

To assess the users' understanding of urban mobility, the inverse pyramid of traffic priority from the Institute for Transportation and Development Policy (ITDP) was presented (Figure 2), which ranks, in descending order of priority: pedestrians, cyclists, public transport, freight transport, and cars and motorcycles, with the user having to answer whether he or she agreed with this prioritization of traffic.

Figure 2

Transport mode hierarchy defined by the PNMU guidelines

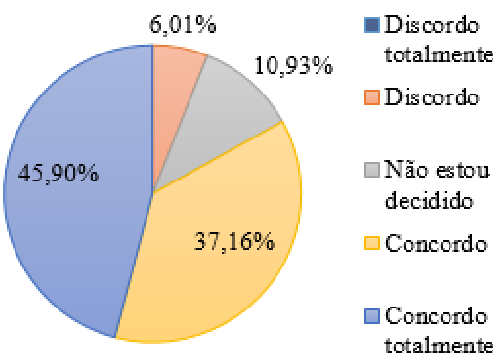


Source: ITDP (2013).

A survey questionnaire was also applied, suggesting the creation of more exclusive lanes for cars, such as Via Mangue in Recife, Pernambuco, as an alternative to congestion in urban centers, or more viaducts. Although there is a high level of understanding about the priority of pedestrians over other modes of transportation (Figure 3), with more than 80% of people agreeing completely with the ITDP pyramid, about 61% of users believe that building more car-only lanes is a good solution (Figure 4).

Figure 3

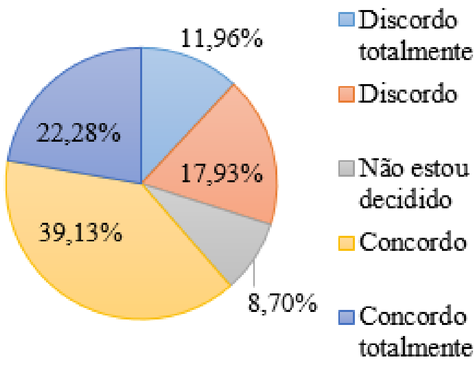
Understanding of the ITDP inverse pyramid in the study area



Source: Elaborated by the authors.

Figure 4

Exclusive lanes for motorized transport are a good solution to congestion



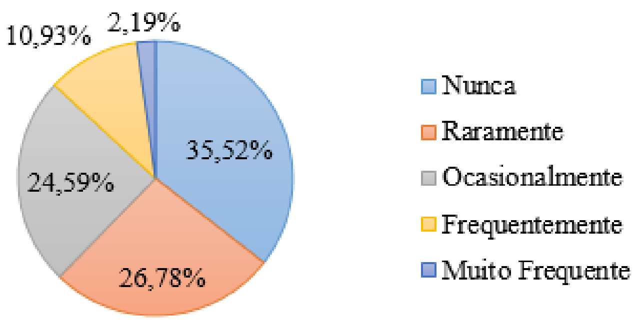
Source: Elaborated by the authors.

Awareness actions

In general, few users have participated in actions promoted by the university regarding sustainable mobility (rides, lectures, workshop, extension project, specific subjects), as shown in Figure 5. A considerable amount (about 35%) has never been involved in these actions. It is worth pointing out the importance of educational institutions in promoting a paradigm shift, providing spaces for discussion on and learning about the subject.

Figure 5

Participation in awareness actions promoted by the university

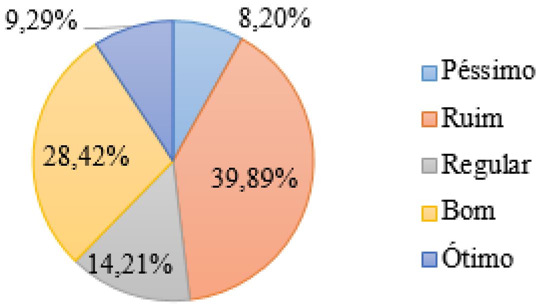


Source: Elaborated by the authors.

Although few users actively participate in them, about 51% of those who participate believe that the dynamics are effective, including excellent, good, or fair (Image 6). The results between POLI and FCAP users were similar, meaning that there is agreement on the evaluation of the effectiveness of traffic awareness actions, despite the former group participating more actively in them.

Figure 6

Effectiveness of awareness actions



Source: Elaborated by the authors.

When comparing results from the three institutions on the aspect "actions to raise awareness on alternative transportation modes." the scores indicate a better result for the POLI campus, where the index obtained was 0.59, as shown in Table 1, of which 0.34 refer to undergraduate students, 0.053 to graduate students, and 0.054 to professors. Staff did not contribute to the calculation of this indicator, as shown in Table 2. Despite being above average, the score obtained by the university is still considerably lower than desired (1.00).

Table 2

Calculation of the awareness actions indicator based on the data collected - POLI campus

Type of user	Indicator for each type of user	Weighting factor: Campus population (%)	Contribution of each type of user
Undergraduate student	0.575	84.900	0.488
Post-graduate student	0.743	7.000	0.052
Tech/admin staff	0.000	0.000	0.000
Professor	0.733	7.900	0.058
TOTAL		**99.800**	**0.598**

Source: Elaborated by the authors.

The UNICAP campus had the second-best score, 0.56 (Table 1), of which 0.54 was contributed by undergraduate students, 0.013 by graduate students, and 0.006 by professors. Again, there was no contribution from staff for the calculation of this indicator. Although the score obtained is also below the ideal value, there was a greater contribution from undergraduate students to the UNICAP index than for other institutions, totaling approximately 30% of students (Table 3).

Table 3

Calculation of the awareness actions indicator based on the data collected - UNICAP campus

Type of user	Indicator for each type of user	Weighting factor: Campus population (%)	Contribution of each type of user
Undergraduate student	0.588	92.300	0.543
Post-graduate student	0.233	5.700	0.013
Tech/admin staff	0.000	0.000	0.000
Professor	0.306	1.920	0.006
TOTAL		**99.920**	**0.562**

Source: Elaborated by the authors.

On the other hand, the FCAP campus obtained the lowest score, 0.35, of which 0.19 was contributed by undergraduate students, 0.018 by graduate students, 0.015 by service staff, and 0.12 by professors (Table 4). Taking the results of the other institutions as a reference, it can be seen that, besides the decrease in the contribution from undergraduate students, the total score is well below the desired level.

Table 4

Calculation of the awareness actions indicator based on the data collected - FCAP campus

Type of user	Indicator for each type of user	Weighting factor: Campus population (%)	Contribution of each type of user
Undergraduate student	0.373	52.900	0.197
Post-graduate student	0.156	11.700	0.018
Tech/admin staff	0.263	5.800	0.015
Professor	0.413	29.400	0.121
TOTAL		**99.800**	**0.352**

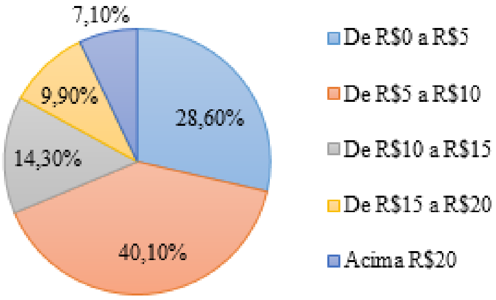
Source: Elaborated by the authors.

Urban transport

To understand how the user travels to the campus, two questions were asked, one about the main mode of travel and another about their respective daily expenditure, as shown in the subsequent graphs (Figure 7 and Figure 8).

Figure 7

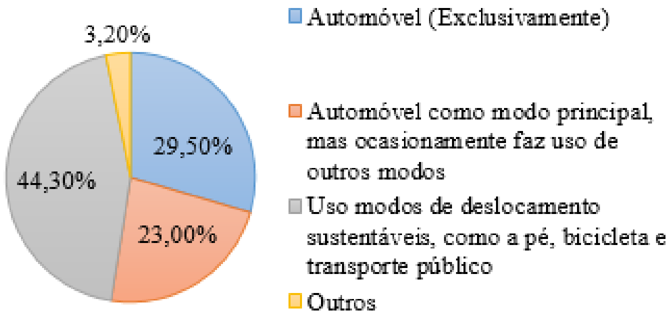
Daily expenditure by the user on transportation to the university



Source: Elaborated by the authors.

Figure 8

Principal mode of transportation to the university



Source: Elaborated by the authors.

The vast majority of respondents (82%) use public transportation. Of these, 52% make transfers to complete their respective routes, riding buses (45%), BRT (24%), or metro (14%).

Using the IMSCamp as a base, it is possible to determine the percentage of users who evaluate the urban public transportation service to be satisfactory, considering a set of aspects such as punctuality, capacity, and frequency. To calculate this indicator, the weight adopted for this section was 0.067 with a final score of approximately 0.026, as shown in Table 5.

Table 5

Stratification of the urban public transport indicator

Evaluation	Score	Weight	Score x Weight
Distance from the bus stop to the user's residence	0.634	0.067	0.042
Frequency of service	0.614	0.067	0.041
Punctuality of service	0.366	0.067	0.025
Travel time	0.254	0.067	0.017
Vehicle capacity	0.066	0.067	0.004
Urban public transportation management and service			**0.026**

Source: Elaborated by the authors.

Public transportation infrastructure

For ease of understaing understanding, the results from this domain were separated between the two campuses of Benfica and UNICAP, due to their geographical locations being suitable for this division, as shown in Table 6.

Table 6

Indicators to evaluate bus stop infrastructure

Evaluation	Score		Weight	Score x Weight	
	Benfica Campus	UNICAP Campus		Benfica Campus	UNICAP Campus
Protection from weather at bus stops	0.660	0.576	0.051	0.034	0.029
Public safety at bus stops	0.257	0.258	0.051	0.013	0.013
Adequate and well-maintained signs at bus stops	0.733	0.765	0.051	0.037	0.039
Seat availability at bus stops	0.493	0.530	0.051	0.025	0.027
Public lighting that ensures visibility around bus stops	0.580	0.485	0.051	0.030	0.025
Bus stop infrastructure				**0.028**	**0.027**

Source: Elaborated by the authors.

In this domain, the presence of exclusive lanes for public transport (blue lanes) was also queried. Note that, in the path to the Benfica campus (score of 0.552), these lanes are more commonly found than in the path to the UNICAP campus (score of 0.356).

Cycling infrastructure

To analyze the existing cycling infrastructure, the responses were also divided between the Benfica and UNICAP campuses, due to the greater proximity between POLI and FCAP. Note that, for the Benfica campus, users claim that there are more bike lanes or bike paths, however, for the UNICAP campus, the route appears to be safer, resulting in indicators that are very close to one another, as shown in Table 7.

Table 7

Evaluation of cycling infrastructure

Evaluation	Score		Weight	Score x Weight	
	Benfica Campus	UNICAP Campus		Benfica Campus	UNICAP Campus
Existence of cycling infrastructure along the route	0.505	0.326	0.060	0.030	0.020
Cohesive and safe cycling infrastructure	0.118	0.278	0.060	0.007	0.017
Cycling infrastructure				**0.019**	**0.018**

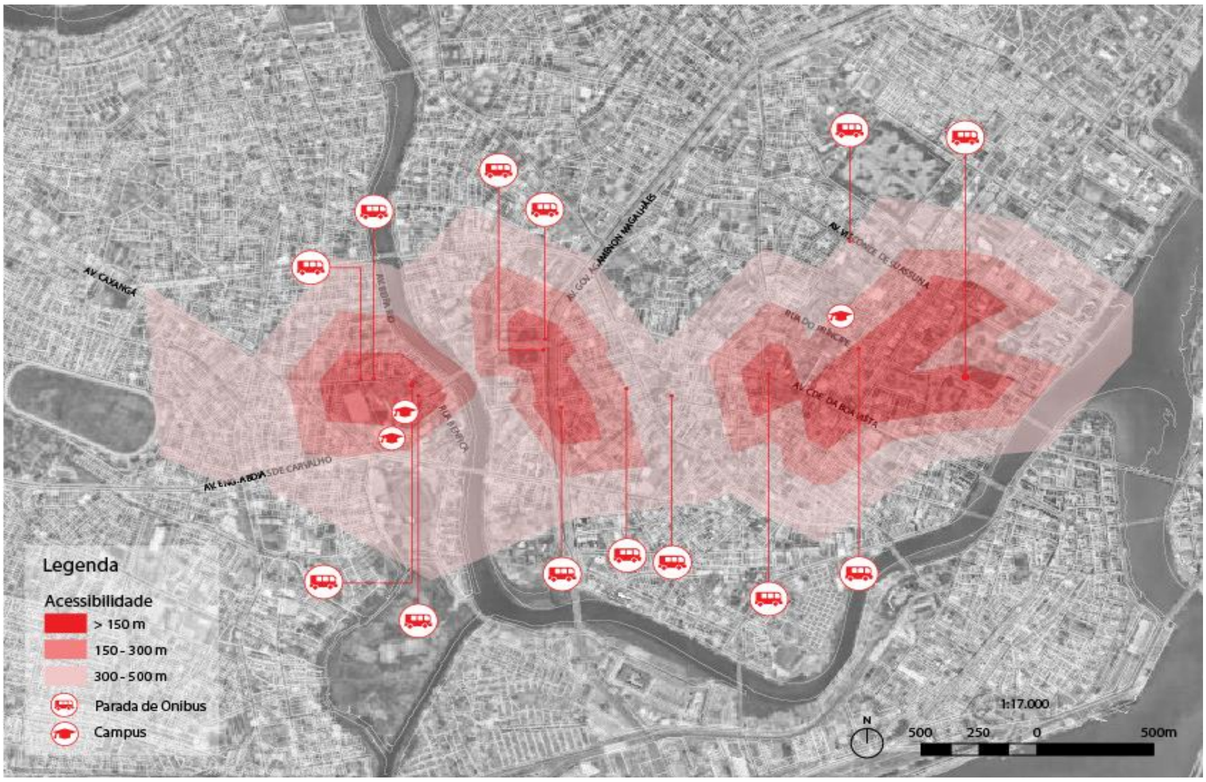
Source: Elaborated by the authors.

Spatial Analysis of Campus Accessibility and Mobility

Another analysis performed was to investigate the average time taken by the user to go from the campus to the nearest bus stop (Figure 9). By analyzing the three main axes, Benfica Street, Conde da Boa Vista Avenue, and Agamenon Magalhães Avenue, in both directions, it can be concluded that, from any point in the neighborhood, the user will not exceed a maximum time of five minutes or 300 meters to a bus stop from either destination.

Figure 9

Accessibility for users from their residence to a bus stop

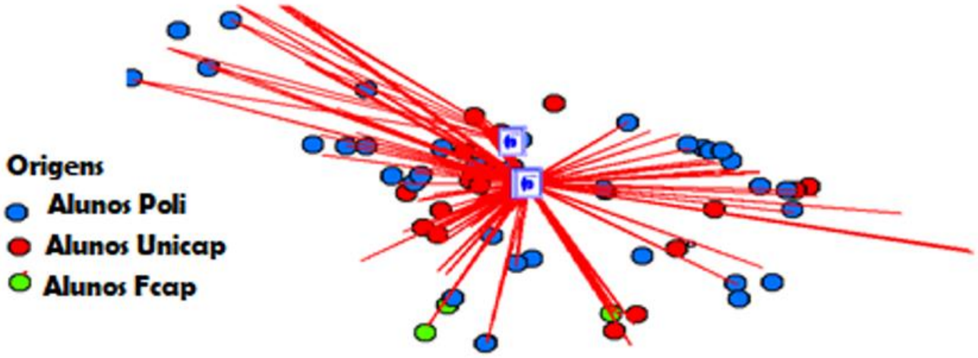


Source: Elaborated by the authors.

The distance a user has to travel from his or her place of origin to the campus is another important indicator of transit system mobility. These distances must be measured over the urban network from the centroids (density-based centers) of each traffic zone to the nearest stop. In this case, centroids were considered to be the UTM coordinates of the households (origin), with distance measured to the stops nearest to areas 1 and 2 (destinations). In the O/D matrix it is possible to identify the origin centroid, the destination stop, and the position it occupies in the ranking, as shown in Figure 10.

Figure 10

Accessibility for users from their residence to a bus stop.



Logradou_3	Velocidade	OriginID	DestinationID	DestinationRank	Total Minutes
Pte Pref Lima de Castro	40km/h	46	64	1	0,538455
Av. Governador Agamenon Magalhães	60km/h	46	53	2	0,55068
Av. Conde da Boa Vista	40km/h	46	56	3	0,575946
R. Paissandu	Não possui indicação	46	55	4	0,619035
R. Dom Bosco	40km/h	46	54	5	0,700228
R. do Principe	Não possui indicação	46	62	6	0,748999

Source: Elaborated by the authors.

Parking

Due to limitations caused by the COVID-19 pandemic, the calculation of this indicator could not be done through field visits. Perceptions of parking capacity, flow, and management actions were obtained from three questions asked in the questionnaire. These questions were assigned weights equivalent to those suggested in Oliveira's Index (2015), arriving at the following result presented in Table 8.

Table 8

Parking infrastructure evaluation

Indicator	Weight	Score			Score x Weight		
		POLI	FCAP	UNICAP	POLI	FCAP	UNICAP
Parking area capacity	0.048	0.172	0.786	0.824	0.008	0.038	0.040
Parking management actions	0.048	0.234	0.429	0.515	0.011	0.021	0.025
Heavy flow in and out of the parking lot	0.048	0.617	0.429	0.897	0.030	0.021	0.043
Parking infrastructure	**0.048**	**0.341**	**0.548**	**0.745**	**0.016**	**0.026**	**0.036**

Source: Elaborated by the authors.

Of the three institutions, the FCAP and UNICAP campuses are the only ones that offer free parking for students, justifying their respective scores of 0.54 and 0.74; however, the capacity of the parking areas does not meet the students' demand, causing congestion at their access points and compromising traffic in the vicinity of the universities. The POLI campus achieves the lowest score (0.34) because it does not have any parking for students, who, in turn, must resort to private parking lots and spaces adjacent to the perimeter of the institution, also compromising local traffic. Beyond this, all three campuses have exclusive and free parking for professors; about 64% of users believe that the management actions (priority parking, rotation, warning measures) are ineffective, and almost 70% of users consider the intense flow of incoming and outgoing vehicles harmful to the campus surroundings.

Conclusions

Population growth has caused the large Brazilian metro areas to develop in a disorderly fashion. When the term mobility is applied, it is important to highlight that not only large cities, but also small areas, such as the TGH, face this complexity, as they are responsible for a large number of displacements and offer a diversity of services to the community. The capital of Pernambuco has faced many problems related to infrastructure and mobility in recent years. Although there are a number of projects and reorganization plans, not everything that is designed will end up being built. The quality of urban mobility depends on good transportation and traffic planning that offers as many alternatives as possible to citizens from all walks of life, duly institutionalized through compatible public policies.

The study revealed that the 82% of users, the vast majority of the interviewees, make use of public transportation. Of these, 52% make transfers to complete their respective routes, riding a bus (45%), BRT (24%), or metro (14%), and often finish their journeys using active modes, such as bicycling or walking. Although necessary, the final score for this indicator was approximately 0.026, meaning that most users evaluate the urban public transportation service offered as unsatisfactory, considering aspects such as punctuality, availability of space, and frequency.

Based on the three principal axes, Benfica Street, Conde da Boa Vista Avenue, and Agamenon Magalhães Avenue, it can be concluded that from any point in the neighborhood, according to both IMSCamp and spatial indicators, the user will not exceed a maximum time of five minutes or 300 meters to reach a bus stop from either of the two destinations. According to the spatial indicators, the average student time is 50 minutes to the UPE/Benfica campus and 30 minutes to the UNICAP campus. On the other hand, the time for a student who lives 10 km away from both destinations is 2.8 times longer than that of the students who live only 5 km away. In this case, it is essential to develop public policies to improve the transportation infrastructure.

In general, the results indicated that undergraduate students, besides being more adept to active modes of transportation, are also more likely to participate in educational activities (rides, lectures, workshops, extension projects) than users from other categories. However, the number of students who effectively participate in these dynamics is still very low (about 35%). It can also be observed that the campuses that obtained the highest scores have a greater participation of students from the engineering, architecture, and urbanism courses, in which there is a greater propensity to discuss urban mobility. This reinforces the importance of educational institutions in promoting a paradigm shift and in providing spaces for discussion on and learning about the subject.

This paradigm shift depends fundamentally on changes in behavior and habits. These changes can come from media and social networks, which, when well-planned, can be a digital meeting point where people, government, service providers, non-governmental organizations, and other of urban mobility actors share information about products and services, the use of non-motorized alternatives (walking and cycling), new ways of using the car (carsharing), and general traffic conditions. These spaces for discussion can add up to a catalyzing social effect that motivates change, such as, for example, the possibility of better use of time lost in traffic jams, for leisure, spending time with the family, taking care of one's health, even ecological aspects such as pollution reduction with a reduction in the number of cars on the road.

It can therefore be concluded that, if there are more actions available that deal with urban mobility (rides, workshops, extension projects, teaching groups, specific disciplines, among others), there will probably be an increase in the adherence of users to these actions. Consequently, contact and familiarity with the discussion about alternative modes of transportation and pedestrian prioritization promotes a greater awareness on the part of users, making them more likely to reconsider the unnecessary use of the private car.

For future study, it would be recommendable to expand the research using spatial analysis methods combined with multicriteria analysis to refine the indices and better assess the level of each indicator of sustainable urban mobility.

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