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Walkability and importance assessment of pedestrian facilities in Phnom Penh City

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Abstract: *Walkability is a measure that assesses the extent to which roadways are conducive to pedestrian walking. Walking, being an eco-friendly means of transportation, has many advantages including reduced adverse environmental effects, enhanced individual self-sufficiency, and improved physical well-being. Phnom Penh, similar to many cities, prioritizes cars, leading to a lack of pedestrian-friendly infrastructure. Accordingly, a significant number of residents are forced to depend on automobiles or motorcycles for transportation, thereby intensifying the issue of traffic congestion and environmental pollution in the urban area. The objective of this research is to determine the value of walkability by renewing pedestrian amenities, as well as the level of satisfaction and importance, and thus the relationship between accessibility, supporting facilities, safety, and comfort factors that influence walkability. A total of 120 pedestrians were examined at three separate locations along Russian Confederation Blvd. The GWI walkability index was developed using nine variables to evaluate the significance and effectiveness of the proposed sidewalk. According to the preferred weighing, ITC has a high walkability level of 68.25%, while RUPP and IFL have high to medium levels (59.50% and 59.35%, respectively) compared to other Asian cities. Additionally, we explore the relationship between walkability and accessibility factors, supporting facilities, and overall convenience for pedestrians in Phnom Penh. The research identifies four crucial criteria accessibility, supporting infrastructure (likely including sidewalks and amenities), and potentially two others that significantly contribute to a city's walkability score. Particularly, a strong correlation exists between walkability and accessibility, along with the presence of supporting facilities.*

Keywords: Walkability, Global Walkability Index, Pedestrian facilities, Sidewalks

1. INTRODUCTION[*]

Regular physical activity, such as walking, is crucial for maintaining good health since it aids in preventing several illnesses, including cardiovascular disease, diabetes, and hypertension. Engaging in regular walking can enhance relationships with others, therefore benefiting persons' mental health [1], [2], [3]. Walkability refers to the extent to which the physical infrastructure of a street or neighborhood is conducive to walking, and the design of a residential area directly impacts its ease of access [4],[5]. Walkability offers several advantages, such as enhanced accessibility, financial investments, and improved quality of life within the community. In a more comprehensive method, the utilization of analytical techniques is expected to enhance public support for walking and other forms of transportation that do not include motorized vehicles. Pedestrians, particularly youths, the elderly, and individuals with enhancements, are vulnerable users [6],[7]. Roughly 50% of the estimated 1.27 million persons who die in road traffic crashes annually are pedestrians, cyclists, and motorcyclists. Hence, it is essential to address the needs of these vulnerable individuals who use the streets to ensure their journeys are secure. Strengthening pedestrian safety measures will result in a

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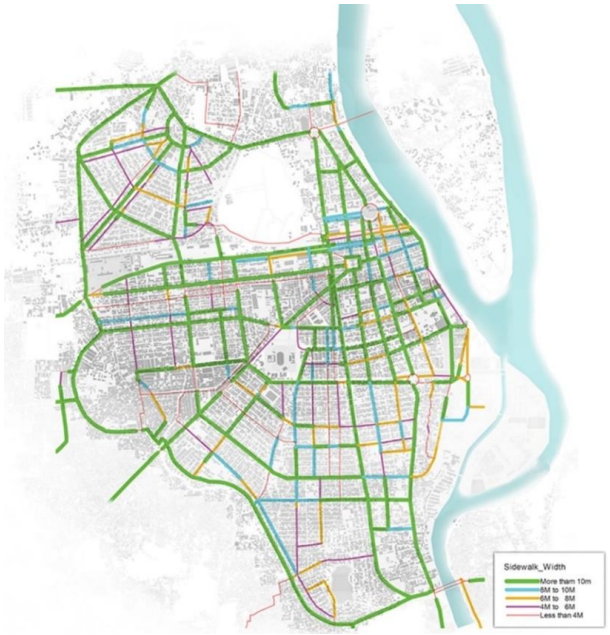
reduction in the number of deaths. Modifications to infrastructure have a crucial role in enhancing road safety, particularly by promoting the safety of pedestrians and cyclists and reducing fatalities [1],[8],[9].

1.1 General Pedestrian Sidewalk Environment in Phnom Penh

Phnom Penh, a city in Cambodia, is suffering fast growth characterized by extensive urban expansion and economic progress. As urbanization progresses, the evaluation of walkability and pedestrian infrastructure becomes increasingly crucial for maintaining the quality of life for residents of cities. When conducting a walkability evaluation of Phnom Penh, it is important to take into account many factors such as street design, safety measures, availability of destinations, public transit options, and pedestrian infrastructure. While the majority of the city's roadway network follows to a thoughtful layout, certain areas may suffer from a lack of sidewalks. Walking conditions can be dangerous in densely populated regions and when crossing high-speed streets due to the incidence of narrow or non-existent sidewalks. However, there is an issue about infractions, namely when businesses violate upon sections of the sidewalks, so obstructing pedestrian movement.



Source: PPUTMP Project Team
Fig. 1. Conditions of Pedestrian Sidewalks in Phnom Penh

The road inventory assessment in Phnom Penh Capital City (PPCC) reveals that several arterial routes have pedestrian pathways that are a minimum of 10 meters in width. However, most of the main highways in the city have sidewalks that are fair 4 meters in width. There are road gives within the town center that are less than 4 meters wide [10]. According to comments made by walkers in a questionnaire of pedestrians, the sidewalks before to the public experiment were thought to be "difficult to walk on account of illegal parking" (98.10%) and "difficult to walk on account of on-street vendors" (86.30%) [10] as shown in Fig.1.

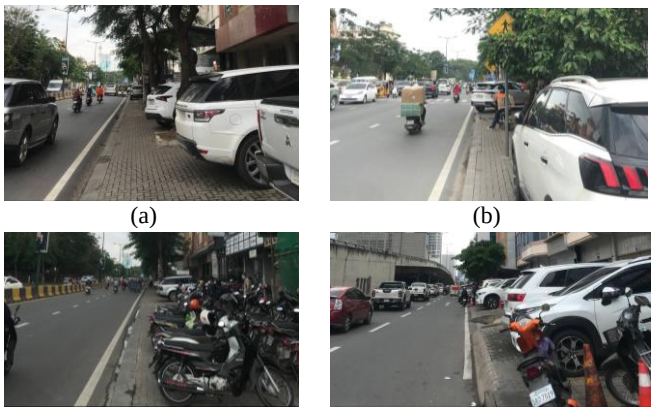


Fig. 2. (a), (b) Sidewalk at Institute of Foreign Languages (IFL), (c) Sidewalk at Royal University of Phnom Penh (RUPP), (d) Sidewalk at Institute of Technology of Cambodia (ITC)

1.2 Pedestrian sidewalk environment in the city center

The pedestrian walkway environment in the city center requires an additional investigation. Using the Public Experiment attention region as a guide, the study's target location is one with a high use of sidewalks by foreign tourists. Wat Phnom, Central Market, River Side, St.178, the National Museum, the Royal Palace (and Silver Pagoda), St.240, the Independence Monument, the Boeng Keng Kang Area, and the Toul Sleng Museum define this area. The sidewalks around Wat Phnom, the National Museum, the Royal Palace (and Silver Pagoda) and the Independence Monument are relatively wide and comfortable to use. This is because these areas are popular tourist destinations, and the city government has made an effort to make them pedestrian-friendly. However, the sidewalks around Central Market and the Toul Sleng Museum are rather difficult to walk due to the presence of illegally parked vehicles and their usage for terrace table seats by cafés and as display spaces by connecting shops. This makes it difficult for pedestrians to walk on the sidewalks, and it can also be dangerous.

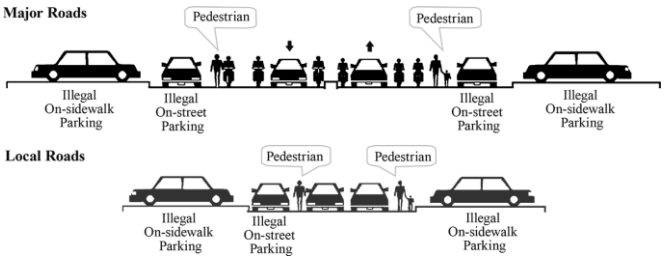
1.3 Mayjor roads

Norodom and Monivong are two of the most important streets in Phnom Penh, and they are both well-suited for walking. The sidewalks along Norodom are wide and relatively free of illegally parked vehicles, making them a comfortable place to walk. There are also several pedestrian crossings along the street, making it easy to cross the road safely. The sidewalks along Monivong are not as wide as those on Norodom, but they are still relatively large. There are also

several pedestrian crossings along Monivong, making it easy to cross the road safely. On the other hand, both Norodom and Monivong are lined with shops, cafes, and restaurants, making them great places to explore on foot. They are also home to several tourist attractions, such as the Royal Palace, the National Museum, and the Wat Phnom.

1.4 Illegal parking on the sidewalk

The issue of illegal parking on the sidewalk is prevalent in Phnom Penh. It can impede the safe movement of pedestrians and delay access to businesses and residences. As per article 7 of the recently enacted sub-decree on penalties under the road traffic regulation, drivers operating light vehicles and heavy vehicles will suffer penalties of approximately $18 and $36 respectively for parking in areas prohibited by the regulation. Nevertheless, the enforcement of the rule is inconsistent, leading to a persistent occurrence of illegal parking by several drivers. Several factors contribute to the prevalence of illegal parking in Phnom Penh. One factor contributing to the issue is the insufficient availability of parking places within the city. Furthermore, the enforcement of parking restrictions is frequently lenient. The following are some of the consequences of unauthorized parking on the sidewalk in Phnom Penh: Pedestrians are inconvenienced by the challenge of securely walking when parked autos obstruct the sidewalk. This particularly applies to individuals with impairments, the elderly, and parents using strollers. Businesses are adversely affected when cars are parked on the sidewalk as it obstructs access to businesses and hampers consumers' entrance and entrance. When cars are parked on the sidewalk, it causes traffic congestion by reducing the width of the road and obstructing the ability of cars to pass each other. This might result in the accumulation of vehicles and subsequent delays in traffic flow.



Source: PPUTMP Project Team

Fig. 3. Unsafe and Uncomfortable Walking Environment in the City Center

1.6 Sidewalk environment problems/issues

The sidewalk environment in Phnom Penh is a challenge for pedestrians. There are a number of problems and issues that make it difficult and sometimes dangerous to walk in the city. Phnom Penh has a rich history and culture, and its sidewalks are a testament to that. However, the sidewalks are often occupied by illegally parked vehicles, outdoor café seating, merchandise display, and planters. This makes it difficult and sometimes dangerous for pedestrians to walk on the sidewalks. As a result, people have little alternative but to take a walk on the roadways, making such circumstances extremely unsafe for pedestrians. For foreign tourists who go by foot the majority of the time, this condition has made the city streets boring to visit and the walking environment appalling.

1.7 Current problems/issues

The assessment of the research areas reveals six distinct factors that contribute to weak and dangerous pedestrian accessibility and movement. The following items are; the issues include automobiles parked illegally on sidewalks, waiting areas being used by Motodop and other para-transit vehicles, illegally built compartments on sidewalks, absence of accessible railings and stairs for the handicapped, inadequate pedestrian signage, and insufficient facilities and regulations for traffic safety nets.

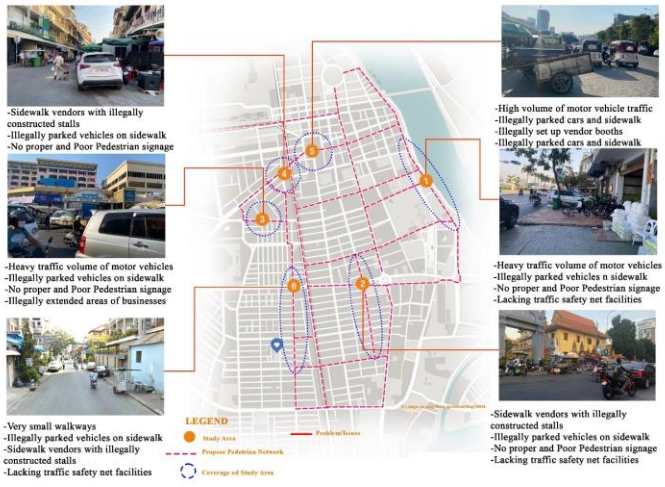


Fig. 4. Current conditions of the pedestrian network

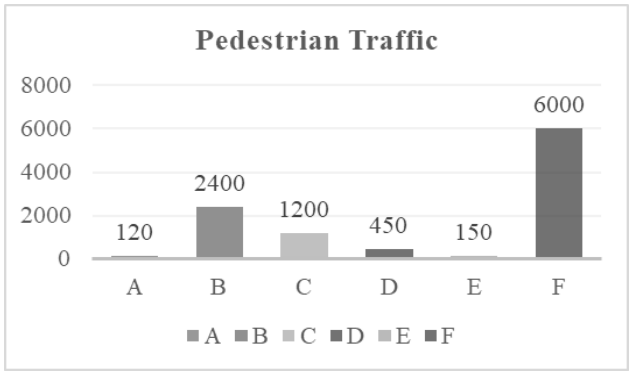
The current state of the planned pedestrian network walkways. Although there are irregular problems, such as lot owners encroaching on the sidewalks in the Toul Sleng area, the overall physical condition is satisfactory, with an average width of 5 meters. The figure provided illustrates the present condition and problems faced by the pedestrian network. During general, it seems like there are plans to restore and maintain the pedestrian walkways throughout the community. The walkways in close proximity of Wat Phnom, the National Museum, the Royal Palace (including Silver Pagoda), the Independence Monument, and the Riverside District towards Norodom are spacious and uninterrupted, providing a convenient and comfortable strolling experience. The excellent state of this promenade facilitates convenient access to several tourist attractions in the city centre, including Wat Phnom,

Central Market, Riverside area, St.178, the National Museum, the Royal Palace (with the Silver Pagoda), St.240, Independence Monument, Boeung Keng Kang district, and Toul Sleng Museum.

1.9 Pedestrian Traffic

The pedestrian density refers to the number of pedestrians observed at different times and days. The outcomes of the visual examination exhibited diverse factors across different research domains. Study area 'F' clearly achieved the highest ranking, with study area 'B' following closely after. Consequently, these two prominent areas are crucial pedestrian pathways that warrant examination for the replication of urban development in other locations inside Phnom Penh. The pedestrian density is measured in terms of the number of individuals per hour, as indicated in Figure 5.

A: Kampuchea Krom St. (Kampuchea Krom St. represents Study area A as the median of the group)
B: Central Market
C: Riverside Area
D: St. 51
E: St. 103(113) Genocide Museum Area
F: Orussey Market



Source: PPUTMP Project Team
Fig. 5. Increases in pedestrian use of sidewalks (Total for All 4 Routes)

1.11 Traffic Accidents

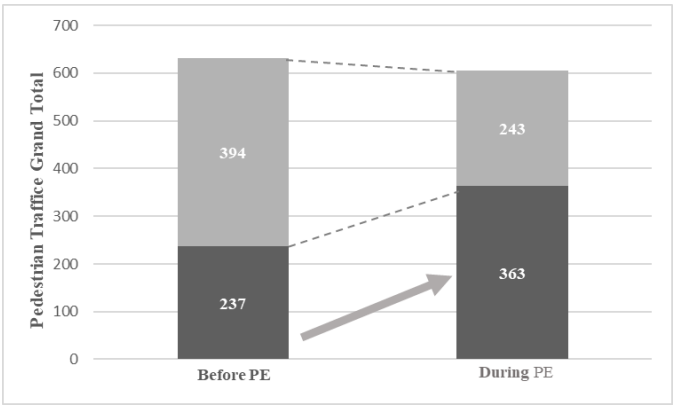
Pedestrians are at risk of damage or fatality in the present walking conditions. Handicap International conditions that pedestrians in Cambodia are very vulnerable to destruction due to the absence of sidewalks, traffic signs, traffic signals, and other safety precautions on the roads. In 2011, pedestrians accounted for 13% of all fatalities. In 2011, there was a notable increase of 17% compared to 2010. There has been a 23% increase in the number of pedestrian fatalities during the past five years. While the figure below shows that the total number of pedestrian fatalities in the country is less than 0.2% of the entire population, the economic impact, as estimated by Handicap International, is worrisome. Based on the information presented in Table 1, pedestrians ranked second in terms of the number of fatalities. The situation of road users, including pedestrians, in Cambodia, particularly in Phnom Penh, is evidently characterized by a significant lack of safety measures.

Table 1. Percentage of fatalities by mode of transport, 2011

Type of road user	2010		2011		Comparison
Motorbike	1209	67%	1262	66%	4%
Pedestrian	217	12%	254	13%	17%
Bicycle	72	4%	51	3%	-29%
Family Car	140	8%	144	8%	3%
Passenger Vehicles	28	2%	36	2%	29%
Goods Vehicles	76	4%	81	4%	7%
Agriculture vehicles	49	3%	51	3%	4%
Other	25	1%	26	1%	4%
Total	1816	100%	1905	100%	5%

Sources: Handicap international

1.12 Before and After the Public Experiment

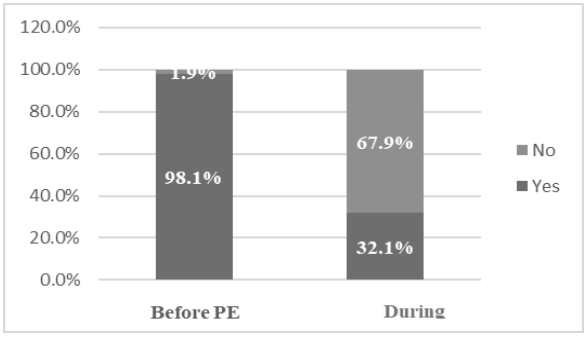


Source: PPUTMP Project Team
Fig. 6. Increases in pedestrian use of sidewalks (Total for All 4 Routes)

As a result of the public experiment, there is a 30% improvement in sidewalk use in the pilot area, which was previously difficult due to illegally parked automobiles. Pedestrians interviewed who said they felt comfortable strolling on the sidewalks scaled from 10% before the experiment to more than 50% after.

Q: How do you feel when you walk on this sidewalk?

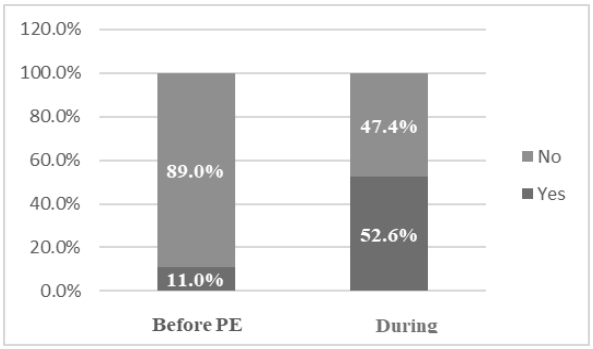
a) Difficulty of walking due to illegal parking



Source: PPUTMP Project Team

Fig. 7. Sidewalk condition (Illegal Parking)

b) Security of walking safely



Source: PPUTMP Project Team

Fig. 8. Sidewalk condition (Safety)

1.13 The Clean Air Initiative for Asian Cities (CAI-Asia)

The walkability calculation utilizes the worldwide walkability index (GWI) method, which Gota modified from the Clean Air Initiative for Asian Cities (CAI-Asia) to be more appropriate for the circumstances of huge Asian cities, which plan to have more pedestrians than other areas [11],[12]. Walkability influences active modes of transportation and encourages the mixing of urban transportation [13]. Walkability influences active modes of transportation and encourages the integration of urban transportation [13]. An environment that is walkable is essential for promoting active transportation [14]. Another study demonstrates that a walkable mixed-use development benefits those who use public transportation because it makes it easier for them to get around [15]. A walkable city environment will encourage commuters to use public transportation [16]. If a city prioritizes making its areas walkable, its citizens health will improve, and traffic congestion will decrease.

The purpose of this study is to respond to various research questions, like the way to increase the value of walkability by revitalizing pedestrian facilities, the level of satisfaction and importance of pedestrian facilities, and hence the relationship between accessibility, supporting facilities, safety, and comfort aspects influencing walkability.

The objective is to calculate the enhanced GWI walkability index by considering nine elements and assess the significance and effectiveness of the new sidewalk on Russian Conf. Blvd based on pedestrian opinions and identifies the correlation between walkability and accessibility, as well as the presence of supporting amenities and convenience factors.

The Global Walkability Index (GWI), a method for quantifying walkability, was initially developed based on research conducted in Beijing, Washington, DC, and New Delhi. According to GWI, there are 14 factors that influence walkability. These factors include: the proportion of road accidents involving pedestrian facilities, pedestrian conflicts, safety of crossing facilities, perceptions of safety and crime, behavior of motorized vehicles, maintenance and cleanliness of sidewalks, facilities for people with disabilities, supporting facilities, sidewalk obstruction, availability of crossing facilities, funding for the construction of pedestrian facilities, availability of technical guidelines related to pedestrian facilities, pedestrian safety regulations, and pedestrian conflicts [12]. The Clean Air Initiative for Asian Cities (CAI-Asia) conducted a study on the walkability evaluation method. During the research, 14 parameters in the GWI were reduced to 9 parameters that impact the Walkability Index. Therefore, five parameters were excluded from consideration: (1) the percentage of road accidents involving pedestrian facilities; (2) the allocation of funds for the construction of pedestrian facilities; (3) the existence of technical guidelines pertaining to pedestrian facilities; (4) regulations governing pedestrian safety; and (5) the extent of accessibility provided by pedestrian facilities. The specifications were adjusted to accommodate the specific conditions of large Asian cities with a significant pedestrian presence. These nine characteristics are relevant for describing the walkability index in major Asian cities [11].

Therefore, this method was selected as the approach for evaluating the Walkability Index in Phnom Penh. In the alternative GWI approach, the allocation was determined by calculating priority for improving pedestrian infrastructure. Participants were administered a questionnaire in order to obtain an assessment score. The numbers 2, 4, 8, and 10 were assigned to the first, second, third, and fourth priorities, respectively, and so forth. The assessment findings are derived from the respondent's priorities, which include two main factors: (1) The width and cleanliness of the sidewalk, and (2) The removal of obstructions that delay pedestrian passage on the sidewalk. (3) Enhancing pedestrian lighting, (4) Decreasing traffic speed on highways, (5) Improving accessibility for those with disabilities, and (6) Expanding pedestrian crossing areas. The decisive conclusion was that crossing centres were the least prioritized criterion according to the respondents. A total of 4,500 pedestrians have been surveyed in the 13 cities. The participants were requested to evaluate the walkability of a

particular region, articulate the characteristics of a favourable pedestrian environment, and identify specific enhancements they would desire in their walking environments. Respondents submit responses addressing variations in priority for enhancing pedestrian infrastructure and facilities. In addition, the weighting was created by taking into account the respondents' perceptions, as indicated in Table 3. Furthermore, for the purpose of streamlining information processing, the nine parameters were assigned codes ranging from P1 to P9. In addition, the Walkability Index was categorized into green, amber, and red groups based on the weight of each criterion, as indicated in Table 4.

1.2 Hypothesis

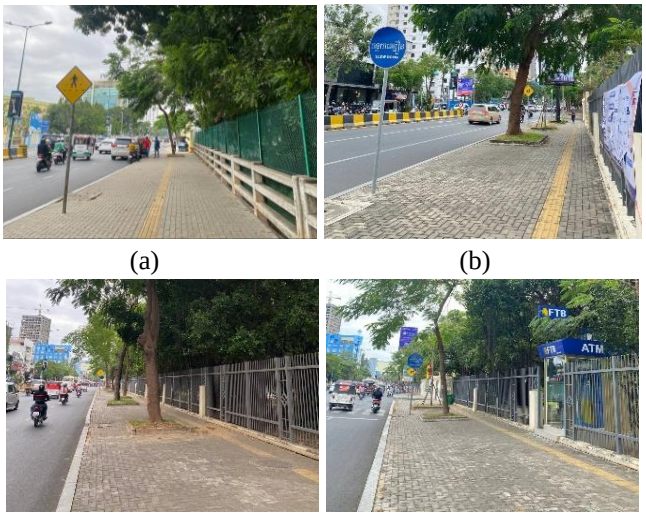
The hypotheses proposed in this study are as follows: (1) Applying pedestrian facility revitalization as a pilot project has a beneficial effect on the importance of walkability; (2) The satisfaction and interest level of pedestrians positively influence the value of walkability, and (3) There is a significant correlation between the accessibility aspects, supporting facility aspects, comfort aspects, and convenience aspects of pedestrian facilities.

2. METHODOLOGY

2.1 Survey location

Fig. 9. The Russian Conf. Blvd on central Business district

The Russian Conf. Blvd corridor was selected as the research site due to its status as the largest financial district in Phnom Penh. This area experiences a higher volume of pedestrian traffic compared to other locations and has recently undergone revitalization in preparation for the 32nd Sea Games and 12th ASEAN Para Games. In these specific areas, the city of Phnom Penh implemented elevated criteria for pedestrian infrastructure, including the width of sidewalks, the amenities provided, and the quality of materials utilized. The Russian Conf. Blvd has been designated as a pilot project area for the building of pedestrian infrastructure. Three places were selected in the vicinity, namely (1) Institute of Foreign Languages (IFL), (2) Royal University of Phnom Penh (RUPP), and (3) Institute of Technology of Cambodia (ITC), because to their significant foot traffic and their proximity to public transportation. Furthermore, the ITC area, IFL region, and RUPP area attracted a significant number of people seeking to engage in physical exercise, making them popular destinations for individuals seeking to be physically active.



(a) (b)

(c) (d)

Fig. 10. (a) Sidewalk at Institute of Technology of Cambodia (ITC), (b) Sidewalk at Institute of Foreign Languages (IFL) (c), (d) Sidewalk at Royal University of Phnom Penh (RUPP)

2.2 Method of collecting data

Data was collected by the distribution of questionnaires and conducting interviews with pedestrians at three specific sites along Russian Conf. Blvd. Data was collected through the use of questionnaires to assess each variable according to the users' perceptions. A five-point rating scale, ranging from 1 to 5, was used to score the responses. The previous walkability studies conducted by Gota et al utilized surveyors for the evaluation. In the present study, the evaluation was carried out by the participants. However, the researchers shared a cohesion in their utilization of nine specific factors, with a special emphasis on the modified GWI parameter. This set of records employed a sampling method known as purposive sampling. In this approach, sampling is conducted in a random manner, mostly guided by the boundaries established by the researcher. Objective sampling, sometimes referred to as decision,

selective, or subjective sampling, is a methodical and intentional sampling method that relies on the researcher's explanation and criteria to select the sample population for the study [15], [17]. Currently, participants have been instructed to fill out a survey that consists of nine different GWI criteria.

In a study conducted by Hung et al. (2010), the objective was to evaluate the dependability and accuracy of walking perception and comprehension among residents of Hong Kong [17]. Analysed were data from 124 accurately chosen samples of the working group, which encompassed diverse locales and factors such as residential density, road network connection, and social cost levels. Several research studies have focused on assessing the walkability and importance of pedestrian facilities in the central business district (CBD) of the capital city of Indonesia. These studies involved surveying 200 respondents by distributing questionnaires and conducting interviews with pedestrians at five locations along Thamrin-Sudirman road in September 2019 [18]. The proper application of Cochran's (1977) sample size calculation for both continuous and categorical data. In addition, we will briefly explore the formula developed by Krejcie and Morgan in 1970 for estimating the sample size for categorical data. It is crucial to emphasize that this approach yields the same sample sizes in all scenarios when the researcher modifies the t-value based on population size, a need when the population size is 120 or less. However, it is important to exercise attentiveness when applying normally used sample size tables derived from Krejcie and Morgan's method, as they presuppose an alpha level of .05 and a margin of error of .05. Although there are additional formulas that can be used, these two formulas are the most frequently utilized. According to Westland (2010), Boomsma (1982) conducted a study that recommended a minimum sample size (n) of 100. However, in specific circumstances, it is necessary to have a minimum sample size of 200.

The nine statements addressed various aspects related to pedestrian issues, including conflicts with other modes of transportation, the presence of sidewalks, the availability of pedestrian crossings, the safety of these crossings, motorist behaviour, supporting facilities, security concerns, infrastructure for disabilities, and sidewalk obstruction due to criminal activities. A numerical rating ranging from 1 to 5 was assigned to each question. A grade of 5 signifies the optimal condition, whilst a rating of 1 signifies the worse state. In order to show appreciation for the responders who have completed the questionnaire, the surveyor team has distributed commemorative pens.

The respondent profile data indicates that the majority of respondents are female, and the majority of age groups fall to the range of 18–25 years and 26–35 years. In addition, 5% of individuals have a high school education background, whereas 95% have a diploma. Meanwhile, the bulk of salaries fall into

Table 2. shows the respondents profiles based on the collected data.

Characteristics		N% ITC	N% RUPP	N% IFL
Respondents		40(33)	40(33)	40(33)
Gender	Male	24 (60)	29 (72.5)	24 (60)
	Female	16 (40)	11 (27.5)	16 (40)
Age	18-25	18 (45)	40 (100)	2 (5)
	26-35	22 (55)	-	4 (10)
	36-45	-	-	6 (15)
	46-55	-	-	12 (30)
	56-65	-	-	6 (15)
	>65	-	-	2 (5)
Occupation	Teacher	4 (10)	-	2 (5)
	Architect	4 (10)	-	2 (5)
	Engineer	14 (35)	-	2 (5)
	Student	14 (35)	40 (100)	34 (85)
	Employed	2 (5)	-	-
	Employed	2 (5)	-	-
	Layer	2 (5)	-	-
Education	Diploma	38 (95)	40 (100)	40 (100)
	Junior high school	2 (5)	-	-
				-
Monthly Income	Lower (<14,800,000 KHR or <USD 285.71)	36 (89.47) 2 (5.26) 2 (5.26)	40 (100) - -	38 (95) 2 (5) -
	Middle (14,800,000 KHR- 3,580,000 KHR or UAD 285.71-USD 500)			
	High (> 3,580,000 KHR or USD 500)			
Travel Purpose	Exercise	6 (15)	4 (10)	14 (35)
	Working	14 (35)	-	2 (5)
	Sightseeing	7 (17.5)	18 (45)	18 (45)
	School	11 (27.5)	18 (45)	6 (15)
	Shopping	2 (5)	-	-

Note: 1 USD = 4,087.19KHR, as exchange rate of 3 January 2023

three categories: low income (14,800,000 KHR or USD 285.71), middle income (14,800,000 KHR-3,580,000 KHR or USD 285.71-USD 500), and high income (> 3,580,000 KHR or USD 500). These categories are determined by the level of education, with 89.47% of individuals with a high school education or below falling into the high-income category, and 5% and 95% of individuals with a diploma falling into the middle- and high-income categories, respectively. Meanwhile, the majority of salaries fall into the low-income category, with a range of 14,800,000 KHR or USD 285.71. Middle income salaries range from 14,800,000 KHR to 3,580,000 KHR or USD 285.71 to USD 500. High income salaries are above

3,580,000 KHR or USD 500. These income categories account for 89.47%, 5.27%, and 5.26% of salaries, respectively. Moreover, within the occupational group, engineers constitute the largest proportion, accounting for 14%. The data indicates that the majority of respondents in the area are students, and they belong to the working-age population. Moreover, the bulk of respondents have indicated that 45% of them travel for school purposes, while another 45% travel for sightseeing objectives.

2.2 Method of analysis

The research utilized the modified GWI methodology, as it is more effective for the urban conditions present in Asian cities. Researchers and respondents evaluated walkability using a perceptual technique. The authors Gota et al., n.d. considered these nine factors suitable for describing the walkability index in major Asian cities. Additional research is required to adjust those 9 factors. In order to determine the average importance and performance values, the score was multiplied by a factor of 20 to obtain the Walkability Index for each parameter. To obtain a Walkability Index on a scale of 100, the average score per location and per parameter was multiplied by 20. Furthermore, it is necessary to multiply each of these factors by their respective weights in order to calculate the total Walkability Index, as indicated in Table 7. Therefore, the Walkability Index of each parameter may be determined, as demonstrated in equation 1. Equation 2 demonstrates the magnitude of the entire Walkability Index. The overall Walkability Index represents the measure of walkability for the entire region, which is utilized in computing the Walkability Index specifically for the Phnom Penh Road area.

$$Walkability\ Index\ (WIp)\ Parameter = \frac{\Sigma(\text{Weight of Parameter x Score of Parameter}}{n}$$

(Eq. 1)

Walkability Index Total (Wi_t)= a_1P_1+ a_2P_2+ a_3P_3+…. + a_9P_9 **(Eq. 2)**

Where:
WI_p=Walkability Index Parameter
WI_t =Walkability Index Total
a_i = Weight of Parameter
P_i= Score of Parameter

Additionally, the studies carried out a descriptive evaluation to discover the importance and performance (IPA) of every parameter. IPA is a realistic and powerful approach that could assist policymakers to become aware of provider or product elements whose allocation of resources could contribute to higher satisfaction of users [19]. The IPA diagram was good analyzed by considering each attribute in order of its relative importance [20]. IPA is used as a manage tool in assessing the importance and performance level of products or services from the respondents' perspective [21].

Table. 3. Nine parameters of walkability assessment

Parameter	Code	Remarks	Weight
Pedestrian conflicts with other modes of transportation	P1	Pedestrian conflicts with bicycles, motorbikes and cars.	15
Availability of sidewalk	P2	Availability of sufficient sidewalk, surface quality, and cleanliness.	25
Availability of pedestrian crossings	P3	Availability of pedestrian crossing facilities, such as zebra cross, pelican cross, pedestrian overpass and pedestrian underpass.	10
Safety of pedestrian crossings	P4	Safety when crossing the road.	10
Motorist Behavior	P5	The behavior of motorist to the pedestrians by giving priority.	5
Supporting facilities (amenities)	P6	Availability of supporting pedestrian facilities such as pedestrian signs, pedestrian marking, chairs, wayfinding, green hedge, trees, and trash cans.	10
Infrastructure for disabilities	P7	Availability of facilities for disabilities such as tactile paving and sidewalk ramp.	10
Sidewalk obstruction	P8	There are permanent or temporary obstacles on the sidewalk.	10
Security from Crime	P9	Safety for pedestrian from the threat of crime, especially at night.	5

Source:[11].

Table 4. Sidewalk assessment.

Walkability Index (WI)	Category	Sidewalk
WI ≥70	Green	Highly walkable
50< WI ≤70	Amber	Waiting to walk
WI ≤ 50	Red	Not walkable

Source:[11].

IPA evaluation become carried out to assess every variable primarily based totally at the questionnaire of the users' perceptions through the use of a 5-score scale, scored 1 to 5.

Data from the distribution of the performance and important questionnaires on each walkability parameter (P1-P9) were inputted in Excel software. Then, the average for each item were calculated (there were 40 for each location) to get an average score. Resulting, the common effects for every indicator within side the vital and overall performance sections had been organized. The results were plotted in a Cartesian diagram composed of four quadrants automated using IBM SPSS Statistic software. Thus, the spread of each parameter for each quadrant depended on the SPSS output. The graph of IPA quadrant is proven in Fig 11 [22].

Quadrant I is labeled "concentrate here" indicating that the parameter has highly excessive importance, however, it's no longer as predicted by the respondent; thus, its much had to be stepped forward soon. Quadrant II is labeled "keep up the good work." displaying that the parameter has fantastically excessive significance and an excessive delight level. The variables in this quadrant are deemed a supporting factor for users 'satisfaction, so those variables should be kept. Quadrant III is labeled "low priority," illustrating that the walkability-associated variable has relatively low importance and is perceived by the users as superfluous with relatively high satisfaction. Quadrant IV is labeled "possible overkill," mentioning that the walkability associated variable reduces because of its below-common significance and carrier level.

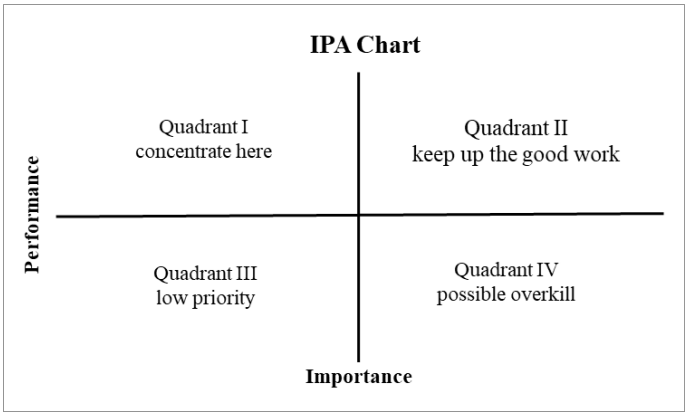


Fig. 11. Importance and performance analysis (IPA)

Aspects linked with pedestrian facilities are accessibility aspect, supporting facilities aspect, safety aspect, and convenience aspect. Meanwhile, other research stated that the factors related to walkability are sidewalk condition, traffic safety, security, comfort, and attractiveness [23]. In addition, correlation evaluation categorizes 9 parameters into 4 aspects. The grouping was based on the similarity of parameter characteristics to the aspects shown in Table 5.

Pearson correlation was used in this research because it is a parameter measurement that produces a correlation coefficient that attends to measure the strength of the linear relationship between two variables. If the connection among variables isn't always linear, then the Pearson correlation coefficient no longer mirrors the electricity of the connection among the 2 variables, despite the fact that the two variables have a sturdy relationship.

Data processing and validity tests were conducted using the IBM SPSS software program (Statistical Product and Service Solution 25). An easy correlation evaluation method (bivariate correlation) was used to determine the correlation among variables and the degree of impact of the present correlation. The easy correlation of the coefficient price confirmed the quantity of correlation among variables [24].

Table 5. Grouping of parameters to the aspects.

No	Aspect	Code	Parameter
1	Accessibility Aspect	P2	Availability of sidewalk
		P7	Infrastructure for disabilities
2	Supporting Facilities Aspect		Availability of pedestrian crossings
			Supporting facilities (amenities)
3	Safety Aspect	P1	Pedestrian conflicts with other modes of transportation
		P4	Safety of pedestrian crossings
		P5	Motorist Behavior
		P9	Security from crime
4	Convenience Aspect	P8	Sidewalk obstacle

Source: [22].

3. RESULTS AND DISCUSSION

The walkability index (WI) for each parameter is determined through having respondents answer the pedestrian perception questionnaire. The index was evaluated using a five-point scale with values ranging from 1 to 5. The higher walkability index illustrated that the pedestrian facilities on that parameter can accommodate the interests of pedestrians. The walkability index results for each parameter are shown in Table 6, and the walkability index based on weight is shown in Table 7. The higher walkability index illustrated that the pedestrian facilities on that parameter can accommodate the interests of pedestrians. The walkability index results for each parameter the results of the walkability index at the RUPP area and the P4, approximately the protection of pedestrian crossing

facilities, which result from a pelican pass with dwindling avenue markings and the conduct of motorists. Sometimes, motorists no longer prioritize pedestrians while crossing at the at a crosswalk. The crosswalk location, relative to the starting place and vacation spot of the pedestrian, turned into the place.

Table 6. Walkability index per parameter

Parameter	ITC		RUPP		IFL	
	Score (S)	WI=Sx20	Score (S)	WI=Sx20	Score (S)	WI=Sx20
P1	3.10	62	3.45	69	3.35	67
P2	3.62	72.50	2.45	49	2.45	49
P3	2.77	55.50	2.65	53	2.70	54
P4	2.75	55	2.90	58	3.05	61
P5	2.92	58.5	2.65	53	3.10	62
P6	3.95	79	2.85	57	3.05	61
P7	3.87	77.50	3.45	69	3.00	60
P8	3.80	76	3.45	69	3.50	70
P9	3.60	72	3.65	73	3.35	67

Table 7. Total walkability index based on weight

Parameter	Weigh (W)	ITC		RUPP		IFL	
		WI	WI x W	WI	WI x W	WI	WI x W
P1	15	62	9.3	69	10.35	67	10.05
P2	25	72.50	18.125	49	12.25	49	12.25
P3	10	55.50	5.55	53	5.3	54	5.4
P4	10	55	5.5	58	5.8	61	6.1
P5	5	58.5	2.925	53	2.65	62	3.1
P6	10	79	7.9	57	5.7	61	6.1
P7	10	77.50	7.75	69	6.9	60	6
P8	10	76	7.6	69	6.9	70	7
P9	5	72	3.6	73	3.65	67	3.35
WI total	100		68.25		59.50		59.35
Category			Amber		Amber		Amber
Assessment			Waiting to Walk		Waiting to Walk		Waiting to Walk

The assessment was based on the results of interviews with respondents and surveys observations during data collection regarding the condition of pedestrian crossing facilities.

2.2 Importance and performance analysis (IPA)

In the first location is at the ITC area, quadrant I showed the factors that were considered important by respondents, but the results of the analysis showed low-quality performance. Parameters included in Quadrant I was P1 Pedestrian conflict with other transportation modes. These conflicts often rise due to insufficient infrastructure for pedestrians, such as lack of

sidewalks or crosswalks, as well as aggressive driving behaviors. Parameters included in quadrant II showed the factors that were considered important by respondents, and they had a high performance. These parameters included in quadrant II were P7 infrastructure for persons with disabilities, P8 sidewalk obstacles, and P9 safety from crime. These parameters had ramps, textured pavements, and audible signals that allowed comfortably. P9, safety from crime, may include factors like people with disabilities to navigate the environment safely and the presence of good perceptions from respondents, P7, infrastructure for persons with disabilities, may include features like curb lighting, physical features that provide clear sight lines, and measures to reduce crime like CCTV cameras and community policing. These parameters help to build a safe and accessible pedestrian environment that supports walkability.

Furthermore, quadrant III showed the factors that were considered important by respondents, but the results of the analysis showed low-quality performance. Parameters included in quadrant III are those that are currently good but not necessarily important for walking P3, the availability of pedestrian crossings, may include aspects like the number of available crossings, the location of crossings relative to pedestrian demand, and the design of these crossings to ensure safety for all users. P4, or crossing safety, may include measures like pedestrian signals, raised crosswalks, measures like pedestrian signals, raised crosswalks, curb extensions, and other safety features that help reduce the risk of pedestrian-vehicle conflicts. P5, the behavior of motorists towards pedestrians, may include factors like yielding behavior, speed control, and adherence to traffic rules. These parameters are good to have in place, but they may not be the most critical in determining whether a neighborhood or city is walkable.

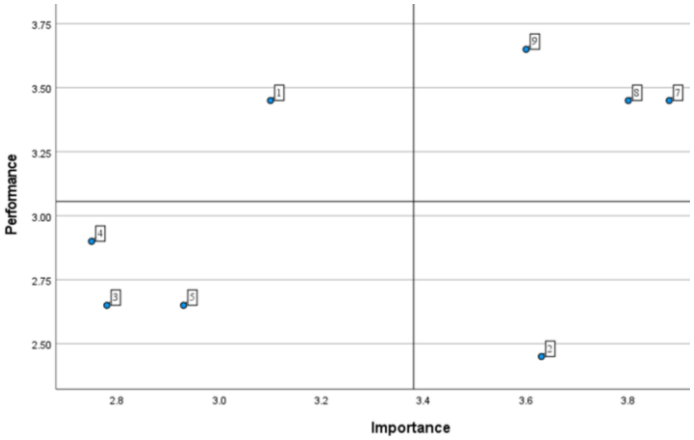


Fig. 12. IPA at (a) Institute of Technology of Cambodia (ITC)

Second location at IFL area, regarded as quadrant II, showed the factors that were considered important by respondents and they had a high performance. Parameters in quadrant II included P1 Pedestrian conflict with other transportation modes, P7 Supporting infrastructure for people with disabilities, P8 Sidewalk obstruction, and P9 security from crime. Pedestrian centers taken into consideration to be excessive in overall performance have been the width of the sidewalk which turned into capable of accommodate pedestrian movement, particularly at height hours withinside the morning and evening. In addition, Quadrant III confirmed parameters that have been taken into consideration much less crucial with the assistance of using respondents and it had a low performance. The parameters in quadrant III consisted of P2 the presence of availability of sidewalk, P3 availability of pedestrian crossings, P4 crossing safety, P5 behavior of motorists and P6, supporting facilities.

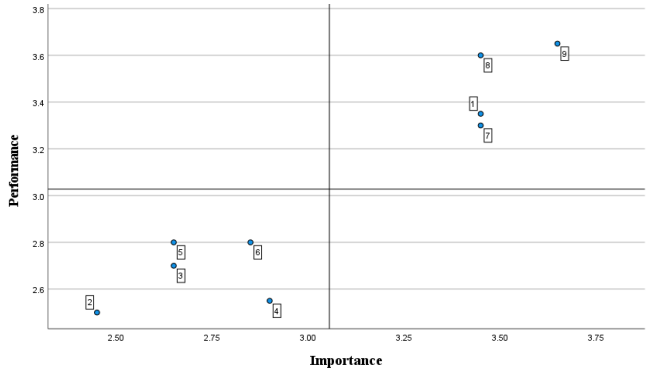


Fig. 13. IPA at Institute of Foreign Languages (IFL)

In the third location at the RUPP area, there were three parameters located in quadrant II that showed the factors that were considered important by respondents, and they had a high performance. The parameters in quadrant II included P1 sidewalk obstruction, P9 security from crime, pedestrian conflict with other transportation modes, and P8 pedestrian train facilities that needed to be maintained, including green hedges with a width of 5 m as a separator between motorized vehicle lanes and sidewalks. IPA at three locations shown in Fig. 4.

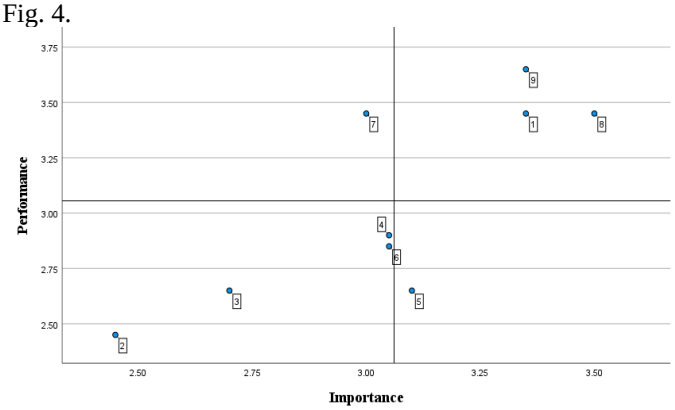


Fig. 14. IPA at Royal University of Phnom Penh (RUPP)

2.2 Analysis of correlations

Accessibility aspect

The result of the correlation analysis between accessibility aspects and walkability showed that P2 and P7 had a Pearson correlation value of 0.855. It indicated a value of 85% or a strong correlation between the accessibility aspect and walkability. The significance value was ($p<0.05$). Thus, H0 changed into rejected, or there has been a full-size correlation among accessibility components and walkability, inclusive of the continuous availability of sidewalks and the continuous tactile paving for people with disabilities. Sidewalk accessibility was designed nicely with the idea of continuity that connects all transit transportation.

Table 8. Correlation of accessibility aspect and walkability

		Accessibility Aspect	Walkability
Accessibility Aspects	Pearson Correlation	1	.855**
	Sig. (2-tailed)		<0.001
	N	240	240
Walkability	Pearson Correlation	.855**	1
	Sig. (2-tailed)	<0.001	
	N	240	240

**. Correlation is significant at the 0.01 level (2-tailed).

Supporting facilities aspect

The correlation analysis of the supporting facilities to the walkability (P3 and P6) presented the value of 0.819. Hence, it was a strong correlation along with a significant value of $p<0.05$. Thus, there has been a giant correlation among the helping facilities' components and walkability. Supporting facilities were available, such as pedestrian crossings, trees, green hedges, pedestrian signs, wayfinding, and chairs. In addition, the existence of supporting facilities indicated that the area had a high walkability.

Table 9. Correlation of supporting facilities aspect and walkability

		Accessibility Aspect	Walkability
Accessibility Aspects	Pearson Correlation	1	.819**
	Sig. (2-tailed)		<0.001
	N	240	240
Walkability	Pearson Correlation	.819**	1
	Sig. (2-tailed)	<0.001	
	N	240	240

**. Correlation is significant at the 0.01 level (2-tailed).

Safety aspect

Safety aspects consisted of P1, P4, P5, and P9. The correlation value between the safety aspect and walkability was 0.836. Thus, there has been a low correlation among the protection component and walkability. In addition, the safety aspect is significantly influencing the respondent's decision to use pedestrian facilities. The safety aspects consisted of pedestrian conflict with other modes of transportation, safety for pedestrians, motorist behavior, and security for crime.

Table 10. Correlation of safety aspect and walkability

		Accessibility Aspect	Walkability
Accessibility Aspects	Pearson Correlation	1	.836**
	Sig. (2-tailed)		<0.001
	N	480	480
Walkability	Pearson Correlation	.836**	1
	Sig. (2-tailed)	<0.001	
	N	480	480

**. Correlation is significant at the 0.01 level (2-tailed).

Convenience aspect

The analysis result showed that the influence of the convenience aspect on walkability consisting of P8 had a Pearson correlation value of 0.472. Thus, there was a low correlation between the convenience aspect and walkability. The convenience aspect included the presence of obstructions on the sidewalk. Even though there were obstructions such as utility boxes on the sidewalk, the respondents still felt comfortable walking on the sidewalk.

Table 11. Correlation of Convenience aspect and Walkability.

		Accessibility Aspect	Walkability
Accessibility Aspects	Pearson Correlation	1	.472**
	Sig. (2-tailed)		<0.001
	N	120	120
Walkability	Pearson Correlation	.472**	1
	Sig. (2-tailed)	<0.001	
	N	120	120

**. Correlation is significant at the 0.01 level (2-taile)

3.1 Discussion

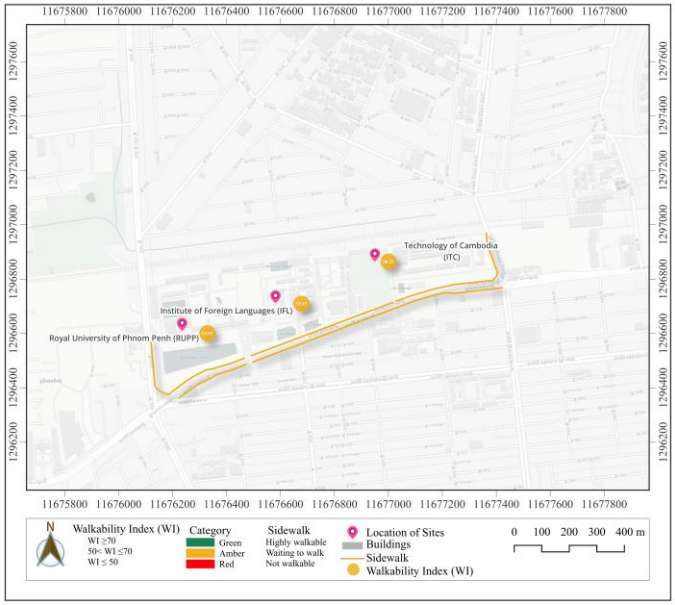


Fig. 15. Locations of the results on a map

The evaluation of new pedestrian facilities on Russian Conf. Blvd. revealed a walkability index at three locations categorized as Amber or "Waiting to walk" with values ranging from 59.35 to 68.25. As a result, it could comprehend walkable pedestrian centers that could be used by everyone, particularly inclined sidewalk customers such as the elderly, younger children, and those with disabilities. Explanations by surveyors may reveal the availability of centers for the disabled, such as tactile paving and sidewalk ramps. Furthermore, respondents gave an excessive score for the provision of incapacity facilities, particularly at the ITC, IFL, and RUPP, which all received a P7 rating, for infrastructure for disabled people, with a score greater than 77.89. The higher the Walkability Index (WI), the better the sidewalk's overall performance within accommodating pedestrian motion and movement that can be easily reached on foot and does not require a motorized vehicle. The Walkability Index concept is required because it can specifically identify the characteristics of sidewalks based on parameters. This system simplifies the process of putting together an assessment for improvements.

According to the IPA results, four parameters were determined to be important and performed well: (1) Pedestrian Conflicts with Different Transportation Modes, (2) Availability of Sidewalk, which includes adequate sidewalk width, (3) Availability of pedestrian crossing, and (4) Support facilities for people with disabilities, such as continuously tactile paving on the sidewalk and ramp slope. These parameters must remain relevant to performance. This method simplifies the process of putting together in order an assessment for enhancements. This parameter evolved into preventing crime, requiring an overall performance improvement to meet the needs of sidewalk users.

The results of the correlation analysis revealed that the accessibility and assistance center components were taken into account as having a strong relationship with walkability. The accessibility elements were properly implemented, including the continuous use of sidewalks and tactile paving for people with disabilities. The pedestrian accessibility was well-designed with the concept of continuity that connects all transit modes on Russian Conf. Blvd Road. Furthermore, to meet the expectations of sidewalk users, supporting facility aspects such as the presence of green hedges, pedestrian signs, way finding, trash cans, and chairs were properly implemented on the sidewalk. Respondents expressed a high level of satisfaction and importance for an increase in pedestrian facilities on Russian Conf. Blvd.

The accomplishment of improving pedestrian facilities on Russian Conf. Blvd has implications for Phnom Penh's urban transportation development policies. Further pedestrian facility development policies were carried out through the execution of the concept of a road diet, which included widening the existing sidewalk, reducing the number of lanes for motorized vehicles, and reducing on-street parking. The implementation of the road diet concept makes Phnom Penh more walkable and accessible to those who use public transportation. As a result, traffic accidents and fatalities have decreased significantly, and air quality has improved. Furthermore, the road diet has given pedestrians and cyclists more space, making it easier and safer for them to navigate the city. This has resulted in increased physical activity and a healthier population. The road diet has also benefited the local economy, as businesses along the redesigned streets have seen increased foot traffic and sales. Overall, the implementation of the road diet concept in Phnom Penh has been a success, and other cities around the world should consider taking similar measures to improve. Because this study was only conducted in the Russian Conf. Blvd avenue area, more research in other areas is needed [25]. Reducing the number of motorized vehicle lanes, reducing motor vehicle access, and reducing on-street parking will make an area walkable [26].

According to the TomTom Traffic Index 2021, Phnom Penh ranks as the 113th most congested city in the world, with a congestion rate of 30%. The congestion rate has decreased compared to 61% in 2017, which indicates that there have been some improvements in traffic management and road infrastructure in the last few years. However, traffic congestion still remains a major issue in Phnom Penh, particularly during peak hours, and the city government and local authorities are working on implementing measures to improve mobility and reduce congestion [27]. So, the concerns about the concept of a road diet causing Phnom Penh to become more congested are not proven. This achievement can be used as a lesson for other big cities in Asia, especially in developing countries.

4. CONCLUSIONS

The revitalization of pedestrian centers as a pilot project has had a significant impact on walkability. The revitalization of pedestrian facilities on Russian Conf. Blvd. reveals that the three locations are classified as amber, or "waiting to walk," with values ranging from 59.35 to 68.25. The sidewalk on Russian Conf. Blvd. allowed pedestrians to move around comfortably and safely. As a result, it could involve walkable pedestrian centers that could be used by all people, particularly vulnerable sidewalk customers such as the elderly, younger children, and those with disabilities. There were four parameters that were considered critical and had excessive performance: (1) pedestrian conflicts with other modes of transportation; (2) sidewalk availability, such as sufficient sidewalk width; (3) pedestrian crossing availability; and (4) support facilities for people with disabilities, such as continuously tactile paving on the sidewalk and ramp slope. These parameters must remain relevant to performance. At the same time, there was a parameter that was thought to be important, but it performed poorly. This parameter evolved into crime prevention, necessitating overall performance improvement to meet the needs of sidewalk users.

The research findings of this study emphasize that the walkability index in the Russian Conf. Blvd region shown correlations with several factors that affect walkability, including characteristics of accessibility, supporting facilities, convenience, and safety. The correlation analysis indicated a strong association between walkability and factors such as accessibility, safety, and supporting infrastructure. On the other hand, it was supposed that the convenience factor had a limited correlation with walkability. The novelty of this study is in the identification of the correlation between walkability and the four parameters that impact walkability. Further investigation is required to confirm these findings across many countries and regions. The study's findings demonstrate that implementing the street weight loss program concept can enhance walkability by revitalizing sidewalks. The road diet concept involves the reduction of car lanes and the reallocation of space to accommodate pedestrians, bikes, and public transportation. This strategy has the capacity to enhance road safety for all individuals. Revitalizing sidewalks using the road diet concept is a viable method for enhancing the livability and sustainability of cities. The Russian Conf. Blvd area, helping as a pilot region for sidewalk reconstruction, has the potential to serve as an example for other locations. The current research is limited due to its exclusive focus on ITC, IFL, and RUPP sites. It is sensible to conduct additional studies in different revitalized areas to strengthen the findings. The results of this study can attend as a proposal for international readers on the transformation of a city that was previously focused on cars into one that emphasizes pedestrians. This revolution has significant implications for improving the number of people using public transportation. In accordance with future study recommendations, the authors should also evaluate the air quality in Phnom Penh, as the city's air quality is affected by traffic congestion.

- Research the effects of climate change on the temperatures experienced during a walk in Phnom Penh, including any noticeable changes over time.
- Based on the user's input, it can be concluded that they are interested in creating a map of the walkability index. This map would likely show the walkability score of different areas, allowing individuals to determine the most walkable areas in a given location. This information could be useful for city planners, real estate developers, and individuals looking for walkable neighborhoods.

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