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Master's Thesis

Developing a walkability analysis tool with focus on Ho Chi Minh City's particular urban environment

Submitted by

Quoc-Quang Luc Bernard TRAN, BSc

Andrei SOLOMON, BSc

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Supervisor:

Assoc. Prof. Priv.-Doz. Dipl.-Ing. Dr.nat.techn. Juliane Stark
Institute for Transport Studies
Department of Landscape, Spatial and Infrastructure Sciences

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Developing a walkability analysis tool with focus on Ho Chi Minh City’s particular urban environment

Verfasser:

Quoc-Quang Luc Bernard TRAN, Bsc

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Betreuung:

Juliane Stark

Assoc. Prof. Priv.-Doz. Dipl.-Ing. Dr.nat.techn.

BOKU

IVe

Institut für Verkehrswesen
Department für Raum, Landschaft und Infrastruktur
Universität für Bodenkultur Wien

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STATUTORY DECLARATION

We herewith declare that we have written and composed this master's thesis about the topic "Developing a walkability analysis tool with a focus on Ho Chi Minh City's particular urban environment" independently. We did not use any other sources, figures, or resources other than the ones stated in the references.

Furthermore, we declare that, to our best knowledge, this work has never been submitted by us or someone else at this or any other university.

Vienna, January 2022

Andrei SOLOMON (manu propria) Quoc-Quang Luc Bernard TRAN (manu propria)

Distribution of the work

The research for this thesis was conducted jointly by Andrei Solomon and Quoc-Quang Luc Bernard Tran. In the table of contents behind the chapter headings, square brackets with the name initials indicate the author of the individual parts of the thesis.

[AS] = Andrei Solomon

[QT] = Quoc-Quang Luc Bernard Tran

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Table of Content

Abstract

This thesis aims to create a Walkability Evaluation Tool that measures the walkability in the context of Ho Chi Minh City. The tools' purpose is to assess and promote the walkability of a neighbourhood to encourage short walking trips. Through an online survey about walking habits in HCMC and a literature review, walkability factors were developed. A total of 12 indicators were integrated into the Walkability Evaluation Tool for Urban Areas in Vietnam (WETUAV). The walkability score resulting from the WETUAV was then tested and compared with Walk Score®. Walk Score® is a tool that measures the walkability of individual addresses based on proximity to nearby amenities. The input of the WETUAV was manually entered by users assessing data provided by Google Street View, video footage or on-site route examinations. The Walkability Evaluation Tool was tested in five routes in HCMC with different urban typologies. The results of the five test routes confirmed that the WETUAV was capable of identifying as well as locating shortcomings in the different route segments with its integrated walkability indicator score. Compared with the results of Walk Score®, the WETUAV score had a higher accuracy regarding the evaluation of the three main reasons preventing people from walking in the particular urban environment of Vietnam. These include the quality of the walking infrastructure, local climate conditions, and pedestrian encounters with other road users. Further development of WETUAV includes introducing indicators evaluating the needs for pedestrians with reduced mobility and analysing how much the subjectivity of a user influences the end scores. The tool can help policymakers to see if projects are addressing pedestrian needs or assist public transport operators to enhance the accessibility of their network.

Kurzfassung

Ziel dieser Arbeit ist, ein Instrument zur Bewertung der Begehbarkeit zu entwickeln, das die bauliche Umgebung von Ho-Chi-Minh-Stadt bewertet. Zweck dieses Tools ist die Bewertung der örtlichen Begehbarkeit und die Förderung des Zu-Fuß-Gehens. Anhand einer Online-Umfrage über die Gehgewohnheiten in HCMC und einer Literaturrecherche wurden Indikatoren für die Begehbarkeit entwickelt. Insgesamt wurden 12 Indikatoren in das Walkability Evaluation Tool for Urban Areas in Vietnam (WETUAV) integriert. Die Ergebnisse des WETUAVs wurden anschließend getestet und mit Walk Score® verglichen. Walk Score® ist ein Instrument, das die Begehbarkeit einzelner Adressen auf der Grundlage der Distanz zu nahen gelegenen Einrichtungen misst. Die Eingaben des WETUAVs erfolgen manuell durch eine/n Benutzer/in, der Daten aus Google Street View, Videomaterial oder einer vor Ort Begehung auswertet. Das WETUAV wurde auf 5 Routen in HCMC mit unterschiedlichen Umgebungen getestet. Die Ergebnisse der Testrouten bestätigten, dass das WETUAV geeignet ist, mit seinen integrierten Indikatoren Mängel in den verschiedenen Streckenabschnitten zu identifizieren und zu lokalisieren. Im Vergleich zu den Ergebnissen des Walk Score® wies der WETUAV-Score eine höhere Genauigkeit bei der Bewertung der drei Hauptgründe auf, die Menschen vom Gehen abhalten. Dazu gehören die Qualität der Fußgängerinfrastruktur, die lokalen klimatischen Bedingungen und den Konflikten zwischen Fußgänger/innen und anderen Verkehrsteilnehmer/innen. Zu den Aussichten des WETUAVs gehören die Weiterentwicklung von Indikatoren zur Bewertung der Bedürfnisse von Fußgänger/innen mit eingeschränkter Mobilität und die Analyse des Einflusses der Subjektivität eines Nutzers auf die Endergebnisse. Das Tool kann politischen Entscheidungsträgern/innen dabei helfen festzustellen, ob Projekte auf den Bedürfnissen von Fußgänger/innen eingehen, oder öffentliche Verkehrsunternehmen dabei unterstützen, die Zugänglichkeit ihres Netzes zu verbessern.

Definition of terms

Alleyway: a narrow, usually paved, passageway between buildings or other structures used by pedestrians and slow-moving vehicles.

Business spillover: stores spreading their selling area on the sidewalk.

Condominium: a building or a building complex containing several individually owned apartments or houses.

Shophouse/ tube house: The shophouse, commonly called the "tube house", is the most common type of building in HCMC. It consists of houses from 1 to 4 floors covering nearly the entire land plot it is built on. The dimensions are typically around 3 – 4 m of width and 15 to 25 m of depth having only one street access. They are built perpendicular to the streets and their design fits perfectly to their trade purposes. Starting at main streets and reaching back to narrow alleyways, shophouses give access to most people to the street.

Walkability shortcoming: An assessed route segment that fails to meet a certain standard.

List of abbreviations

CAWI:	Computer-Assisted Web Interview
CBD:	Central Business District
DVOS:	Driving vehicles on the sidewalk
ED:	Encroachment density
GIS:	Geographic information system
LOS:	Level of Service
MRT:	Mass Rapid Transit
N/A:	Not applicable
PAPI:	Pen-and-Paper Interview
POI:	Points of interest
RWNL:	Roadway width or number of lanes
SAVAL:	Sidewalk availability
TC:	Traffic congestion
TOD:	Transit-Oriented Development
VND:	Vietnamese Dong
WETUAV:	Walkability Evaluation Tool for Urban Areas in Vietnam

1 Introduction

1.1 Background [AS & QT]

Ho Chi Minh City (HCMC), the economic hub of Vietnam, is chronically suffering from heavy traffic congestions. According to the Statistical Yearbook of HCMC (2019), the average population in 2018 reached 8.79 million inhabitants. As of 2020, the municipality of HCMC is divided into 5 rural districts (huyện), and 16 urban districts (quận) (Figure 1.1-1). By the end of 2020, the former eastern urban districts 2, 9 and Thủ Dức merged to form the new municipality called Thủ Dức city. This sub-city remains under the administration of HCMC and therefore the districts of Thủ Dức city were included as part of HCMC in this thesis. Furthermore, the city has two seasons that are divided as follows: the rainy season (May – November) and the dry season (December – April). In 2018, the rainfall during the rainy season was around 2200 mm whereas the dry season of the same year experiences a rainfall of approximately 200 mm (Ho Chi Minh City Statistical Yearbook, 2019). The average temperatures vary little throughout the year, which remains around 28 °C. Furthermore, the city receives an average of 2400 – 2700 hours of sunshine per year (ADB, 2009).

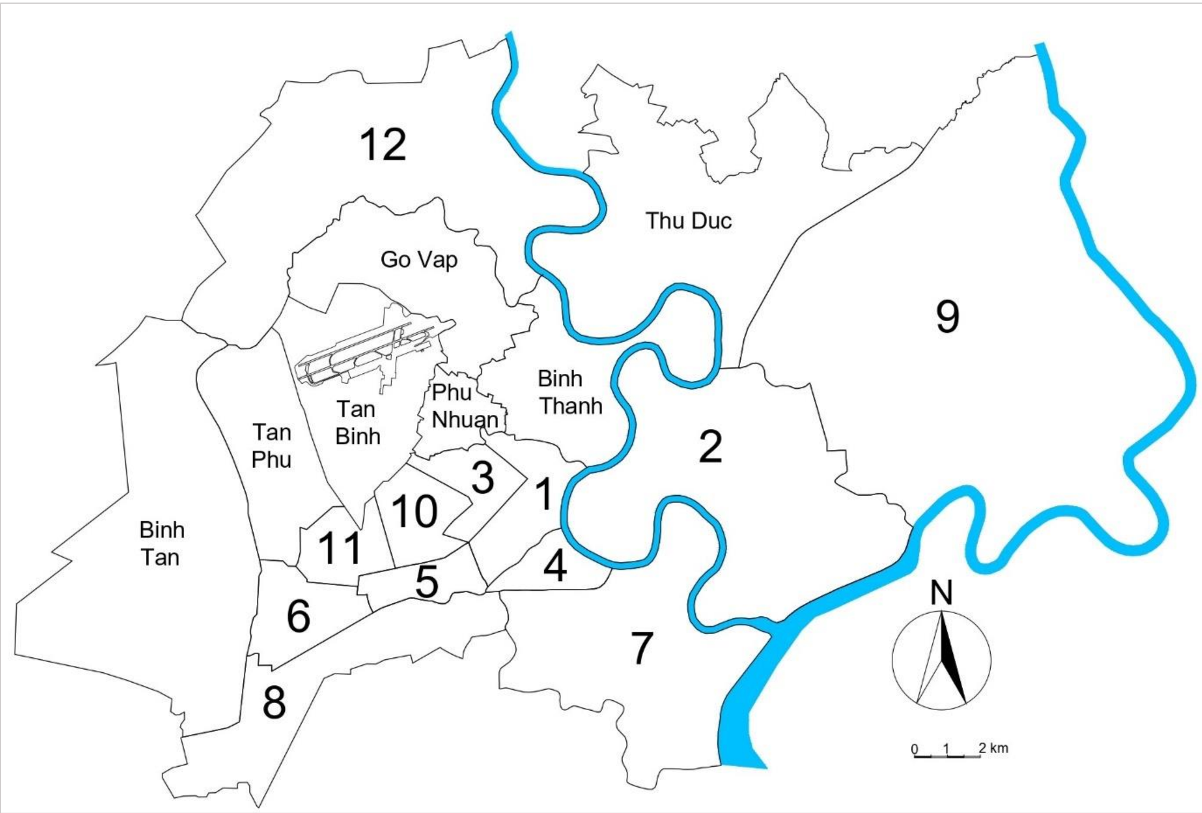

Figure 1.1-1: Urban district map of HCMC. Source: Author's own based on map data ©2021 Google

In 1986, the central government introduced economic reforms, also referred to as Đổi Mới, literally meaning “renovation”, switching from a centrally planned economy to a more market-oriented one. Since then, rapid urbanisation, population growth and increased household income have contributed to the rise of motorised vehicle ownership. In 2013, motorcycles accounted for 86.3 % of all trips and 98.6 % of households owned motorcycles, making it the most popular means of transportation (Table 1.1-1). The rate of motorcycle ownership per household increased from 2002 to 2013 by 4.3 percentage points (JICA Study Team, 2015).

Table 1.1-1: Vehicle ownership rate of household [%]. Source JICA Study Team, 2015

Vehicle Type Number		HCMC	
		2002 (HOUSTRANS)	2013 (METROS)
None		1.2	0.3
Bicycle		48.7	28.6
Motor-Cycle	1	34.2	18.4
	2	37.3	48.8
	3 or more	22.8	31.3
	Subtotal	94.3	98.6
Car		1.2	8.2
Other vehicles (bus, truck, three-wheeler)		1.3	1.0

This popularity finds its roots in HCMC’s historic network of small alleyways inaccessible to cars, favourable climate conditions and increased household income. However, motorcycles are also causing a lot of issues, one of them being the deterioration of the local environment through air and noise pollution, resulting in chronic health issues. However, in terms of energy efficiency, they are the most energy-efficient mode of private motorised mobility available (Storch et al., 2008).

The motorcycle is regarded as one of the more hazardous modes of travel. Non-fatal traumatic brain injuries and loss of productivity due to permanent disabilities resulting from motorcycle accidents can heavily affect the economic status of a household (Hoang et al., 2008). Sidewalk encroachment in form of parked vehicles, as well as driving vehicles bypassing traffic jams, are threatening pedestrians’ safety. This is considerably discouraging most people from walking, although there seems to be a potential for walking trips regarding distances. As described by the JICA Study Team (2015), residents of HCMC have a common habit of travelling by motorcycles for short-distance trips, that are within 100 to 200 m in length. The average sidewalk width of the entire city is 1.76 m. This number varies significantly between the 19 urban districts. As shown in Figure 1.1-2, the Old Inner area influenced by the French colonial urbanism inherited from large sidewalks with an average width of 2.52 m. The New Inner area and belt area have had sidewalk widths shrinking to 1.00 m and 0.43 m respectively.

To modernise the city, newly built suburban areas have the widest sidewalk width, with an average of 2.72 m (ibid.).

Figure 1.1-2: Wide sidewalks in the older inner area inherited from the French colonial period. Source: Author's own, 2019

Despite the absolute number of road accidents decreasing in HCMC over the last years, between 2013 - 2015, a rise of 217.0 % of children fatalities and 260.0 % of children injuries involved in traffic accidents were observed. Expressed in absolute numbers, children fatalities increased from 35 to 111 and children injuries from 15 to 54 in the 2013 - 2015 period (VU & Nguyen, 2018). According to the same study, only 18.7 % of primary school children were using active travel modes for commuting to school, although primary schools are often within a walkable range from home. More than half of the secondary and high school students were going to school by motorcycles of more than 50cc with 20.0 % of them driving illegally (VU & Nguyen, 2018). This clearly emphasises the need to create a safe walking environment for the most vulnerable road users, being the children and elderly.

When compared to pedestrians under the age of 30, elderly pedestrians are nearly five times more likely to be injured in an accident. Furthermore, the bodies of elderly people cope less effectively with (severe) damage from accidents than it does in younger adults (Adler & Ahrend, 2017).

Nowadays, the economic growth and the related emergence of the middle class tend to shift more and more towards private cars, worsening existing transport problems (Gibert & Pham, 2016). Since shophouses in inner districts of the city have no space to expand to accommodate cars, new car-centric designed settlements, sometimes in form of gated communities, are being built in the outskirts of the city (Storch et al., 2008). Unfortunately, this leads to segregation of the society and urban sprawl, lowering urban densities and the city's infrastructure efficiency. Oversized road designs are significantly increasing walking distances between the neighbourhood's facilities. Wider streets with plenty of lanes also mean longer crossing distances for pedestrians (ITDP, 2018). In Vietnam, where motorcycles never prioritise pedestrians, wide streets add a perceived barrier between both sides of streets. Since urban development often occurred faster than urban plans could be implemented, Ho Chi Minh City's infrastructure has been put under a lot of strain (MBA, 2018). This heavily impacts the quality of life. An uncontrollable car increase will lead to negative social, ecological, economic impacts. Unfortunately, transport planners often have a vehicle-centred approach rather than a human-centred design. In the HCMC Transport Masterplan 2020, the focus was mostly on developing costly infrastructure measures such as elevated highways, and/or flyovers encouraging the use of private vehicles. According to MBA's research (2018), the HCMC Transport Master Plan 2020 only focuses on establishing a framework to develop the infrastructure and enhance the public transport system, but does not include the active travel modes (non-motorised).

In order to create a walking-friendly environment, compactness, social diversity, and a vibrant mix of uses is of essential importance (Storch et al., 2008). Ho Chi Minh City already inherited an extreme compact urban form during the uncertain times of war, where unregulated development due to massive immigration from the rural areas was the norm. This created a rich diversity of the social, cultural, and economic activities which take place within the urban areas (ibid.). Due to the lower economic prosperity in the years following the end of the war, access to motorised vehicles was reserved for the wealthier. This naturally created walking-friendly neighbourhoods.

In many regions, sidewalks are both the most important and the most underappreciated public space. They are also the public space where most people congregate and socialise. In HCMC, aside from transportation, the sidewalk is a location to trade, socialise, and eat. In terms of square meters, a city's sidewalk system regularly outnumbers its parks and huge open areas, despite the fact that it has not received any awards for urban design efforts (Kim, 2015).

The current implementation of an Urban Mass Rapid Transit (MRT) should be accompanied by an accessibility study of a 500 – 800 m radius around the station (JICA Study Team, 2015). A particular focus should be done considering the walkability along MRT lines since most public transport users access the system on foot.
Small and encroached sidewalks will also create difficulties in the expansion of public transportation since there is insufficient space for passengers at bus stops (ibid.). Past projects in public transport improvements have failed to meet an increase in ridership. This is due to the unreliability of public transport as well as fierce competition with ride-hailing services. Therefore, there is currently no viable alternative to curb the use of private vehicles.

1.2 Problem statement [QT]

In HCMC, pedestrians account for only 3.0 – 5.0 % of the modal split (Emberger et al., 2013) compared to 86.3 % for motorcycles (JICA Study Team, 2015). The economic take-off of the last decade led to an increase in car ownership from 1.2 % in 2002 to 8.2 % in 2013 (Table 1.1-1). However, HCMC's compact urban structure has only 9.0 % of its built-up land dedicated to transportation, which consists of 2800 km of conventional roads and 5,000 km of alleyways, thus making it unsuitable for cars. A car ownership level of 250 vehicles per 1,000 persons would already lead to immediate congestion (Huynh & Gomez-Ibanez, 2017). Active travel modes, such as walking are considered to be a sustainable, environmentally friendly, and healthy alternative to individual motorised vehicles in an urban context. Promoting walking can help the city to enhance the quality of life and mitigate transport congestion. According to the JICA Study Team (2015), motorcycles are commonly used by people of HCMC to commute short distances of less than 200 meters and 54.7 % of intra zonal trips are shorter than 1 km. Huynh & Gomez-Ibanez (2017) found out that the average trip distance of pedestrians in HCMC is 1.2 km. As a result, there seems to be a potential for increasing the share of walking trips regarding distances. Nevertheless, traffic congestion and the flexibility of the motorcycle lead motorcyclists to use sidewalks, making walking a perilous and unattractive task. A poor walking infrastructure, heavy encroachment and unfavourable climate conditions may also be some of the reasons discouraging people from walking.

One of the most popular existing walkability evaluation tools is Walk Score®. It assesses the number of points of interest such as restaurants, coffee shops, grocery stores, schools, or parks as well as the proximity to those places. Other indicators include road metrics, like block length or intersection density, as well as population density (Walk Score®, 2021). By testing Walk Score® in HCMC, a lot of neighbourhoods were reaching very high scores, most of them achieving the highest score "walkers paradise".

However, this does not reflect the reality in the city, where walking is rather perceived as dangerous and unpleasant. HCMC as well as many other Asian cities could achieve high scores in Walk Score® because of the traditionally mixed-use character of the cities (Fabian et al., 2010). This is the reason why the new Walkability Evaluation Tool for urban areas in Vietnam was developed. The tool will help to evaluate the quality of the walking environment in Vietnamese urban areas by including indicators describing the built environment while taking into consideration the local walking habits. It is essential to find a set of indicators that already exist in the international walkability literature and combine it with the indicators that reflex Vietnamese walking habits. Understanding the walking behaviour is important to promote walking as a sustainable travel mode alternative to motorised vehicles.

Before designing a tool describing the walking space in HCMC, it is important to find out more about the reasons preventing people from walking. This was done through an online survey, where the authors tried to identify the most relevant walkability factors. The challenge is to find enough indicators to accurately calculate the walkability while limiting the complexity of the tool.

Experience has shown that traffic congestion, as well as heavy air pollution, threatens HCMC's quality of life. Promoting the benefits of walking and raising awareness of the current condition in the different communities in HCMC is a key to developing a more sustainable lifestyle.

1.3 Research purpose [QT]

1.3.1 Walkability Evaluation Tool for Urban Areas in Vietnam

This thesis aims to create a walkability evaluation tool for urban areas in Vietnam (WETUAV) that has higher accuracy than existing walkability tools. The input data of the route consists of on-field observations, Google Street View imagery or video footage. The collected data will be evaluated by the surveyor with the help of an input table in Excel. The scores are divided into different route segments and include an overall walkability score, as well as indicator scores. The walkability score consists of the average value of every indicator of a route segment. This mean walkability score makes it difficult to determine unfavourable walking conditions of a route. Therefore, it is important to also identify low indicator values that point out walkability shortcomings encountered during the walk. Furthermore, it should be user-friendly, easy to use and adapted for short walking trips up to 20 minutes. The results should be accurate for each type of urban environment in Vietnam and the design should be flexible enough to deal with missing data. The weights of the indicators should be carefully selected to illustrate the Vietnamese features. After analysing the findings of the survey, a walkability evaluation tool is developed in Excel based on a set of indicators that reflects the convenience of walking in the context of HCMC.

1.3.2 WETUAV's requirements

Contrary to existing walkability evaluation tools, the Walkability Evaluation Tool for Urban Areas in Vietnam (WETUAV) does not use GIS Data. Instead, the input data is based on the assessment of video footage, on-field observations, or Street View imagery such as Google Street View, which, when combined, have their benefits and drawbacks, as discussed in chapter 6.2. While the possibility of using multiple data sources increases the tool's flexibility, video footage assessment represents a more suitable pedestrian point of view and provides more accurate data regarding climate conditions and time of the day. This is important since those parameters can influence shade exposure and street activity. However, it is more time consuming and, in some cases, using Street View imagery services turns out to be more convenient. Finally, the tool is tested in five different neighbourhoods in HCMC and compared with Walk Score®.

1.3.3 Benefits for local authorities

The WETUAV can help point out dangerous walking situations to local authorities. The tool can also be used to analyse to what extent new development projects contribute to higher walking friendliness compared to the existing situation. For example, the walkability score could be one of the criteria used to determine whether or not to issue building permits. Authorities willing to increase the pedestrian mode share in a certain neighbourhood can use the WETUAV in areas facing serious congestion to identify shortcomings regarding pedestrians' friendliness. After locating and removing bottlenecks on selected pedestrian routes, the result of the study, supplemented by campaigns raising the awareness of the benefits of a walking-friendly neighbourhood, can increase the liveability of a city.

1.3.4 Benefits for local communities

Involved citizens or citizen groups can use the WETUAV to discuss potential solutions for their active mobility concerns. These could be safer routes for school children or sidewalk encroachment issues affecting pedestrian safety. Design ideas can be submitted to the competent authorities which can lead to low-cost investment pilot projects. In case of a successful trial phase, the project can be transformed into a more permanent structure.

This bottom-up approach can lead to the more social interaction of a local community and increase the acceptance of mobility projects.

1.3.5 Benefits for traffic/spatial planners

The results of the WETUAV can provide valuable data to traffic and spatial planners. The tool is able to assist planners by describing pedestrians' accessibility of public transport stations, analysing the use of the public space, and deepening the expertise about travel behaviours and travel patterns.

The WETUAV indicator and walkability score help to identify the most suitable street to improve its walkability by enhancing the urban space allocated to pedestrians. Moreover, a deep understanding of walking habits can help design a walkable and socially vibrant neighbourhood.

1.3.6 Benefits for land developers

For land developers, the outcome of the WETUAV can be a marketing argument. Walkable neighbourhoods tend to have higher real estate values and increased quality of life. This can include, e.g., lower air and noise emissions due to a reduction of motorised traffic, a compact neighbourhood with all daily necessities within walking distance, or a safer environment for children regarding traffic.

1.4 Research questions [AS & QT]

Based on the problem statement, the authors identified a research potential for developing a tool that describes the pedestrian built environment in Vietnamese urban areas and helps raise awareness of the current walking conditions. Projects involving walking infrastructure improvements are often excluded from HCMC's Transport Masterplans (MBA, 2018), despite its lower investment costs compared to transit infrastructure. Designing walking-friendly streets mainly consist of redistributing the public space more equally between the different transport modes.

Through the use of the WETUAV, it may be possible to illustrate on a citywide map the walkability of every street. This can help the authorities enhance the pedestrian infrastructure, as well as the walking conditions. With a high population growth rate putting a lot of pressure on the city's existing transport infrastructure, an efficient way to evaluate the current walking situation is required.

This points mentioned above led to the following research questions:

(1) What prevents people from walking in HCMC?

(2) Which indicators can be developed to create a walkability evaluation tool under consideration of HCMC's sidewalk life and its motorcycle dominated economy?

(3) How does the Walkability Evaluation Tool for Urban Areas in Vietnam perform in comparison with Walk Score®?

1.5 Working steps [QT]

Before creating a walkability evaluation tool adapted to Vietnamese urban areas addressing the research aims and research questions, it was necessary to collect existing walkability factors from national and international literature. Opposed to developed countries which are mainly car-dependent, Vietnam is a motorcycle dependent country. Therefore, factors describing the relation between motorcycle users and pedestrians needed to be found.

This was done through a literature review (WS 1). The factors influencing walkability are mainly extracted from “Pedestrians first, tools for a walkable city” designed by the Institute for Transportation and Development Policy (2018). The aim of their work was to propose an alternative to western and eurocentric standards that are often inefficient and too complicated to be implemented in other parts of the world. Therefore, their tool proposed measurement methods that promote walkability on a global scale. Their indicators were subdivided into the following three levels:

- Metropolitan urban area (citywide)
- Neighbourhood
- Block (street-level)

Based on this literature, the authors intended to design a walkability evaluation tool that is capable of evaluating the walkability focusing primarily on the neighbourhood and street-level, describing walking trips of up to 20 minutes of duration. This equals trips reaching up to 1.5 km, assuming that the average pedestrian speed is around 1.2 m/s in Asian cities (Fabian et al., 2010). This distance is within the range of the average pedestrian trip length in HCMC of 1.2 km assessed by Huynh & Gomez-Ibanez (2017). By dividing the evaluation scores into street segments, the street-level evaluation will also be covered. Lastly, by adding up multiple walkability evaluation scores of routes on a citywide walkability map, greater areas describing the walking-friendliness can be created to illustrate the development of the pedestrian network. By updating it regularly, the trends of the quality of the walking infrastructure can be assessed.

The second working step (WS 2) was to understand the mobility behaviour of HCMC's residents. Therefore, an online survey was conducted in the municipality of HCMC to collect sociodemographic data, mobility behaviour data, transport mode perceptions and expectations of the walking environment. The outcome of the survey will first be processed by removing invalid answers, translating, and theme coding open-ended questions before using descriptive statistics to investigate the mean values that were observed in the results.

The outcome of the second working step will serve as a basis for the third working step (WS 3), which consists of selecting relevant walkability factors and create the formulas for the walkability indicators for the design of Walkability Evaluation Tool for Urban Areas in Vietnam (WETUAV) in Excel. The indicators are ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Based on the findings of the first and second working steps, indicator weights were set by the authors. A sensitivity analysis was conducted for three different scenarios, representing diverging priorities of various stakeholders, to explore the influence of the indicator weights on the overall WETUAV Walkability index result.

The fourth and final working step (WS 4) was to test the Walkability Evaluation tool for Urban Areas in Vietnam. This step was important to verify if the WETUAV performed as expected in the Vietnamese urban environment it was designed for. The performance and limitations of the WETUAV are discussed by comparing the results with Walk Score®.

1.6 Structure [QT]

The main objective of this paper is to provide an easy to use and efficient tool to describe walkability in Vietnamese urban areas. Aiming to guide the reader to find the required information without having to read the entire paper, the structure of the thesis was divided into several chapters as follows (Figure 1.6-1):

Chapter 1 gives an introduction to the topic of walkability, the research aims and research questions. The motorcycle dependency of Ho Chi Minh City and the problematic increase of cars are discussed.

Chapter 2 outlines the findings of the literature review about the topic of walkability. Factors describing the walkability from international sources are selected, and the Vietnamese features of the pedestrian built environment are analysed.

Chapter 3 describes the layout and the questions of the online survey regarding walkability habits in Ho Chi Minh City. The platforms used to share the questionnaire and surveying period are further discussed. The methods used for the data processing and data cleaning of the results are summarised.

Chapter 4 deals with the presentation of the survey results using descriptive statistics. This chapter gives the reader an overall understanding of the origins of the walkability indicators used in the WETUAV.

Chapter 5 presents the design of the WETUAV. Each walkability indicator and its associated formula is carefully described. The second part of this chapter introduces the WETUAV design and how it is used.

Chapter 6 is about testing the tool in different neighbourhoods of Ho Chi Minh City. This allows the authors to test the selected indicator weight factors and the influence of negative events on the overall walkability index score. The performance of the WETUAV for five selected routes are then compared with Walk Score®. The different results of both tools are discussed and interpreted. A sensitivity analysis is done to verify the influence of the indicator weights. Lastly, the weaknesses, and limitations of the WETUAV are mentioned.

Chapter 7 discusses the conclusion of this research and summarises the findings, the plausibility of the results, and the future outlook of the WETUAV.

Chapter 8 summarises the different working steps of this thesis.

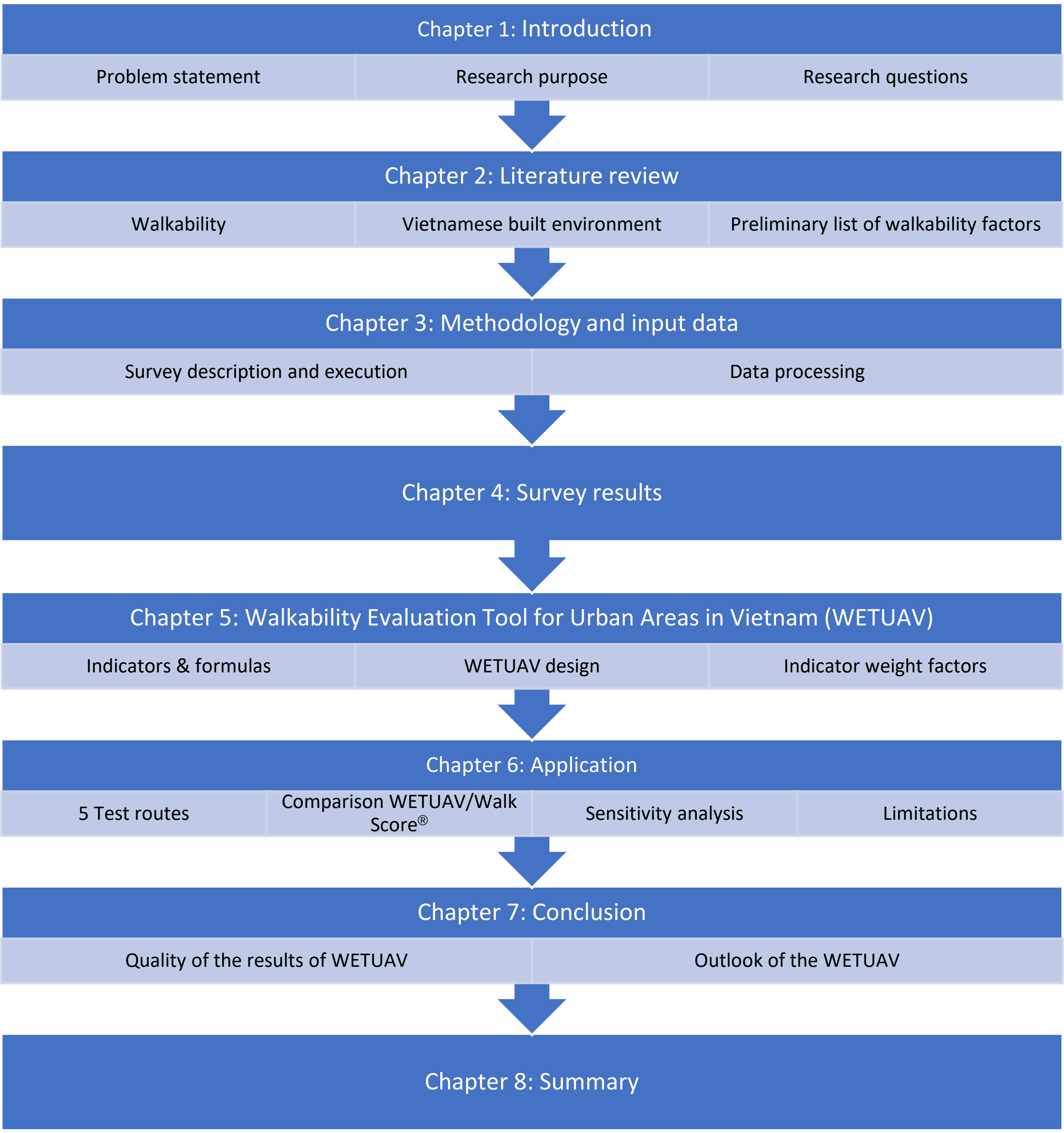

Figure 1.6-1: Structure of the thesis. Source: Author's own

2 Literature review

This chapter is dealing with three important sections that will be presented in further detail. The first section is focusing on collecting data about walkability factors, as well as how different authors from different fields, define walkability. The second is offering some perspective about the struggles that the pedestrians are experiencing in HCMC. The authors of this master thesis chose different studies that tackle various aspects of the walking environment in the city, as well as the importance of street activities that can be found on the sidewalk. Furthermore, details about the compactness of the metropolitan regions focusing on HCMC are analysed. Additionally, the street activity is a key aspect of the traditional Vietnamese culture, so a little bit of context was needed, so that the reader, could better understand the importance of sidewalk life. Noise and air pollution, as well as traffic and pedestrian safety, were also fundamental topics discussed in this section. The last section is summarising all the distinctive subjects that help the reader understand the major problems faced by pedestrians in the city. Lastly, a preliminary list of walkability factors was created. This list is part of the methodology used for the survey in this thesis to collect information about the relevance of walkability factors evaluating the built environment of Ho Chi Minh City.

2.1 Definition of walkability [AS & QT]

Professional, academic, and public discussions use the term walkability to refer to a variety of different occurrences, all of which are distinct from one another. Talk about walkable places is often centred on environmental aspects including compactness, safety, and walkability. Others focus on the possible results of such settings, such as making locations more dynamic, improving transit alternatives, and encouraging physical activity. Walkability is also sometimes used as a shorthand for better design, whether it's based on quantitative measurements or aims to address urban issues on all levels. However different authors from different fields, define walkability as follows:

Carr et al. (2011):

„Walkability can be defined as a neighbourhood's capacity to support lifestyle physical activity."

Duncan et al. (2011):

"Collectively, these features that promote various forms of physical activity (such as walking) can be referred to as 'neighbourhood walkability' and often include access to walking destinations such as retail stores and parks, and community design features such as street connectivity and sidewalk access."

Hajna et al. (2015b):

"The variables that best capture design, diversity and density are street connectivity, land use mix and residential density (collectively referred to as neighbourhood walkability)."

Pivo & Fisher (2011):

"We define walkability as the degree to which an area within walking distance of a property encourages walking trips from the property to other destinations. It interacts with the property users' walking preferences and capabilities to produce the timing, quantity and distance of walking trips that occur. Several different physical and social attributes of the area around a property can affect walkability. As such, it is a multidimensional construct composed of different factors that together comprise a single theoretical concept. Contributing attributes include urban density, land use mixing, street connectivity (i.e., the directness of links and the density of connections), traffic volume, distance to destinations, sidewalk width and continuity, city block size, topographic slope, perceived safety and aesthetics."

Loc & Kim (2018):

"Walkability index is built on seven factors, including residential density, retail floors ratio, mix-land use, intersection density, sidewalk coverage, tree canopy, temperature"

Given the fact that walkability is such a complex term that can be defined in many ways, the authors decided to first have a thorough literature research about the features of typical Vietnamese urban environments, before defining a preliminary walkability factor list (chapter 2.7).

2.2 Vietnam and its compact metropolitan regions [AS]

While reviewing articles and papers regarding Vietnam and its compact metropolitan regions, the study conducted by Storch et al. (2008) came to the author's attention. This study is highlighting the significance of densification and compactness as the most essential efficiency indicators for urban land-use patterns since they help to minimise sprawl and traffic congestion. Aside from that, the dense form of a compact city offers the economies of scale required for efficient infrastructure, as well as allowances for specific types of public urban services and the efficient use of mass transportation networks. However, technological advancements in global mobility nodes, information processing, and telecommunications are speeding up the expansion and dispersion of both commercial activity and population, reaching the point when "geography is no longer significant" (Gordon & Richardson, 1997, p.95).

At the same time, throughout Europe, urban planners push for "compact cities" as the ideal urban shape, in contrast to the reality of sprawling metropolitan growth. A major emphasis of urban planning debates over the last decade has been the subject of how the shape of cities, including building types, site layouts, and population densities, contributes to overall urban sustainability. Following the compact city paradigm, urban design techniques for megacities have the potential to lessen their urban environmental impact. Densification, on the other hand, may be damaging in metropolitan areas that are severely underserved in developing Asian countries. Traditional settlement structures of the inner city districts in HCMC are examples of areas with extremely high densities of population, but inadequate levels of service and infrastructure provision result in serious health problems as well as increased environmental impacts in these urban areas. Consequently, increased density is not the main predictor of the long-term viability of urban constructions (Storch et. al., 2008).

The efficiency with which resources are used and the quality of life of the people are determined by the structure of the settlement and the shape of the built environment that it has. Contrasting and opposing views regarding urban development planning models that may combine high density with a sustainable urban shape have defined urban planning in the previous few decades, and the present conversation on sustainable spatial planning is no exception (Ewing et al., 2002). Cities in emerging South-East Asian countries, such as Ho Chi Minh City in Vietnam, often already have an extremely compact urban form with a vibrant mix of uses, not as a result of planning strategies, but as a result of unregulated development that reflects the diversity of social, cultural, and economic activities that take place within urban areas.

2.2.1 Indicators of efficacy for urban land use in HCMC

In the debate over the sustainability impacts and spatial consequences of poorly managed residential expansion on the outskirts of urban agglomerations, there is a pressing need for a method that can be used to measure and evaluate the dominant structural changes in the urban landscape on a regional scale that is widely accepted. More than that, environmental and spatial planners must be able to illustrate how the managed sprawl of residential areas has genuine implications for effective land-use management as well as significant environmental consequences (Storch et.al., 2008).

Among the most significant consequences of inefficient land use for settlement development is a spatial development in which the spread of residential construction throughout the rural landscape considerably outpaces population expansion, as documented in the area of the spatial and urban planning study. According to Flacke (2003), the efficiency of the resulting regional and urban spatial structure that this spatial development process generates can be measured and analysed by making use of the following spatial and structural indicators:

- Population density,
- Variety of uses and mixed-use,
- The effectiveness of activity centres,
- Affordability and access of urban transportation and service infrastructures in urban areas.

These basic indicators are explored in further detail in the following sections, along with their importance for the metropolitan region of HCMC and their implications for the efficiency with which land resources are utilised.

2.2.2 Population density

The spatial structure of a metropolitan region or agglomeration area is not always visible from the ground, but it can be detected when analysing demographic and land-use-related data. In spatial planning, the first step to analyse the basic spatial organisation is to describe the spatial pattern of population distribution within the built-up area. The focus can be separated into two main indicators: land consumption per resident (density) and the spatial distribution of these densities (density profile). Residential density is the most important indicator to evaluate the efficiency of residential development and land-use management (Ewing et al., 2002). Dispersed suburban residential areas are the spatial manifestation of urban sprawl.

As HCMC and the majority of older European cities have demonstrated, increased residential density does not necessitate the construction of high-rise structures. Attempts to quantify the efficiency of land use in a metropolitan region are made through the usage of residential density. Consequently, if the residential density is decreasing, which is primarily due to a decrease in the size of households and an increase in the amount of living space per person (Couch et al., 2005), the necessary technical and social urban infrastructure, as well as other public service facilities, must be carried by a decreasing number of residents. In the main metropolitan regions of HCMC, the preservation and restoration of a high, but socially acceptable and qualified, population density is a critically essential environmental and economic aim. Both of these aims were also mentioned in the report on Ho Chi Minh City - Osaka City Cooperation Project for Developing Low Carbon City, as useful strategies to expand projects in the city (Global Environment Centre Foundation, 2014).

The average population density in HCMC is roughly 24,767 inhabitants per square kilometre (Figure 2.2-1), while the Old Inner areas have an average density of 31,996 inhabitants per square kilometre, the New Inner areas only reach a density of around 9,100 people per square kilometre (Ho Chi Minh City Statistical Yearbook, 2019). In comparison to the urban districts in HCMC, in Vienna, Austria, the population density in the urban area is 4,631 residents per square kilometre (Statistik Austria, 2021).

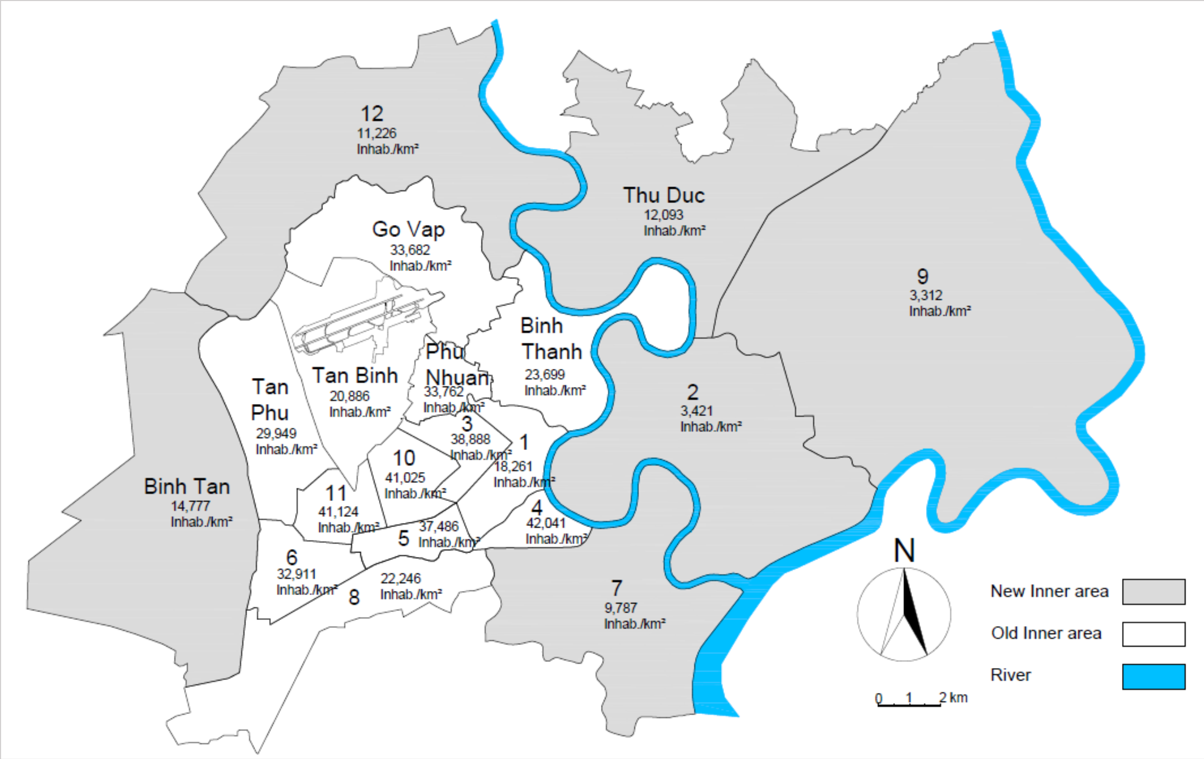

Figure 2.2-1: Population distribution per km² in HCMC, 2018. Source: Author's own based on map data ©2021 Google

2.2.3 Compact metropolitan structure

In agglomeration regions, varied land use with mixed uses may result in a less traffic-generating urban structure. A major objective of spatial planning should be to preserve dense structures with a variety of land uses in settlement areas. Each district of a city must have an acceptable mix of housing, jobs, and facilities to be classed as mixed-use. This might boost urban land use efficiency while also making public transit more accessible and easier to maintain, lowering pollution and enhancing energy efficiency. However, strict land-use separation is a crucial spatial element of urban sprawl, and it is important to understand why. Settlements in large areas are generally separated from shopping malls, business centres, and cultural activity centres (Ewing et al., 2002). As a result, measuring mix is a major indicator of urban compactness (Storch & Eckert, 2007).

An important structure in this highly dense area is the so-called shophouse neighbourhood. According to Storch et al. (2008) shophouses in HCMC can be defined as a flat-roof row house inside the urban environment on a plot around 3 - 4 m wide and 15 - 25 m deep that is normally entered from the narrow side and erected with firewalls on the remaining three sides. The possible addition and stringing together of this sort of structure allows for the building of extraordinarily dense metropolitan areas.

The inner city of HCMC is presently defined by high-density development (Figure 2.2-2). It is made by continuously compacting on both horizontal and vertical axes. The orthogonal land development grid divides the city into 30-60 m deep blocks, which are subsequently divided into double-row lots to maximise utilisation. Individual parcels of land, and hence the entire block, are overbuilt by up to 100 %. Buildings of two to five floors can achieve extremely high densities. In many situations, the only accessible open space is public roadways, which have been reduced to vital necessities for growth. However, it appears that the most important function of public space is to provide opportunities for social interaction (Storch et al., 2008).

In addition, the unusually high degree of density in Vietnam poses important challenges, particularly in light of the country's climate conditions. It is also characteristic of the city centres of other Southeast Asian development hubs that compact horizontal urban structures predominate over other types of urban structures. Martin (2001) argues that the tendency towards spatial concentration in HCMC may be explained by the presence of natural limits and topographical circumstances, as well as by the presence of violent conflicts throughout Vietnam during the 1960s and 1970s.

Figure 2.2-2: Compact urban structure of HCM City, Source: Thang, 2021

2.2.4 Significance of the activity centres

This indicator measures the degree to which agglomerations are structurally spatially concentrated in terms of population and employment. Metropolitan areas are densely populated areas with a lot of activity. Depending on the situation, either population or employment concentrations can provide this centeredness. Compactness in urban areas is a measure of efficiency that is related to centres of all kinds (business, shopping, leisure, culture). Urban sprawl, defined as the lack of any form of activity centre, is characterised as an inefficient land-use structure (Janssen-Jansen, 2005). There are two different types of spatial concentration that may be recognised. At the level of urban planning type, the strength of activity centres reflects how centrally located a neighbourhood is concerning a central activity district. The second type, the regional planning type, is describing how activities are concentrated in a more polycentric way.

The traditional mode of transportation inside HCMC was constrained to cycling and walking, which made medium and long-distance urban links both time-consuming and inefficient, especially for the poor. In HCMC, activity hubs (such as the airport, seaport, commercial centre, etc.) have traditionally been agglomerated, and the city's urban forms have been rather compact as well. Residents of HCMC can make more than two-thirds of all trips by (motor) cycling and walking, thanks to a dominant urban form created by the above-mentioned historical agglomeration of activity centres. Before 1980, almost 80 % of the population rode bicycles; in 2008, approximately the same percentage of the population travels by motorbike (Storch et al., 2008).

In addition, the implementation of market-oriented reforms and the country's expanding integration into the global economy have paved the way for the development of a contemporary consumer society in Vietnam. This development, on the other hand, is accompanied by a growing segmentation of the population and is evident in the shifting patterns of movement as well. Household and workplace are separated, family members and friends live on the other side of town, modern shopping centres on the outskirts of the city offer a more extensive and above all more diverse range of products than traditional markets, and a shift in leisure time habits eventually leads to an increase in traffic flows that are incessantly increasing (ibid.).

2.2.5 Urban Transport

Transportation technology and the accompanying transportation infrastructure expenditures have historically been among the most important factors of urban location and design when it comes to public service infrastructure expenses. Even while urban sprawl encourages people to relocate outside of established densely populated metropolitan regions, the costs of infrastructure (such as transportation and water supply) remain constant.

The expenses of infrastructure must be shared by a smaller number of inhabitants, or services to the remaining population must be reduced (Ewing et al., 2002). For settlements in agglomeration regions to grow efficiently, a minimum residential density per given dwelling area must be determined to ensure effective spatial development (urban districts, suburbs). The compactness of settlement forms that results from this allows for the provision of the following public infrastructures and services:

(1) a public transportation system that is adequately accessible and utilised, and

(2) enough local supply facilities (private and public services).

Existing land-use patterns in HCMC, as well as the spatial structures that derive from them, limit the number of transportation options available. Private automobiles cannot serve as the primary mode of transportation in urban areas with a high residential density such as HCMC, and low-density usage patterns in growing suburbs make it impossible to sustain a functional public transportation system in those areas with low density (Storch et al., 2008).

The restoration of the transportation network in HCMC is likely to be the most difficult undertaking the city will face on its path to becoming a global megacity. While city design in developed nations is mostly focused on minimising vehicle traffic, cities in developing countries are being completely rebuilt to deal with the explosive growth of individual motorised transportation (Rode, 2007).

It is estimated that less than 5 % of travel demand can be met by the public transportation system in HCMC (PC-HCMC, 2007). Because of the poor state of the transportation infrastructure, more than 90 % of commuters rely on private vehicles. Because of the dominance of motorcycles and the ineffectiveness of public transportation, private urban transportation activities have resulted in a rise in emissions.

Private motorised vehicle ownership in Vietnamese cities is on par with that of European cities, except for certain minor differences. Despite this, there remains a significant disparity in the makeup of the vehicle fleet between the two countries (Table 2.2-1). Unlike the European transportation system, which is dominated by private automobiles, the Vietnamese transportation system is dominated by motorcycles.

Table 2.2-1: Motorised vehicle ownership (per 1,000 residents). Source: Magistratsabteilung 66 – Statisches Amt, 2002; TDSI, 2004

City	Motorcycles	Cars	Total
Vienna	42	417	459
Hanoi	412	43	455

The majority of motorised two-wheelers on the streets in Vietnamese cities are powered by four-stroke engines (Schipper et al., 2005). The situation in terms of air pollution is better than that of many other Asian cities, which is a positive development. However, the fast economic development of Ho Chi Minh City (Table 2.2-2 and

Table 2.2-3) has resulted in substantial shifts in buying power and way of life for the population. Due to this continuous tendency, it is projected that uncontrolled traffic growth will result in congestion, saturation of urban areas, and increased air pollution. The People's Committee of Ho Chi Minh City, in collaboration with the Ministry of Transport, has begun the construction of a Transportation Master Plan (JICA et al., 2004) to mitigate the negative consequences of rising living standards and welfare. As described by the JICA Study Team (2015), car ownership mainly depends on the income class (

Table 2.2-3). Once the income reaches the threshold of VND 25 – 30 million/month, which approximately equals 1,971 – 1,170 €/month, the rate of car ownership starts to increase sharply.

Table 2.2-2: Number of vehicles in HCMC in the 2011-2017 period. Source: Vietnam Registration Authority, HCMC Police, 2018

Year	Car	Bus	Truck	Specialised vehicles	Others	Total	Total number of motorcycles
2011	148,158	24,530	102,861	4,020	14,119	293,688	5,029,342
2012	157,233	25,091	106,366	4,062	14,972	307,724	5,465,356
2013	161,303	25,255	109,518	4,027	16,083	316,186	5,899,193
2014	183,327	26,027	119,762	4,055	19,194	352,365	6,352,926
2015	198,951	25,638	129,929	4,444	23,562	382,524	6,889,351
2016	245,121	29,591	149,787	5,077	25,622	455,198	7,287,066
2017	285,612	32,242	165,382	5,500	28,220	516,956	7,440,000

Table 2.2-3: Vehicle Ownership by Income Class. Source: JICA Study Team, 2015

Income Class		Vehicle Ownership [%]			
		Car	Motorcycle(s)		
(VND million / month)	(€ / month)		1	2	3 ≤
< 4.0	< 150.0	0.4	46.7	34.6	8.5
4.1 - 6.0	151.0 - 230.0	0.3	40.3	45.8	10.5
6.1 - 8.0	231.0 - 310.0	0.8	30.0	55.3	12.6
8.1 - 10.0	311.0 - 390.0	1.1	21.2	58.1	19.8
10.1 - 15.0	391.0 - 580.0	1.4	12.3	55.0	31.9
15.1 - 20.0	581.0 - 780.0	2.3	7.1	41.8	50.4
20.1 - 25.0	781.0 - 970.0	3.9	5.9	34.5	59.0
25.1 - 30.0	971.0 - 1170.0	7.0	5.8	23.2	70.3
30.1 - 50.0	1171.0 - 1950.0	20.3	5.3	27.3	67.0
> 50	> 1950.0	36.4	6.7	32.6	58.7

Urbanisation and population growth are key development imperatives in Vietnam during the coming decades. To comprehend the ramifications of this increase in urban planning, one must first comprehend the current urban transformation process and its obstacles. The urban shift from traditional to contemporary civilisations in rising megacities like HCMC has to be better understood. Urban regions in Vietnam show the importance of urban design in explaining dominating transportation modes. The significance of motorcycles in urban transportation as well as their human and environmental implications is very high, this is due to the fact that they are a major mode of mobility in Vietnamese cities like HCMC and Hanoi. Motorcycles are the cheapest means of private motorised transport in many cities. However, they are a major source of air and noise pollution in these places. However, in terms of energy efficiency, they are the finest private motorised transportation option (Storch et al., 2008).

The study conducted by Storch et al. (2008), regarding the compactness of urban areas in Vietnam, as well as sustainable urban development, clearly shows the benefits of concentrated, mixed-use communities with jobs concentrated in the CBD (central business district). An approach for sustainable urban development in Vietnam appears to be the preservation and improvement of urban compactness.

2.3 HCMC's Sidewalk life [AS]

Sidewalks are the most vital and underappreciated public area in many places around the globe. They also have the potential to be a great democratising environment because of the way this network of pavement extends its tentacles to reach people in many sections of the city, drawing them into intimate arrangements. Another important function of sidewalks is that they are economically significant as a mode of mobility and a social safety net. In HCMC sidewalks are a highly democratic space. It is common to see people from diverse social strata coexisting, hanging out with one another, and assisting one another (Kim, 2015).

Taking into consideration that people continue to relocate to urban areas at record rates, sidewalks are also becoming increasingly vital, particularly for low-income and disenfranchised urban inhabitants who are attempting to make a livelihood in this area of the country. A series of sidewalk clearing regulations, conducted by Doan Ngoc Hai, was adopted by the Vietnamese government in the early 2000s; however, it was not until the mid-2000s that these policies were truly enforced in earnest. In the year 2015, sidewalks and public places were routinely patrolled by police officers and traffic inspectors (Kim, 2015). The new paradigm appears to be that pedestrians on the sidewalk must keep moving to avoid being hit by motorised vehicles. As this is a problem that frequently occurs in HCMC, the authors of this master thesis decided to include this topic in the survey that will be further described in chapter 4.3.2. The safety indicator played a very decisive role in the survey because it is important to understand, why people, even if it's only for a couple of meters, prefer to use a motorised vehicle instead of walking.

The most vulnerable persons are street sellers, and due to the sidewalk clearing policies, like the ones imposed by Doan Ngoc Hai (CVD, 2017), thousands of vendors across the city continue to move around with their products on their shoulders, on bicycles, or wheeled carts, rather than remaining in one place. The argument expressed in the policy papers is well-known: it is needed to clear street vendors off the sidewalks for traffic congestion and public health, as well as to be a contemporary, world-class city, to be able to accommodate everyone (Kim, 2015). In comparison to the clearing policies led by Doan Ngoc Hai, Leung & Le (2019), found out that by allowing the presence of street vendors and street sellers in neighbourhoods or near schools, can positively affect active travel.

Moreover, taking a closer look at the factors that can influence the sidewalk life in Ho Chi Minh City, it is useful to divide and categorise the current situation into 3 different chapters, in order to have a better understanding of the legislation, politics, social aspects that surround the city. Dealing with the above-mentioned aspects might help the people involved in planning sidewalks, like traffic/spatial planners, land developers etc., to have a better understanding of what can be done and what factors must be taken into consideration when improving the walking situation in the city.

Based on the peer-reviewed study conducted by Kim (2015), three theories were developed:

1. Spatial Ethnography – Importance of both physical and social space
2. Property Rights Theory on the Sidewalk – The right to own property in a public space is a political and social compact based on the use of government authority
3. Critical Cartography: Mapping Overlooked Spaces and People – The importance of visual research methods (*Maps* – A visual story of the world and the way thing's function)

2.3.1 Spatial Ethnography: Physical and social space of city's sidewalks

The main focus of the following three sections, regarding spatial ethnography and property rights of public space, as well as the focus of this particular section about critical cartography, is to underline both the social and physical dimensions of the sidewalk practices, how they are socially negotiated, and the city they construct. To grasp on the concept of spatial ethnography, the author of the book *„Sidewalk City: Remapping Public Space in Ho Chi Minh City"* (University of Chicago Press, 2015), mentions that both physical space and social space, need to be taken into account. Kim (2015) started by creating a spatial ethnography approach that combines social science research with physical spatial analysis to reveal how sidewalks are utilised, as well as the social processes and meanings associated with that use. This is important because the city's spatial practices and claims have changed as a result of fast population shifts and accompanying political economics.

The spatial ethnography is being built on the daily urbanism sensibility of looking with a new eye at places and people in the city that are frequently overlooked. The phrase is most closely associated with Margaret Crawford's work in the USA, which highlights "unlovely" aspects of city life such as yard sales and sidewalk selling or vending (Chase et al., 2008). She sees these spatial practices as both subversive and innovative, as they frequently incorporate a large section of the American underclass. Her work is part of a greater shift in the humanities and social sciences toward the everyday.

Some political scientists, for example, have concentrated their research on the power of everyday politics and the role of peasants in influencing policy in Vietnam and China (Kerkvliet, 2009). However, everyday people are not necessarily a coherent, organised group; in metropolitan contexts, a range of people with various techniques and understandings are involved (Harms, 2011). Similarly, some Asian historians have devoted themselves to chronicling the lives of the impoverished and local families (Cherry, 2011). For instance, it is true that countries under imperialism and colonialism require a great deal of scholarly attention to be paid to government and political leaders.

Kim (2015) further found out that spatial ethnography reflects the spatial shift in critical history in its method of investigation. This approach opposes harsher views of postmodern urbanisation that are preoccupied with the privatisation of public space, violence, and oppression, among other things (Zukin, 1991). While the critical theory may be critical of common urbanism's relative optimism, it may also be critical of its emphasis on what might potentially be understood as coping strategies by people who have been disenfranchised by global capital circuits.

Instead of dismissing geography as a component of uneven power relations, the emphasis on the local calls for feeding the global scale vision with microscale facts on real living practices (Turner & Schoenberger, 2012). The usage of a city's public spaces has only been examined informally by a few (Kayden, 2000), but when one takes the time to watch on the ground, one may discover some startling and revelatory ideas for spatial practices of resistance (Hou, 2010).

Moreover, daily urbanism is couched in the design discourse, which has been deficient in its conceptualisations of society: who is in it, how it is structured, and what human desires and behaviour are exposed in this context. Lang (1994) harshly criticises post-war urban planning practices as a kind of individualistic, creative self-expression characterised by a lack of profound knowledge about human life and a lack of understanding of the built environment.

Specifically, there are political ramifications to narrowing one's attention on constructed form, especially when design practice tends to remain in the realm of the wealthy, neglecting the diverse range of individuals that use urban space. Therefore, the fundamental theme of everyday urbanism is to take another look, putting aside some of the typical ideological and professional presuppositions, and employing ethnographic research into how people use city areas to inspire design solutions (Kim, 2015).

For example, intelligent design solutions necessitate a more in-depth grasp of the design challenge. Because modern urbanisation is a result of migration into cities, urban designers should consider the needs of a diverse public when planning public space. Furthermore, the public may include individuals who are not highly organised or well represented, who may not be citizens of a democratic country, but who are still occupying space. Consequently, the duty for ethnography rests with urban design, as a result of this (Kim, 2015). In addition, according to Kim (2015), ethnography is the most important social science research approach that has the highest chance of removing conceptual blinders from the data. It is necessary to spend substantial time at the study site, watching and engaging in it on its terms, while using ethnographic methodologies.

The few Western researchers who have studied Vietnamese public spaces have observed, that the traditional distinctions between private and public spaces expected in the West do not hold in the Vietnamese context. When the state controls all the lands and when government regulations extend into family planning techniques and the distribution of work inside the household, the home is no longer the ultimate private domain. In the same way, what is generally thought of as public places in the West, such as streets and sidewalks, are frequently the location of private home activities in developing countries (Drummond, 2000).

Furthermore, people are generally the centre of ethnographies of public space and sidewalk life, which is understandable. To give an example, Duneier's ethnography of New York sidewalk vendors begin by introducing the reader to a single vendor named Hakim before expanding our understanding of how his struggle to make a living on the sidewalk is tied to people in city hall, the discomfort of passers-by, and larger social structures and mundane practices (Duneier, 1999). Traditional ethnography in the fields of anthropology and sociology, on the other hand, does not generally examine physical space.

Taking the case of sidewalks in Ho Chi Minh City, it was found that in addition to pedestrian counts broken down by age and gender, spatial ethnography revealed several additional use categories, including a variety of street vending types, leisure activities, motorcycle parking, store spillover and unoccupied space. Given the significant public discussion about what constitutes proper and inappropriate use of the sidewalk, how much space these activities were taking up, and what types of externalities they were causing, these categories were relevant. Due to the numerous claims and conflicts for modern urban space, spatial ethnography will invariably demand the inclusion of a political lens in its analysis (Kim, 2015).

Consequently, in addition to mapping or critical theory, spatial ethnography entails establishing knowledge of local spatial social connections through participant observation and in-person interviews while on the ground. Talking to people, engaging in the use of space, and not making assumptions about a local system but rather being open to learning about it are the fundamental distinctions between the trajectory of public space research techniques established by Lynch (1960) and the trajectory proposed by the author (Kim, 2015).

Lastly, incorporating social science research into the physical design is not a new problem to be solved. Since the 1970s, at the very least, the discipline of urban planning in the Western world has attempted to combine the two. True interaction between these two disciplinary orientations, on the other hand, has remained difficult. As a result, each has concentrated on some elements of public space while ignoring others, and the lack of integration has prevented the identification of possible synergies that may lead to improved understanding and planning (Kim, 2015).

2.3.2 Property Rights Theory on the Sidewalk: Use and interpretation of public space

Today's HCMC began as two separate but symbiotic towns (In the year 1931, the two towns, Saigon and Cholon, were merged): Saigon, built as a mini-Paris with monumental buildings connected by boulevards and traffic circles, and Cholon, built as a Chinatown with narrow streets that curved toward the river by the French colonialists and Chinese immigrants, respectively. The fact that their respective countries' economic and political institutions were built differently, as well as the fact that cultural norms concerning public space were derived from distinct histories and traditions, meant that they looked and worked differently (Kim, 2015). It is also important to notice, that HCMC exemplifies how the same physical place (sidewalk) may be used and interpreted in a variety of ways, by looking at its changes that occurred during the postcolonial national’s period, the post-war communist period, as well as the market reform period.

Moving on next to the theories of property, they are extremely significant because they help explain how claims to space are justified and operationalised in contemporary society, which is critical. "Property rights" has become a politically charged phrase in the context of the HCMC case, according to Kim 2015. Not only that but the term is also being used in a much larger meaning than the establishment of private property rights in a market economy, as described by Kim (2015). It also covers the numerous different social systems for arranging space that may be used in this context. With this in mind, to comprehend sidewalk space in Vietnam and not only, it must first be identified not just the various members of society and neglected areas in the city, but also the roles and laws that govern those spaces. To identify these norms, people must consider the importance of the written legal laws and codes, and also the importance of the spatial practices in action. This comes as a result of the frequent divergence between law and practice. Furthermore, one of the most important ideas provided by property rights theory is that property rights are not so much about one's ownership of a thing as they are about one's connection with all other members of society. Thus, a person’s right only exists to the extent that other individuals agree to restrict themselves and respect the right in question (Rose, 1994).

In determining a specific property regime, the two most significant variables are:
(1) the structure of economic lives that property rights enable, and
(2) the methods by which government institutions enforce property rights and legitimise their power.

Essentially, the inference is that the right to own property in public space, as well as any other area, is a political and social compact based on the use of government authority to promote specific types of economic interests. In particular, the application of property rights theory to the current conflicts over public space, as well as the study conducted by Kim (2015) of HCMC's sidewalks, reveals that one of the underlying key issues in the debates is the legitimacy of competing livelihood practices. Lower-income individuals require space to recreate and interact throughout the present historic process of urbanisation, which is seeing millions of people relocate to the city in search of employment and opportunity. As a result, many people flock to the city's wide and free places. Aside from that, given the expensive and rising rents in cities, those who are without a place to call home are turning to public places such as streets and sidewalks to make ends meet. The density of people and the numerous claims on public space create tensions and difficulties (Brown, 2006). As seen by the social issues and policy discussions taking place in cities throughout the world, people are in the midst of a time of active rewriting of the public space norms. In cases like HCMC, with increasing densification of contemporary urbanisation, individuals are being forced to reassess the function of the sidewalk, as well as the possibilities of different occupations and lifestyles that it may support. Sidewalk vending is considered a lawful activity in Ho Chi Minh City, according to some, because it offers a major source of income for around 30 % of the population and provides low-cost meals, home products, and services. Others believe that this use of sidewalk space gives major nonmonetary benefits because it is a cultural tradition that has been around for a very long time. Others, on the other hand, think that sidewalk vending has negative externalities, such as traffic congestion and food safety risks, and that

Vietnam has to develop out of it. The question of whether sidewalk behaviour has a net cost to society or benefit is not so much an economic debate as it is a dispute in morals and social attitudes.

A more basic question in resolving these public space conflicts is establishing the spectrum of beneficial uses that society considers to be acceptable. If beginning to consider the potential of numerous legal uses on a sidewalk, the question of property rights becomes one of spatial coordination: What is the best way to coordinate several users on a certain sidewalk?

First, it becomes obvious that the layout of urban space is inextricably linked to the economic and social costs and benefits that are at the heart of the debates. The geographical features of real estate inevitably led to the consideration of at least two basic problems. First and foremost, how could the physical form of property influence the types of rights that arise? According to contemporary research, the features of immovable real property have developed a theory of property rights founded on the concept of exclusion, which does not function as well with water, trees, or intellectual property as it does with other types of property (Smith, 2008). Second, what type of society does the institution of property rights create for its members? Concerning the issue of sidewalks, this is a very essential and crucial question to consider. It will not be possible to address the physical environment that people are creating and its liveability if they restrict their attention to solely social connections between rights holders and the rest of society. In addition to producing an ideal property rights institution, an optimal physical reality needs to be produced.

Additionality to Kim’s (2015) study, the study, conducted by Aliaga-Linares (2010), discovered that sidewalk selling practices in Vietnam differ significantly from those in North and Latin America in several crucial aspects. First and foremost, because the players participating in Vietnam are largely fellow citizens, there is no express or tacit discrimination against them based on foreign immigration, whether documented or undocumented. Following that, vending in Vietnamese cities appears to be becoming more prevalent, with vendors appearing on almost every sidewalk in the city, further undermining ideas of otherness. There is a remarkable amount of social empathy for sidewalk sellers, which is the third and most noticeable characteristic. However, Kim (2015) highlights that street vendors in Vietnam have described situations in which local police assisted them in circumventing the law so that they may continue to sell their wares. The legitimacy of vending on the sidewalk resulted in the creation of a sidewalk space system that challenges and shapes the city's rules and ordinances regularly. In this regard, the HCMC's might be regarded as part of a broader global conversation in which public space assumptions are being re-examined. Some communities are attempting very daring initiatives that would have been deemed chaotic five or six decades ago but are now regarded as normal. Finally, how the use of sidewalk space is negotiated between users, property owners, inspectors, and local governments in different areas, is an extremely significant component of the HCMC sidewalks. Other than tracking public space usage, property rights theory provides guidelines for investigating legitimacy claims as well as enforcement institutions. As cities deal with how to arrange their cities as they develop with immigrants and new spatial behaviours, property theory may be used to assess the advantages and disadvantages of various systems of sharing sidewalk space (Zhou et al., 2008). It also directs the consideration of how local sidewalk regimes correspond to the structure of economic lives and the costs of government for different segments of the population.

2.3.3 Critical Cartography: Mapping overlooked spaces, street activity and people

As was mentioned earlier, the main focus of the previous sections, regarding spatial ethnography and property rights of public space, as well as the focus of this particular section about critical cartography, was to underline both the social and physical dimensions of their sidewalk practices, how they are socially negotiated, and the city they construct. This section is going deeper into the study conducted by Kim (2015), which emphasises the importance of visual research methods. Integrating spatial and social data is made possible via the use of these visual research methodologies, which is particularly important given the fact that spatial analysis is a gap in the property rights literature.

Using maps to depict urban planning research is the ideal visual representation in this situation because, in addition to generating research, urban planning is also a profession that intervenes in society and communicates with the public through the language of maps. It disseminates suggestions and proposals on how to enhance and make public investments for the benefit of the general population. Maps were also considered to be useful and revealing for this master thesis, but unfortunately, Vietnam does not provide access to open government data, that can be processed and then further analysed. In comparison with other countries, like for example Austria, where these visual representations can be accessed via a simple internet search, in Vietnam the simple access to this kind of data is very limited due to the political regime. A researcher like Kim Annette M. who spent a lot of time in Vietnam managed to get access to this kind of data, and after that, she could better analyse the sidewalk conditions and was able to draw some important conclusions that can be read in the following paragraphs.

Kim's (2015) study underlines that because sidewalk sellers and proper public space usage have become a topic of public debate in Vietnam, the maps used to identify the location of the street vendors, can't be free of a political message. The Vietnamese national government has been on a path of introducing policies to clear and further regulate the sidewalk and beginning around 2007, to enforce clearance, particularly in front of the high-end office buildings within the historic downtown that are more and more replacing the colonial, lower-density architecture (Decision 3305, 2009). In certain cases, conflicts with sellers have become violent (Quynh 2013). Among the official justifications given for clearing regulations and enforcement are discussions of modernism, reliable and safe transportation, better public health, and food safety, as well as encouraging foreign tourists to the region.

Recent studies of Vietnam's informal economy, on the other hand, have found that street selling is a major source of food and employment in the country and that it will only grow in importance as the country's population continues to migrate (Lincoln, 2008). Meanwhile, opinion pieces in publications and interviews with key informants revealed views on the cultural significance and convenience of sidewalk selling, as well as the vibrancy of the city's street life. In other words, various competing narratives about what is proper and attractive on the sidewalk are being circulated, and there is some opposition to the state's efforts to clear the sidewalk. As a result of the unequal power of street vendors in comparison to formal property owners and city planners, it may appear impossible to discuss changing the property regime governing sidewalks in a way that could include migrants and sidewalk vendors, particularly in a non-participatory, one-party communist government system. Such moves, on the other hand, are not unusual. According to a recent study, pushback by lower-income and rural communities in Vietnam and China to land acquisition for private real estate development has sometimes resulted in higher compensation packages when their property is seized for private real estate development (Po, 2011).

Furthermore, when considering the institutional structure and connection between Ho Chi Minh City and the central government, it appears that altering social discourse in the media and ordinary public dialogue is one of the more realistic paths for institutional reform. Vietnam is now engaged in a time of serious rethinking and reconstruction of its sidewalk concepts. Storylines compete for attention by presenting different perspectives on the sidewalk: what the space should be used for and who should be permitted to use it. Also important is, that while individuals may be completely immersed in their surroundings, maps can help them become more mindful of their surroundings and comprehend what they are seeing. Maps may also draw attention to a few components in the world, among the millions of objects that can be seen, by drawing their lines over them. They offer information about the element's characteristics as well as a visual representation of how those elements are physically linked to one another. A visual story of the world and the way thing's function is provided by maps in this manner. Maps, in addition to presenting a story, may also provide instructions on how to explore the world (Kim, 2015).

Moreover, the mapping of sidewalk life transforms it into a studyable socio-spatial phenomenon, which is something that ought to be taken seriously. While there are public discussions over whether sidewalk life should be eliminated, research and information production through maps provide more data to the conversation. For example, it was discovered that motorbike parking occupies a greater proportion of sidewalk area in central HCMC than do street sellers. Not to mention, that without the ability to represent and validate current sidewalk spatial activities through mapping, it appears that it will be much simpler to spread the message that they are not valuable, virtually denying their existence. It is far too easy to dismiss the activities of people on the sidewalks as a barrier to more essential undertakings such as the modernisation and globalisation of the city (Kim, 2015).

In conclusion, the previous sections on spatial ethnography and property rights of public space as well as this section on critical cartography are aimed at highlighting the social and physical components of their sidewalk behaviours and how they are socially contested. The author of the book "Sidewalk City: Remapping Public Space in Ho Chi Minh City" (University of Chicago Press, 2015) notes that both physical and social space, which were in detail described in this chapter, must be taken into consideration to understand spatial ethnography. By combining social science research with physical spatial analysis, Kim (2015) was able to uncover the social processes and meanings that are related to the use of sidewalks. In essence, it is the structure of economic life, that property rights permit and the ways by which government institutions enforce property rights and justify their authority, that is most important in defining a certain property regime. Also, property rights theory has been used in contemporary public space disputes. Like mentioned above, Kim's (2015) analysis of HCMC's sidewalks has revealed that the validity of competing livelihood activities lies at the heart of these disagreements. An exclusionary theory of property rights has been created by modern researchers, however, it does not work as well with intellectual property, water, or trees as it does with other forms of property (Smith, 2008). Additionally, according to Kim's (2015) research, the maps used to indicate street vendor locations in Vietnam can't be devoid of a political message since sidewalk merchants and proper public space use have become an issue of public discussion in Vietnam. Even under a non-participatory one-party communist government system, it may look hard to debate revising the property regime regulating sidewalks in a way that would allow for the inclusion of migrant and sidewalk sellers in the discussion. Despite the fact that sidewalk life is a matter of public discussion, researching and creating information through maps might bring further facts to the argument.

2.4 Noise pollution [AS]

As a result of its severe influence on the overall quality of life in communities across the world, noise pollution caused by vehicle traffic is a major global problem. When it comes to traffic noise in Vietnam, it has become an increasingly obvious and critical problem in major areas such as Ho Chi Minh City, particularly. Moreover, noise pollution affects pedestrians (Davies & Van Kamp, 2008) as well as the ones that are directly participating in the daily traffic (Finegold et al. 1994). Because of the considerable amount of noise pollution, people tend to prefer another mode of transport, such as motorcycles and other motorised alternatives. Having these alternatives and being constantly submitted to high noise pollution, makes active mobility very unattractive. For example, noise pollution in metropolitan areas has long been acknowledged as significant harm to people's quality of life on a worldwide scale. The negative consequences of noise include a variety of negative effects on people's physical well-being as well as the disruption of their everyday activities (Davies & Van Kamp, 2008). Community members in affluent nations have responded quickly to the need to control such consequences, as indicated by the enormous number of rules and noise ordinances in place today (Miedema HME, 2007).

Apart from buses, which are the only mode of public transit in these large cities, the motorcycle is the most popular mode of transportation due to its low cost, flexibility, and ability to adapt to changing road conditions. According to the Department of Traffic Safety at the Ministry of Transport (Dtinews, 2019), Vietnam, had in the year 2018, 58 million motorcycles, making it one of the countries with the greatest per capita motorcycle ownership in the world. Furthermore, motorcycles account for about 96 % of all local transportation in Vietnam, according to the World Bank. As much as 85 % of the population's transportation demands are met by motorbikes in Ho Chi Minh City, creating chaotic traffic flow and excessive horn blaring throughout the day. Figure 2.4-1 illustrates the situation of the traffic problem in Vietnam.

Figure 2.4-1: Traffic jam at an intersection in HCMC. Source: Saigoneer, 2016

To have a better grasp on the noise levels in HCMC, intensive noise measurements were executed in September 2007 as part of research carried out by Phan et al. (2010). Obtaining a complete dataset of noise was accomplished, which comprised 24-hour noise measurements in addition to short-term noise recordings. It was also possible to quantify the volume of traffic by replaying video camera records Phan et al. (2010) discovered that the traffic noise in Ho Chi Minh City was characterised by comparatively high levels of noise exposure due to the huge number of motorcycles and frequent horn sounds. The sound of horns had a significant influence on noise exposure in Ho Chi Minh City, with a measurable impact of 4 dB to almost close to 0, when horn sounds were absent.

The measurement sites in Ho Chi Minh City are displayed in Figure 2.4-2. The noise levels were measured at 8 distinctive locations. Each location was chosen because of the different characteristics of the area. For example, location 7 is one of the highly populated areas, in comparison to location 6 which has a narrow street, but the traffic volume is extraordinarily high. The measurement was conducted for a period of 24-hours, at a reference location 1.2 m above ground and 1–12 m distant from the road shoulder using sound level meters, which they found to be effective. Every second for a total of 24 hours, A-weighted sound pressure levels were measured. A total of eight sites in Ho Chi Minh City were subjected to further noise measurements at 10-minute intervals, as well as noise recordings, to acquire data for frequency analysis (Phan et al., 2010).

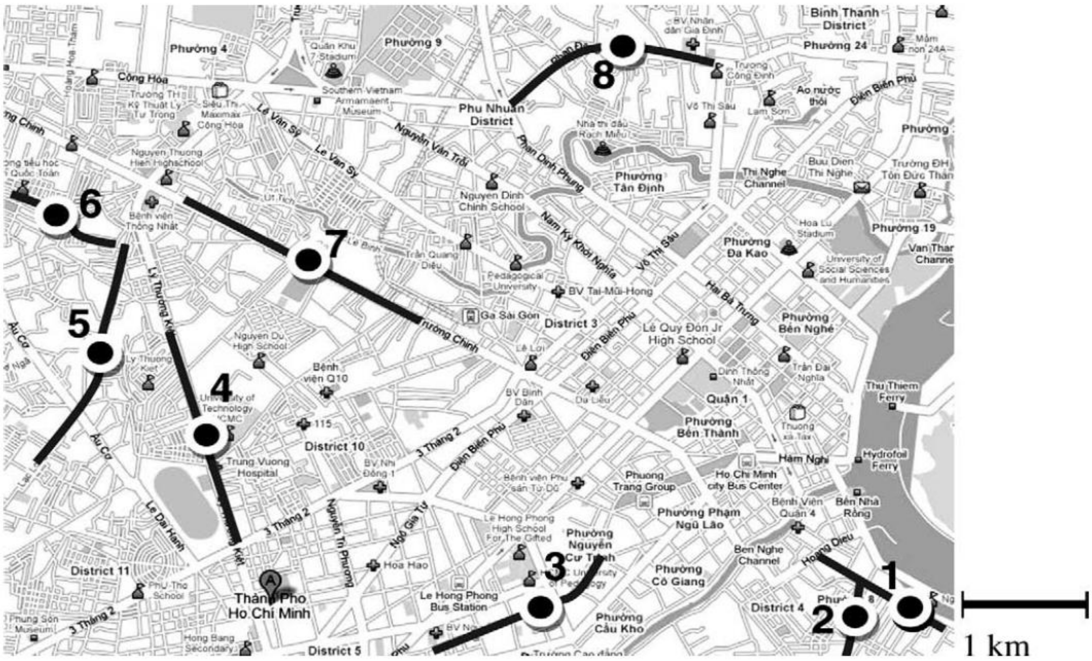

Figure 2.4-2: Map of noise measuring sites in Ho Chi Minh City. Source: Phan et al., 2010, p.481

During the 24-hour noise measuring period, a video camera was used to track the volume of traffic by vehicle type. The sampling intervals were 10 minutes in length for each hour of the day. The quantification of traffic was carried out afterwards when the videotape had been reproduced. Traffic flows were grouped into three vehicle categories: $\boldsymbol{Q_M}$ = motorcycles, $\boldsymbol{Q_C}$ = cars/light trucks, and $\boldsymbol{Q_H}$ = heavy vehicles. Aside from that, noise measurements were also carried out in Kumamoto, Japan, to obtain a noise dataset from a city in a developed Asian country (Phan et al., 2010). In Ho Chi Minh City, the daily average number of vehicles from all sites is projected to be over 140,000 (Table 2.4-1), with motorbikes accounting for approximately 94 % of total traffic on a daily average basis. In comparison with HCMC, the daily average number of vehicles in Kumamoto was only 37,050 (Table 2.4-2). However, it is important to say that the measurements were conducted in the year 2007, where the number of motorised vehicles was significantly smaller, compared to 10 years later (See Table 2.2-2).

Table 2.4-1: Traffic volume in Ho Chi Minh City. Source: Phan et al., 2010

Measuring points	**No. of lanes**	$\boldsymbol{Q_M}$[-]	$\boldsymbol{Q_C}$[-]	$\boldsymbol{Q_H}$[-]	% of $\boldsymbol{Q_M}$	% of $\boldsymbol{Q_C}$	% of $\boldsymbol{Q_H}$	$\boldsymbol{Q_M+Q_C+Q_H}$ [-]
Site 1	1	33,444	198	12	99	1	0	33,654
Site 2	1	67,359	590	407	99	1	1	68,356
Site 3	2	156,060	7584	936	95	5	1	164,580
Site 4	4	156,096	6816	2580	94	4	2	165,492
Site 5	4	131,196	5472	3468	94	4	2	140,136
Site 6	1	73,584	2208	792	96	3	1	76,584
Site 7	2	239,031	13,773	4974	93	5	2	257,778
Site 8	4	201,924	11,064	5496	92	5	3	218,484
Average		132,337	5963	2333	94	4	2	140,633

Table 2.4-2: Traffic volume in Kumamoto, Japan. Source: Phan et al., 2010

Measuring points	No. of lanes	Q_M[-]	Q_C[-]	Q_H[-]	% of Q_M	% of Q_C	% of Q_H	Q_M+Q_C +Q_H [-]
Site 1	2	3030	19,236	1020	13	83	4	23,286
Site 2	4	3486	44,628	2700	7	88	5	50,814

Furthermore, the noise levels in Ho Chi Minh City fluctuate by around 10 decibels, with frequent sharp peaks due to audible horn sounds, indicating that the traffic noise in this city has an impulsive, percussive nature. The average noise levels for all the sites tested in HCMC, as well as in Kumamoto, are provided in Table 2.4-3. The daily average noise levels $L_{Aeq.day}$ was greater than 72 dB in the total sample of monitoring sites in Ho Chi Minh City (Phan et al., 2010).

Table 2.4-3: Noise levels in Ho Chi Minh City and Kumamoto. Source: Phan et al., 2010

Noise metrics (dB)	$L_{Aeq.day}$	$L_{Aeq.night}$	$L_{Aeq.24h}$
HCMC			
Site 1	69	69	72
Site 2	72	72	76
Site 3	74	74	77
Site 4	68	68	71
Site 5	71	71	74
Site 6	71	71	76
Site 7	73	73	75
Site 8	76	76	77
Kumamoto			
Site 1	70	66	68
Site 2	70	67	69

Effect of horn sound on noise exposure

According to the facts presented above, it is noteworthy that traffic noise in Ho Chi Minh City has an impulsive, percussive nature, which is primarily owing to the frequency with which horns are sounded. In HCMC, horn sounds accounted for up to 12 % of the entire measurement time at its highest (see Table 2.4-4). Horn sounds were eliminated from the acquired $L_{Aeq.10\ min}$ to investigate the possibility of a negative influence of horn sound exposure on noise exposure. Table 2.4-4 shows the findings of the study done by Phan et al. (2010), which reveal that traffic noise in Ho Chi Minh City has decreased by an average of 0.7 decibels.

Table 2.4-4: Results of noise levels with and without horn sounds for Ho Chi Minh City. Source: Phan et al., 2010.

Noise metrics (dB) HCMC	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
$L_{Aeq.10\ min}$	73	74	67	66	67	71	69	68
$L_{Aeq.}$ without horn sound	73	74	66	65	67	70	67	67
$L_{Aeq.}$ difference	0	0	1	1	0	1	2	1
$L_{Aeq.}$ horn sound	78	81	75	72	74	75	75	74
% of time occupied by horn sound	4	2	5	4	4	9	12	5

Although horn sounds contribute a very tiny percentage to overall noise exposure, their psychological impact may be larger due to the shocking impacts that such noise has on the listener, like pedestrians.

In conclusion, Phan et al. (2010) conducted an acoustic survey that demonstrated that ambient noise levels caused by traffic are significantly greater in developing countries compared to cities in affluent countries like Japan, for example. Furthermore, although automobiles are the most popular mode of transportation in industrialised nations, motorcycles are by far the most prevalent mode of transportation in Vietnam. In general, excessive levels of noise are caused by frequent horn sounds, which are particularly prevalent in HCMC.

2.5 Air pollution [AS]

In recent years, air pollution has been a major source of concern in Vietnam. Over the past five decades, ambient air pollution, which is mostly generated by the burning of non-renewable fossil fuels for energy production, transportation, and industry, has gotten worse (Rowshand et al., 2009). There have been several studies that have found that air pollutants such as particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and ozone (O_3) are responsible for increasing deaths in various populations around the world, particularly in those suffering from respiratory and cardiovascular diseases (CVD) (Beckerman et al., 2012). In the case of PM_{10}, this refers to any particulate matter in the air having a diameter of 10 µm or less. This includes smoke, dust, soot, salts, acids, and metals, to name a few examples. When gases produced by motor vehicles and industry experience chemical interactions in the atmosphere, particulate matter can be created indirectly.

According to a global study of the burden of diseases conducted in the year 2000, nearly two-thirds of the estimated 800,000 deaths and 4.6 million lost years of healthy life worldwide caused by exposure to air pollution in that year occurred in developing countries in Asia (World Health Organization, 2002) as well as the fact that this phenomenon has persisted until fairly recently (World Health Organization, 2014).

Despite this, research on the relationship between air pollutants and health effects has been conducted primarily in developed countries rather than in developing countries of Asia, where the lower-income population is subjected to high levels of air pollution and has less capacity to cope with air pollution-related issues than the richer population. In order to assess the health consequences of air pollution in developing Asian countries, researchers must rely heavily on extrapolation from studies conducted in developed countries, which is highly unpredictable. As a result, the assessment of the health consequences of air pollution in developing Asian countries is fraught with uncertainty (HEI International Scientific Oversight Committee, 2010).

Air pollution is a major problem in Ho Chi Minh City, which is the largest and most populous city in Vietnam. Growing industrial activity and motorised vehicles (Table 2.2-2) have contributed to an increase in all aspects of environmental pollution, with air pollution being the most serious problem. This has a significant impact on the quality of life of its residents (Nguyen et al., 2002). The high number of motorised vehicles on the road in HCMC's metropolitan regions is the most significant cause of air pollution. A prior analysis revealed that motorised vehicles were responsible for a significant amount of overall air pollutants (CO, 90 %; Hydrocarbons, 60 %; and NOx, 50 %) in HCMC, which was previously unknown (DS, 2001). HCMC's suspended particulate matter levels are consistently 2–6 times higher than the maximum permitted limits, according to data collected from monitoring stations on-road locations around the city (CEFINEA, 2001).

As mentioned before, the vast majority of inhabitants in HCMC commute by motorcycle, which indicates that they are exposed to air pollution as a consequence of traffic congestion and road construction. Thus, it is critical to evaluate the impact of such exposure on the health of the general population in this big metropolitan area, as opposed to the health of children.

To further analyse the impact of air pollution in HCMC, Phung et. al (2016) collected data from the air quality monitoring system at the centre for environmental monitoring and analysis of the HCMC Environmental Protection Agency (HEPA). The data were obtained from the archive for the period from 1st February 2004 to 31st December 2007. Because of the significant number of missing values, data from other periods were not included in this analysis.

From 1 February 2004 to 31 December 2007, data on hospitalisations due to respiratory diseases and cardiovascular diseases were extracted from daily hospital admissions at the two largest hospitals in Ho Chi Minh City, Gia Dinh Hospital and 115 People`s Hospital (Table 2.5-1). There was a total of 43,595 admissions for cardiovascular and respiratory disorders (with a daily mean of 31) and 33,045 admissions (with a daily mean of 23) for cardiovascular and respiratory diseases during the research. There were discrepancies in cause-specific admissions between the male and female groups, even though male and female groups had equal values for the daily mean of hospital admissions for the two reasons. More respiratory admissions occurred in the age range of 5–65 years olds than in the senior age group (65 and older years), according to the study. However, the number of cardiovascular admissions was greater in the senior group than in the younger group at the same period (Phung et al., 2016). Additionally, daily PM_{10} levels ranged from 11.6 to 209.9 µg/m³ with a mean of 74.0 µg/m³, which is lower than the standard (150.0 µg/m³) of the Vietnam National Technical Regulation on Ambient Air Quality (MONRE, 2013), but higher than the European Air Quality Standard or the WHO guideline (50.0 µg/m³) (World Health Organisation, 2005). The number of days in which the Vietnamese national standard was surpassed was 36 (2.5 % of the study period), but the number of days in which the WHO standard guideline (50.0 µg/m³ 24-hour mean) was exceeded was 1126 (79% of the study period). The daily levels of other air pollutants ranged from 2.8 to 55.2 µg/m³ (mean 18.9 µg/m³) for NO_2 , 1.4 to 192.0 µg/m³ (mean 30.3 µg/m³) for SO_2 , and 0.9 to 117.0 µg/m³ (mean 40.0 µg/m³) for O_3 .

Table 2.5-1: Descriptive Statistics of air pollutants, weather conditions, and hospital admissions. Source: Phung et al., 2016, p.325

	Minimum	Maximum	Mean (SD)
Air pollutants			
PM_{10} (µg/m³)	11.6	209.9	74.0 (29.7)
NO_2 (µg/m³)	2.8	55.2	18.9 (7.4)
SO_2 (µg/m³)	1.4	192.0	30.3 (30.5)
O_3 (µg/m³)	0.9	117.0	40.0 (15.6)
Weather conditions			
Temperature (°C)	23.1	32.0	28.1 (1.4)
Humidity (%)	51.0	97.0	74.8 (7.3)
Respiratory admissions			
All	2	50	23 (8)
Male	1	31	12 (5)
Female	1	29	11 (5)
5–65 year-olds	1	39	17 (7)
65 + year-olds	0	19	6 (3)
Cardiovascular admissions			
All	5	67	31 (8)
Male	2	33	14 (5)
Female	3	34	17 (5)
5-65 year-olds	2	32	13 (4)
65 + year-olds	3	35	18 (5)

According to Mehta et al. (2013), the levels of air pollutants in HCMC changed according to the seasons, with greater levels of air pollutants during the winter months and lower levels during the summer months, which might have an impact on health outcomes in the city. Per known seasonal trends for air pollution variables, variations in climatic circumstances were noted, with more frequent rainfalls occurring during the rainy season helping to purify the environment of air pollutants. In addition, because the temperature in HCMC remains consistent at 28°C all year, there is no need for heating, which implies that burning/combustion did not contribute to the variance in temperature.

When it comes to cities in low-income countries, air pollution is now considered a new respiratory risk that necessitates the rapid implementation of systems for measuring pollution levels as well as epidemiological surveillance to prevent the health consequences of air pollution from occurring (Nejjari et al., 2003). According to the findings of the study conducted by Phung et al. (2016), the average PM_{10} concentration was 74.0 µg/m³ (see Table 2.5-1), which was relatively high (higher than the current WHO guideline) and higher than those found in other Asian studies, such as 65.06 µg/m³ in Korea from 2000 to 2006, 52.1 µg/m³ in Bangkok from 1999 to 2003, and 50.1 µg/m³ in Hong Kong from 1994 to 1995, although still lower than the levels found in different studies.

To conclude, the study conducted by Phung et al. (2016) confirms that air pollutants (PM_{10}, NO_2, SO_2) were strongly associated with daily hospital admissions for respiratory and cardiovascular diseases in the population of HCMC, with the highest association being for respiratory diseases. A prevention program to reduce exposure to air pollutants and their adverse health effects should be developed to protect HCMC residents. Promoting active mobility can help to enhance air quality, which can lead to a reduction in respiratory and also cardiovascular diseases.

2.6 Traffic safety [AS]

Globally, traffic safety is a big problem. Pedestrians, cyclists, and motorcyclists account for almost half of all road traffic fatalities worldwide, which is around 1.3 million each year. Over 90% of these fatalities occur in underdeveloped countries (World Health Organisation, 2009). According to the World Health Organization's (2009) research, which examined regulations linked to road safety throughout the world:

“Our roads are particularly unsafe for pedestrians, cyclists and motorcyclists who, without the protective shell of a car around them, are more vulnerable. These road users need to be given increased attention. Measures such as building sidewalks, raised crossings and separate lanes for two wheelers; reducing drink-driving and excessive speed; increasing the use of helmets and improving trauma care are some of the interventions that could save hundreds of thousands of lives every year.”

Traffic accidents are the third leading cause of death (occupying 11 % of all fatalities), behind the heart and cardiovascular disease (18 %) and infectious diseases (15 %). According to estimates, the worldwide economic cost of road accidents is $518 billion per year (World Health Organisation 2004).

To see if there is an improvement or a change in the traffic situation in the last 20 years in HCMC, the authors choose 2 different studies, one done between the years 1996 and 2007 and another one, done later between the years 2017 and 2018. Both of these two studies are analysing the traffic situations in HCMC, giving the reader arguments about why HCMC residents might prefer to take a motorcycle, even for a small distance, instead of walking.

2.6.1 Traffic accidents between 1996-2007

The number of traffic accidents in Ho Chi Minh City has been continuously growing and has now reached a worrying level, according to official statistics. Using extensive data from all road accidents in HCMC from 1999 to 2007, as well as statistical analysis, the paper conducted by Trinh (2009) identified a road accident trend, as well as road safety issues such as an uncontrolled increase in the number of motorised vehicles, a lack of enforcement of traffic rules such as drunk drivers and excessive speeding, a very low level of road user perception, and an existing rule on lane assignment by vehicle class.

Following the implementation of the National Traffic Safety Program by the Ministry of Transport, about 145,760 land-based traffic-related accidents were recorded throughout Vietnam during the 1990-1999 time period. These accidents claimed the lives of 48,436 people and injured 155,649 others. The overall material damage caused by road accidents is projected to be around USD 200 million per year, according to the same article written by Trinh (2009).

According to National Traffic Safety Program (2001-2005), in the year 2000, a total of 22,486 traffic incidents occurred on the road, resulting in 7,500 fatalities and 25,400 serious injuries.

When compared to other Asian countries, the rate of traffic accidents in Vietnam was exceptionally high (Table 2.6-1).

Table 2.6-1: Road Traffic accidents. Source: 1st GRSP ASEAN Seminar 2001; the National Traffic Safety Program Data for Thailand (2000)

Country	Accident Rate (fatalities/million vehicle)
Vietnam	1,102
Thailand	610
Malaysia	597
Singapore	290
Philippines	274

Traffic accidents have resulted in a significant cost to society. According to a recent study by Trinh (2009) on the economic impact of road traffic accidents, the economic loss caused by road traffic accidents in Vietnam in 2006 was projected to be VND 3.616 billion, 140.010,63 Euro (equivalent to 0.5 % GDP).

Also, two very important aspects are to be considered while discussing road traffic accidents in HCMC:

1. The rising of economic prosperity and greater incomes (which has increased vehicle ownership - with over 5 million vehicles per day in mixed traffic)
2. The poor road users' perception

Pedestrians are included in mixed traffic, and even though the traffic is going continually, the pedestrians must walk through the stream of driving automobiles to reach their destination (Figure 2.6-1).

Figure 2.6-1: Sidewalk encroachment forcing pedestrians to walk on the road. Source: Author's own, 2018

In the study done by Trinh (2009), the contrast to neighbouring cities and the entire country of Vietnam, HCMC accounted for 9.26 % of all fatalities and 9.63 % of all injuries in the country between 2002 and 2006. It was determined that the average number of fatalities per 1,000 population in the country was 0.14, but the figure for HCMC was 0.16. In terms of traffic safety, HCMC was deemed to be one of the most concerning areas in Vietnam.

From 1996 to 2007, data on total accidents, fatalities, and injuries were gathered to analyse the trend of traffic accidents in HCMC. It indicated that the traffic accident situation in the examined region went through two separate periods. The first period covered 1996 to 2002, during which time the number of traffic accidents increased steadily over the years. The second one from 2002 to 2007 was given as evidence of a downward trend in road accidents throughout the years; there was a fall of around 66 % in the total number of accidents and a decrease of 17 % in the number of fatalities from 2002 to 2007.

Using the mean and standard deviation (SD) over two periods, the researchers discovered that overall accident and injury dropped by around 25 % and 45 %, respectively, while fatal accidents increased by 11 % (Table 2.6-2).

Table 2.6-2: Road accident trend in two periods. Source: Trinh, 2009

Content		Accident	Fatal	Injury
1996-2002	Average	2,224	983	2,771
	SD	337	244	61
2002-2007	Average	1,656	1,091	1,502
	SD	494	152	768

Sundays were the days in which the greatest number of deadly and severe accidents occurred. The worst recorded hours began at 8 p.m. and peaked between 9 p.m. and 11 p.m., with a 5 times higher rate than the average hour. According to this, the vast majority of the accidents happened over the weekend rather than throughout the working week. Additionally, it is possible that the impact of alcohol had a substantial role in these incidents. Accidents and injuries that have been reported, on the other hand, are not quite as numerous. It is expected that certain incidents that do not result in fatalities or significant injuries do not get officially reported (Trinh, 2009).

2.6.2 Source of traffic accidents

Furthermore, Trinh (2009) published the classification of some of the most common types of accident causes in Ho Chi Minh City, based on data collected between the years 2002 and 2007.

Driver error was found to be responsible for 92 % of all traffic accidents. However, this could be interpreted as a simple violation of traffic laws and regulations. There were two significant violations identified: the first was driving in the wrong lane and the second was non-control speed. The first significant violation (28 %) had a strong correlation between road user perception and driving in the wrong lane. Accidents caused by this were frequently more serious than other types of accidents because of the possibility of a direct head-on collision between opposing cars. The second significant violation was excessive speeding and/or a lack of control over one's speed (20 %). Research has discovered a substantial association between drunk driving and a lack of control over one's speed.

The same study served as a warning to pedestrians, who account for around 8 % of all road fatalities and injuries.

2.6.3 Traffic accidents between 2017-2018

According to the findings of a study conducted by Han & Michelle (2019), some high-risk behaviours among hospitalised motorcyclists in Vietnam were identified. In addition, the study discovered that being unlicensed and colliding at night were both related to worse injury severity among hospitalised motorcyclists. The findings imply that interventions aimed at reducing high-risk behaviours, such as prevention and enforcement, may be effective in reducing the severe morbidity and death associated with motorcycle accidents in Vietnam.

The vast majority of motorcycles in Vietnam are scooters with engine capacity ranging from 50 to 250 cc, according to the International Motorcycle Federation. These vehicles are commonly utilized for everyday commuting in both urban and rural settings because of their adaptability for going on narrow streets and their ease of parking in both locations (Lin et at., 2009). On the other hand, motorcycles in industrialised nations such as the United States, Australia, and Europe have greater engine capacity and are largely utilised for recreational or sporting activities, rather than transportation (Organization for Economic Cooperation and Development, International Transport Forum, 2015). As a result, the features of motorcycle collisions in Vietnam and the risk factors associated with them may differ from those in industrialised nations.

An investigation on the characteristics of the cohort, as well as injury outcomes and crash characteristics, was carried out using descriptive statistics. When it came to the severity of the injury (Injury Severity Score = ISS), there were two categories: mild injury and moderate injury versus severe injury (Stanford et al., 2016). Twenty-four (6.8 %) of the 352 injured motorcyclists in the research were classed as having serious injuries.

Independent variables included in the model were age, gender, education, marital status, previous history of a crash (yes or no), helmet use at the time of the crash (yes or no), motorcycle license at the time of the crash (yes or no), crash type (multivehicle, single-vehicle), speeding at the time of the crash (above, at, or below the speed limit), time of day (6:00 a.m.–5:59 p.m., 6:00 p.m.–5:59 am) and weather (dry, wet). A simple logistic regression model was used to investigate the relationship between each independent variable and the severity of the collision (Han & Michelle, 2019).

According to Han & Michelle. (2019), the findings of their investigation demonstrated that motorcycle crashes had some features in common with other types of vehicle collisions. Table 2.6-3 outlines these qualities in further detail. Multi-vehicle collisions accounted for the vast majority of crashes (n=258, 73.3 %). Upon further analysis, it was shown that 52.3 % (n = 184) of collisions involved two motorcycles, while 21 % (n = 74) involved a motorbike and another vehicle such as an automobile. Approximately 26.7 % (n = 94) of collisions involved a single vehicle, with 13.1 % (n = 46) resulting from the motorcyclist losing control and 13.6 % (n = 48) resulting from the motorcycle colliding with an item, an animal, or a pedestrian.

Table 2.6-3: Characteristics of motorcycle crashes resulting in hospitalisation in Ho Chi Minh City, Vietnam (n=352). Source: Han & Michelle, 2019

Crash characteristics	N	%
Crash type (multivehicle)	258	73.3
Time of the day		
Day (6:00 a.m.-5:59 p.m.)	135	38.4
Night (6:00 P.m.-5:59 a.m.)	217	61.6
BAC level (g/dL) ≥0.05^a	66	46.5
Wearing a helmet at the time of the crash	308	87.5
Using a mobile phone at the time of the crash	33	9.4
Having a motorcycle license at the time of the crash	207	58.8
Speeding at time of the crash (above limit)	93	26.4
[a] Missing data: n=142 participants whose blood alcohol concentration level was tested		

When it comes to night-time crashes, the majority (n = 211, 59 % of all crashes) occur between 6:00 p.m. and 11:59 p.m., followed by the hours of 12:00 p.m. to 5:59 p.m. (n = 73, 20.7 %). The majority of collisions happened in dry conditions as well (n = 273, or 77. 6 % of all crashes). Motorcycle riders were not wearing helmets at the time of the collision at a rate of around 13 % (n = 44).

A total of 142 individuals were tested for their BAC (blood alcohol concentration) at the hospital, with 46.5 % (n = 66) testing positive for a BAC greater than the legal limit (0.05 g/dL).

Overall, 18.8 % of the overall sample (both those who were tested and those who were not) had a verified BAC above the legal limit. It is also very important, that at the time of the accident, 41 % of the participants (n = 145) did not have a motorcycle license. In addition, unauthorised motorcyclists had a threefold greater chance of suffering a severe injury than licensed motorcyclists.

When asked if they were using their cell phone at the time of the collision, 9 % of interviewees (n = 33) said they were. At the time of the collision, one out of every four participants (n = 93) stated that they were travelling faster than the posted speed limit.

According to the findings of research done by Han & Michelle (2019), motorcycle injuries are a serious public health concern in Vietnam, with roughly one in every fifteen participants in this study suffering a severe injury from a motorcycle collision. This is a higher proportion than a study conducted in Taiwan (Lin & Kraus, 2003) but lower than the proportion reported in a study in Nigeria (Elachi et al., 2014).

Moreover, the study discovered that the vast majority of motorcycle collisions happened between the hours of 6 p.m. and 12 a.m. and that these night-time incidents had more than four times the likelihood of causing serious injuries than crashes that occurred during the daylight hours. There might be several other reasons for this discovery:

1. First, riders' speeds may be higher at night, depending on the conditions.
2. Second, motorcyclists, like all other road users, are more likely to be under the influence of alcohol at night, and drinking enhances both the probability of a mishap and the severity of an injury for motorcyclists (Lin et al., 2009). In the study done by Han & Michelle (2019), having a BAC above the legal limit was prevalent (47 % of tested participants and 19 % of all participants) were common. The intake of alcoholic beverages may have had a role in the more severe night-time crashes.
3. It's also probable that poor visibility on dark roadways contributed to the severity of the injuries that occurred. The severity of motorcycle accidents in low-light situations has also been found to be higher in a previous study done by Lin & Kraus (2003). Following these findings, changes in street lighting may play an essential role in lowering the severity of motorcycle accidents in Vietnam (Han & Michelle 2019).

2.6.4 Pedestrian safety

Every year, more than 270,000 pedestrians are killed or injured while crossing roadways throughout the world (unroadsafetyweek.org). In the course of a typical day, many people leave their houses like they would any other — for school or work, places of worship, or the homes of friends – only to never return. Walkers account for 22 % of all road fatalities worldwide (Figure 2.6-2), with some nations accounting for as much as two-thirds of all fatalities in pedestrian traffic. In addition, millions of individuals are wounded or killed in traffic-related accidents while walking, with some being permanently crippled as a result. These tragedies create a great deal of pain and sadness, as well as a financial burden for the families and loved ones involved. The ability to respond to pedestrian safety concerns is a critical component of initiatives to reduce the number of people injured in car accidents. However, unlike other types of traffic accidents, pedestrian collisions should not be seen as inevitable because they are both foreseeable and avoidable in many instances. There is a wealth of information available about the major risks to pedestrians, which include issues related to a broad range of factors such as driver behaviour, particularly concerning speeding and driving while being under the influence of alcohol; infrastructure, particularly in terms of a lack of dedicated pedestrian facilities such as sidewalks, crossings, and islands; and vehicle design, particularly in terms of solid vehicle fronts that are not forgiving to pedestrians if they are struck. A lack of adequate trauma care services in many places also makes it difficult to give the prompt treatment necessary to preserve the lives of pedestrians in the case of an accident (World Health Organisation, 2013).

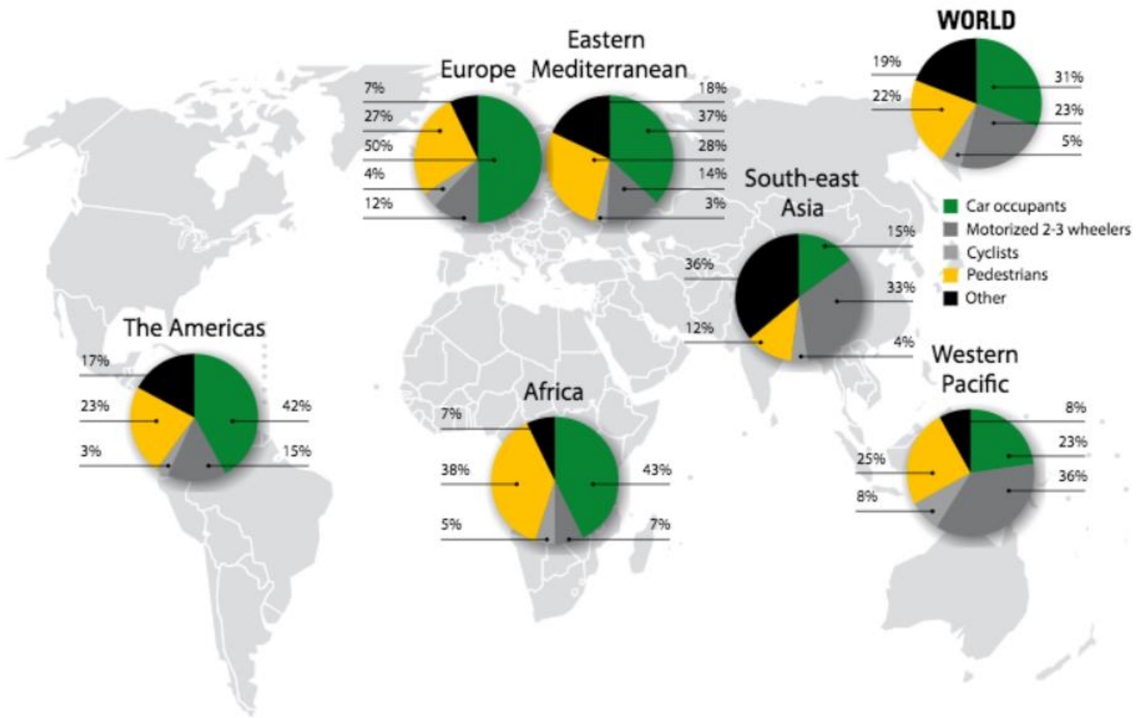

Figure 2.6-2: Road traffic accidents by type of road users. Source: World Health Organisation, 2013

Pedestrians enjoy numerous health and environmental benefits, including increased physical activity, which may result in a reduction in cardiovascular and obesity-related diseases. As a result, many countries have begun to implement policies that encourage walking as a major mode of transportation (Rabl & de Nazelle, 2012). Nevertheless, a higher share of walking trips might raise the likelihood of being involved in a car accident or being injured in a pedestrian accident in specific conditions. The dramatic increase in the number of motor vehicles and the frequency with which they are used around the world, as well as the widespread overlook of pedestrian requirements in roadway design and land-use planning, has increased the number of pedestrians being injured or killed in road traffic accidents (Zegeer & Bushell, 2012). Furthermore, traffic restrictions are not strictly enforced in areas where pedestrians are more vulnerable, which makes them even more vulnerable (Job RFS, 2012).

Vehicle speed, alcohol consumption by both drivers and pedestrians, a lack of pedestrian-friendly infrastructure, and poor visibility of pedestrians are all significant risk factors for pedestrian road traffic injury in urban areas. In many parts of the world, walking is a dangerous activity, and reducing or eliminating the dangers that pedestrians confront is an essential and realistic policy aim. Even though there are effective measures, pedestrian safety does not receive the attention it deserves (World Health Organisation, 2013).

An important link was found between the walking environment and the safety of pedestrians. In a location with poor pedestrian infrastructure and where motorised vehicles are permitted, walking raises the risk of pedestrian injury by a significant margin. The likelihood of a motor vehicle colliding with a pedestrian rises in direct proportion to the number of motor vehicles that interact with pedestrians on the road (Jacobsen, 2003). Enhanced walking environments, as well as local economic growth, social cohesion, improved air quality, and a reduction in the detrimental impacts of traffic noise, are all facilitated by pedestrian safety measures (Job RFS, 1996).

In HCMC, the southern hub of Vietnam, motorcyclists have developed a habit of cruising along sidewalks and promenades, causing significant damage to the pavements. There are hundreds, if not thousands, of commuters who ride their motorcycles on promenades, particularly around important junctions, and this is primarily responsible for the problem.

Many commuters passing through congested junctions choose to drive onto the sidewalk rather than waiting in huge queues at traffic signals to decrease their commute time and avoid standing in line. According to the existing rule, people who ride their motorcycles on sidewalks will be penalised between VND300,000 (11.61 Euro) and VND400,000 (15.47 Euro) depending on the severity of the violation (Tuoitrenews, 2017).

As can be seen in Figure 2.6-3 the sidewalk is being used by motorcyclists as a bypass corridor to avoid having to stay in the long queue lines at an intersection. This kind of behaviour is ultimately affecting the safety of the pedestrians walking on the sidewalk, and also demotivates future walkers for even considering engaging in such an activity.

Figure 2.6-3: Motorcyclist on the sidewalk. Source: e.vnexpress.net, 2017

Approximately 5,291 kids participated in the baseline survey in the study done by Sidik et al., (2018), which revealed their knowledge, attitudes, and reported habits on road safety and transportation to and from school, among other things. Additionally, video observations of pedestrians using the sidewalk and crosswalks were conducted. The level of knowledge about traffic laws and safe pedestrian behaviour was modest, although it varied substantially. Approximately 23 % of students reported that they had been struck by a vehicle while walking in a six-month period; 10.2 % of incidents happened near the school, and 76.4 % were struck by a motorcycle. A sidewalk was not accessible for pedestrians at 14 of the 37 schools, and those that were provided were often encroached upon by motorised vehicles and other barriers.

2.7 Outcome of the literature review [AS & QT]

The literature review chapter seeks to find walkability factors and provide a better understanding of the issues that pedestrians encounter while walking on the streets of Ho Chi Minh City. Sustainable urban developments, focusing on concentrated, mixed-use communities prevent urban sprawl and is believed to have a positive effect on walkability due to shorter trips for daily necessities. The sidewalk life is also playing a very important role in the traditional Vietnamese urban culture. Here, both the social and physical dimensions of the sidewalk practices (street vending, etc.), as well as how they are socially negotiated were emphasized. Rather than only focusing on expanding the amount of space available for motorised vehicles when altering the urban layout of a street, it is recommended that a designated area for street activities should also be considered. Additionally, the topics about noise pollution, air pollution and traffic safety were discussed in detail. For example, the acoustic survey revealed that traffic noise levels in developing countries are significantly higher than in developed countries like Japan. Moreover, while automobiles are the most common mode of transport in developed countries, motorcycles are predominant in Vietnam. This is due to the high import tax on cars, as well as the tight alleyways, which cannot be accessed by larger motorised vehicles. However, the high number of motorised vehicles in HCMC and associated air pollutants (PM_{10}, NO_2, SO_2) was found to be responsible for the high number of daily hospital admissions for respiratory and cardiovascular diseases (Phung et al., 2016). Promoting active mobility helps to improve air quality, thus, reducing air pollution related diseases. Furthermore, the JICA Study Team (2015) found a high share of intra zonal trips in HCMC shorter than 1 km (54.7 %). These findings highlight the potential of raising the percentage of walking trips regarding distances. Regarding traffic safety in Vietnam, it was discovered that around 8 % of all road fatalities and injuries are concerning pedestrians. This data shows the importance of reducing conflicts between road users. Therefore, it is important to create a safe walking environment for pedestrians, i.e., by preventing motorcyclists to bypass traffic queues on the sidewalk during rush hours.

All the issues mentioned above need to be taken into consideration when defining walkability. The built environment and challenges faced by pedestrians in Ho Chi Minh City were analysed through the literature review, and walkability factors that appeared to address these issues were selected and summarised in a preliminary walkability factor list (Table 2.7-1). This list of factors was integrated into the online survey (chapter 3) and is part of the methodology of this thesis to determine the importance and relevance of walkability factors in evaluating the built environment of Ho Chi Minh City.

Table 2.7-1: Preliminary walkability factor list. Source: Author's own

Factors	**Source**
Air pollution	c,f
Insufficient shade	b,f,g
Interrupted sidewalk or sidewalk in bad condition	b,f,g
I don't like to walk	f
High crime rate	a, g
High temperature	b,f,g
Lack of public transport	g,h
Lack of walking amenities	f
Long walking trips	f
Low route attractiveness	f
Rain (climate conditions)	b,f
Traffic noise	d
Traffic safety	e,f,i,j

a) Leung, A., & Le, T. P. L., (2019): Factors associated with adolescent active travel: A perspective and mobility culture approach – Insights from Ho Chi Minh City, Vietnam, pp. 62-63.
b) Loc, D. Q. & Kim G. S., (2018): The effect of built environment on walkability in Ho Chi Minh City Centre district. Journal of the Korea Academia-Industrial cooperation society Vol. 19, No. 9, pp. 290-291.
c) Phung, D., Hien, T. T., Linh, H. N., Luong L. M. T., Morawska, L., Chu, C., Binh, N. D. & Thai, P. K., (2016): Air pollution and risk of respiratory and cardiovascular hospitalizations in the most populous city in Vietnam, Science of The Total Environment, Vol. 557–558, pp. 322-330.
d) Phan, H. Y. T., Yano, T., Nishimura, T. & Sato, T., (2010): Characteristics of road traffic noise in Hanoi and Ho Chi Minh City, Vietnam, Applied Acoustics, Vol. 71 (5), pp. 479-485.
e) Han, T. N. D. & Michelle, B. H., (2019): Characteristics and severity of motorcycle crashes resulting in hospitalization in Ho Chi Minh City, Vietnam, Traffic Injury Prevention, 20:7, pp. 732-737.
f) Fabian, H., Gota, S., Mejia, A. & Leather J., (2010): Walkability and pedestrian facilities in Asian cities: State and Issues. Asian Development Bank, pp. 29-31.
g) ITDP, Institute for transportation and development policy, (2018): Pedestrians first, tools for a walkable city. pp. 32-33.
h) JICA, Japan International Cooperation Agency., (2015): Data collection survey on railways in major cities in Vietnam, pp. 3.14-15.
i) Sidik, M., Parker, L., Le, T. & Hong, B., (2018): Injury Prevention. PW 1415 Students 'walk this way' safely to school. London Vol. 24, Iss. Suppl 2.
Trinh, T. A, (2009): Analysis of road safety situation in HCMC, Vol. 7.

Looking at the input sources, the reviewed literature is based on studies and articles that were conducted during the last decade. However, the issues pedestrians were experiencing in HCMC a decade ago are still relevant today and may have worsened, due to the continuous economic growth and related increase of motorised vehicle ownership.

3 Methodology - Online survey

Through the literature review, the built environment, and the use of public space in HCMC were investigated, and factors influencing walkability were collected. The online survey served to determine (i) the relevance of the walkability factors found in the literature and (ii) to further explore the mobility habits and walking experiences of HCMC's residents. The survey will help answer the *first* research question about identifying the factors preventing people from walking in HCMC, and the *second* research question about what factors are suitable to evaluate the built environment of pedestrians. An online survey with sociodemographic data, walking habits, transport mode perception and walking experience was conducted and is, along with the literature review, part of the methodology used in this thesis to collect information about the relevance of walkability factors evaluating the pedestrian environment of Ho Chi Minh City.

3.1 Survey content [AS & QT]

The data of the survey will be used to create a Walkability Evaluation Tool mainly focusing on walkability in the context of Vietnamese urban areas, as described in chapter 5. Aiming to maximise the number of respondents, the questionnaire, seen in Table 3.1-1, was designed to be completed within 10 minutes. The three main parts of the questionnaire are:

- Sociodemographic data
- Walking habits
- Transport mode perception & experience

The *first part* focused on demographic data of the participant such as gender, age, address, education level, vehicle ownership and driving licenses. The question type used in this part mostly consisted of single choice questions (Table 3.1-1). The *second part* focused on walking habits such as the trip frequency to predefined destinations. Those included work/education facilities, shops of essential goods, shops of non-essential goods, recreational facilities, entertainment facilities and restaurants [five-point Likert Scale ranging from – (-2) nearly never to (+2) nearly daily]. Another question (Q10) focused on the relevance of the walkability factors the authors found in the literature in the context of Ho Chi Minh City and understand which ones are influencing the mode choice [five-point Likert Scale ranging from – (-2) not preventing me at all from walking to (+2) preventing me very much]. The *last part* revolved around the walking experience, starting with the transport mode convenience [five-point Likert Scale ranging from – (-2) very inconvenient to (+2) very convenient], opinions about the positive influence of different street activities [five-point Likert Scale ranging from – (-2) strongly disagree to (+2) strongly agree], and open-ended questions about suggestions concerning pedestrian experience improvement. The last two questions (Q14 and Q15) aimed at finding the most popular walking destinations starting from home, or from work/school, to identify the points of interest of pedestrians. The draft of the questionnaire was initially designed in English. To make the questionnaire accessible to most people, the authors decided to have a bilingual survey, including both English and Vietnamese. The majority of the questions consisted of quantitative data (single choice). This enabled rapid data processing while limiting the scope of subjective judgments.

To supplement the quantitative data, some questions were open-ended. The qualitative approach intended to collect address data [district, ward] and to explore the subjective opinion of the respondents regarding walking trip experiences. The in-depth information gained will help to guide the authors in the design process of the walkability indicators for the walkability evaluation tool. If an answer to a question is mandatory, the individual who is completing the questionnaire will not be able to further progress until they have completed the required response. The entire online questionnaire can be found in the appendix (chapter 13.1).

Table 3.1-1: Survey overview. Source: Author's own

(I) Sociodemographic data			**Question type**	**Answer options**
Q1	*	Gender	Single choice	Male Female
Q2	*	Age	Single choice	< 16 16 - 21 22 – 35 36 - 45 46 – 55 56 - 65 66 – 75 >75
Q3	*	Are you living in HCMC?	Single choice	Yes No
Q4	*	Current Residence (District & Ward)	Open-ended	-
Q5	*	Highest education level	Single choice	- No school - Primary school degree - Secondary school degree - High school degree - University degree - Postgraduate degree
Q6	*	Number of operational vehicles owned by your household	Single choice	- Car(s) - Motorcycle(s) - Bicycle(s) - Electric bicycle(s)
Q7		Your driving licenses	Single choice	- Car driving license - Motorcycle driving license - Truck driving license - Not any driving license
(II) Walking habits & factors preventing from walking				
Q8	*	How often do you visit the following destinations?	Five-point Likert scale: (-2) nearly never (-1) 2-3 times/week (0) 2-3 times/month (+1) < 1 time/month (+2) nearly never	- Workplace/Education - Shops of essential goods - Shops of non-essential goods - Recreational facilities - Entertainment - Restaurants
Q9	*	How frequently do you walk to the following destinations?	Five-point Likert scale: (-2) nearly never (-1) 2-3 times/week (0) 2-3 times/month (+1) < 1 time/month (+2) nearly never	- Workplace/Education - Shops of essential goods - Shops of non-essential goods - Recreational facilities - Entertainment - Restaurants

Q10	*	What prevents you from walking?	Five-point Likert scale: (-2) prevents me not at all (-1) prevents me slightly (0) Undecided (+1) prevents me very (+2) prevents me very much	- Traffic safety - Air pollution - Traffic noise - Rain - Insufficient shade - I don't like to walk - Lack of walking amenities - High crime rate - Lack of public transport - Low route attractiveness - Interrupted sidewalk or sidewalk in bad condition - High temperature - Long walking trips
(III) Travel experience & pedestrians points of interest				
Q11	*	How convenient do you perceive the following transport modes?	Five-point Likert scale: (-2) very inconvenient (-1) inconvenient (0) neutral (+1) convenient (+2) very convenient	- Walking - Cycling - Bus - Motorcycle - Car
Q12	*	Which of the following examples contributes to a greater pedestrian experience?	Five-point Likert scale: (-2) I strongly disagree (-1) I disagree (0) neutral (+1) I agree (+2) I strongly agree	- Street food vendors - Street merchandise vendors - Street services - Street events
Q13	*	What do you think would contribute to a greater pedestrian experience?	Open-ended	-
Q14		From your home, where do you often go by walk? Please indicate the destination/ purpose and the frequency per week. (For example: Visit a neighbour, 3 times/ week)	Open-ended	-
Q15		From your workplace/school, where do you often go by walk? Please indicate the destination/ purpose and the frequency per week.	Open-ended	-
* Mandatory questions				

3.2 Survey approach [QT]

After reviewing and selecting walkability factors from international literature, the authors developed an online questionnaire. The target group of the survey are the people living in the municipality of HCMC. Additionally, a screening question was included in the survey, asking participants if they live in HCMC, further restricting the number of respondents to those who only lived in the study area. The main objectives of the online survey were:

- to conduct the survey in a reduced period of time through simultaneous data collection
- to efficiently collect data from all city districts without needing to physically go on-site
- to eliminate the risk of Covid transmissions due to the ongoing pandemic

The software used to conduct the survey was Google Form. This survey platform was chosen due to its intuitive design and its user-friendliness. Google Form provided several options regarding the question type which included, i.e., single choice, multiple-choice, open-ended, etc. The survey was initially planned to be conducted as a Pen-and-Paper Interview (PAPI) face-to-face on site. This method would have helped the authors to carefully select their target group to balance the sociodemographic profile of the respondents. However, due to the COVID-19 pandemic leading to the border and social distance restrictions, the authors decided to switch to Computer-Assisted Web Interview (CAWI). The benefit is the reduced time to reach the target group by being able to simultaneously send out the questionnaires and no interviewers were needed. However, the drawbacks are that some people do not have internet connections, and are therefore excluded from the survey. This is especially true for lower-income classes and elderly people, who either have no access to digital technologies and social media platforms, or are not familiar with them. The distribution channels used to send out the questionnaire link were:

- social media platforms (Facebook),
- messaging platforms (Viber, Messenger, Skype, Zalo) and lastly
- emails (Gmail, Yahoo mail, etc.)

The people who helped share the link in HCMC were family, former colleagues, friends, and acquaintances of the authors. Before the start of the survey, a pre-test survey was conducted with 10 people to verify if the questions were comprehensive and could be answered correctly. The average time to answer the survey was around seven minutes and below the maximum threshold of 10 minutes, initially set by the authors. The technical feasibility and convenience of using a link shared via social media, messaging platforms, or emails, was examined and no difficulty was found. The pre-test survey was collected in Google Form and the authors discussed the encountered difficulties with the respondents. The pre-test survey included both languages, English and Vietnamese, and was carried out between 15th March 2021 and 17th March 2021. The definition of vehicle ownership per household turned out to be problematic. The translation of "household" did not find its equivalent in the Vietnamese language and was translated as "family". Following discussions with the respondents, it was discovered that the vast majority of them identified "family" as the household in which they currently reside in HCMC. Furthermore, a trial to change the question with a detailed description of the definition of "household" led to more confusion with the test group. Therefore, it was decided to leave the Vietnamese term of "family". Another feedback included lowering the number of mandatory questions for time-consuming open-ended questions to lower the probability of respondents dropping out before submitting the survey. After analysing the feedback and removing potential misunderstandings, often resulting from improper translation, the survey was launched on

Wednesday, 17th March 2021. The survey was accessible for two weeks; the online form was closed on Tuesday, 30th March 2021 when the peak momentum of incoming answers during the weekend was significantly slowing down. Since the study mainly focuses on Vietnamese urban areas, it was decided to limit the scope of the survey to the municipality of HCMC. The goal for the minimum number of responses was initially set at 250 due to the following reasons:

(1) It is a relevant sample size to answer the research questions of this thesis
(2) The authors are constrained to rely entirely upon the help of acquaintances and contacts living in Ho Chi Minh City to successfully conduct the survey.

The questionnaire was created in Google Form, and once the testing phase was over, the link to the questionnaire was emailed out to acquaintances who lived in Ho Chi Minh City. In order to further extend the reach of the questionnaire, it was shared on social media groups. Those groups included:

- dog owner communities in HCMC, which is an interesting group since they are confronted to the city's pedestrians build environment when walking their dogs, and
- expatriate groups, which were chosen to include some English speakers in the questionnaire.

3.3 Data processing and analysis [QT]

During the interview period, a total of 415 responses were collected. Out of 415 respondents, only 404 questionnaires were considered valid. The reasons for the 11 invalid questionnaires include the following: being submitted more than once, and/or being not diligent enough. Or in another words, the responses were considered having been answered randomly or in haste, and therefore excluded for maintaining good data quality. The three open-ended questions needed to be translated into English before being processed using the theme coding method. Each answer was analysed manually and similar topics were put into thematic groups. The ward and district addresses from the fourth question were converted into a uniform addressing system to enable further spatial analysis. For single choice questions, column charts were created in the Excel software using a consistent colour gradient. The questions using the Likert scale were illustrated in figures including the average value and the standard deviation. Some datasets were sorted in ascending order to facilitate their interpretation and comparison. Both open-ended questions, which were not mandatory, experienced a respective drop of 22 and 37 percentage points in the number of respondents. However, the lower participant rate was compensated by multiple responses which led to a higher rate of answers.

In this thesis, the data from the Likert scale are treated as interval data. This means that the intervals between the five Likert points are considered to be evenly spaced. This assumption was necessary to use mean values, standard deviations, correlations, and t-tests for the descriptive statistics. The statistical analysis was done by using the SPSS software provided by IBN to analyse the survey results. The following statistical tests were performed:

- Two-tailed independent sample t-test: This test is used to determine if the null hypothesis should be supported or rejected. In this thesis, this method was used to determine if the mean values that were analysed had significant differences or not. In the alternative hypothesis, the difference between the means was not equal to zero. The confidence interval was set at 95%, consequently, the significance level α was given the value of 0.05.
- Correlation: Spearman's rank correlation coefficient (r_s) compares monotonic relationships between the rank values of two variables. The correlation coefficient can have values ranging from -1.0 to 1.0. A correlation coefficient of 0 indicates no relationship at all, +1.0 indicates a perfect positive correlation and -1.0 a perfect negative correlation. In this study, the effect size by Cohen represents the following scale: r_s = 0.10 to 0.29 correspond to a small correlation; r_s = 0.30 to 0.49 correspond to a medium correlation and r_s = 0.50 to 1.00 correspond to large correlation.

The results of the statistical analysis of the survey outcome can be found in the appendix (chapter 13.2).

4 Survey results

4.1 Sociodemographic data [QT]

The sociodemographic data includes age, gender, education level, current address [ward & district], vehicle ownership and possession of driving licenses (Table 3.1-1). Of the total 404 participants, 392 were living in urban districts defined as the "Inner area" in this study (Figure 4.1-1). The remaining 12 respondents were living in the rural districts outside of the urban centres of the municipality. Furthermore, 236 people resided in the Old Inner area and 156 in the New Inner area.

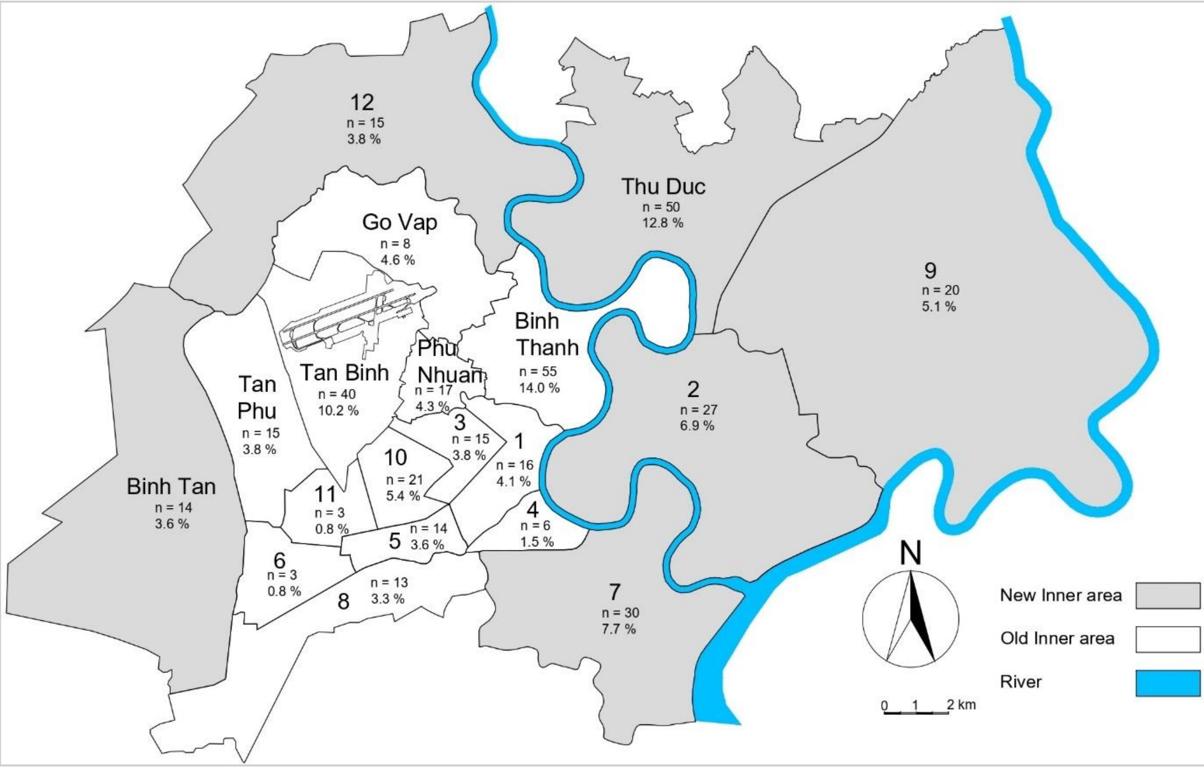

Figure 4.1-1: Distribution of survey respondents in the Inner area. Source: Author's own based on Map data ©2021 Google

4.1.1 Gender and age distribution

The gender distribution indicates a slightly higher share of female respondents (n = 253, 62.6 %) compared to male respondents (n = 151, 37.4 %) (Figure 4.1-2). In 2018, the share of the female population was 52 % and 48 % male (Ho Chi Minh City Statistical Yearbook, 2019). The greatest percentage of participants are in the 22-35 age group (n = 228, 56.4 %), followed by the evenly sized 16-21 age group (n = 67, 16.6 %) and 36-45 age group (n = 65, 16.0 %). The combination of those three groups (n = 360, 89.2 %) represents people less than 46 years old and reveal the high share of young respondents. This highlights that by using modern technologies and social media for the survey, many elder people could not be reached.

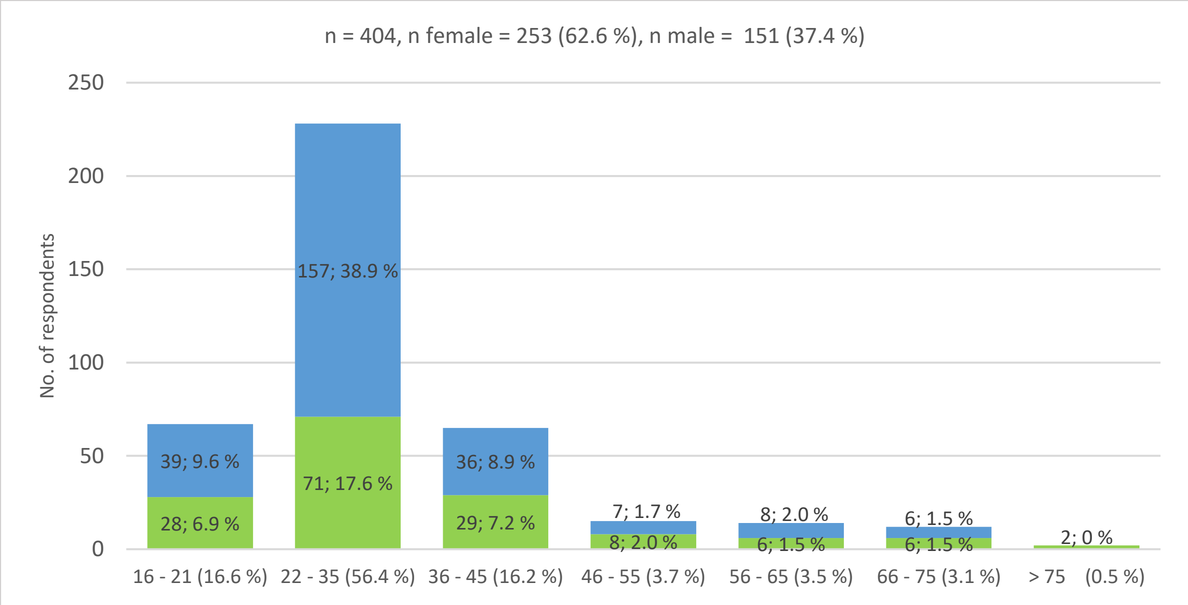

Figure 4.1-2: Age groups of the respondents. Source: Author's own

4.1.2 Education level

Most of the respondents have a high education level with 80.4 % having a university degree and 13.9 % having a postgraduate degree (Figure 4.1-3). The remaining 5.7 % have a high school degree or a lower qualification. This data shows, that by using the CAWI method, people with lower education levels could not be reached. Due to the overrepresentation of highly educated individuals, it was not possible to make a comparison across groups with varying levels of education. This affects the representativity of the sample and limits the significance of the survey results.

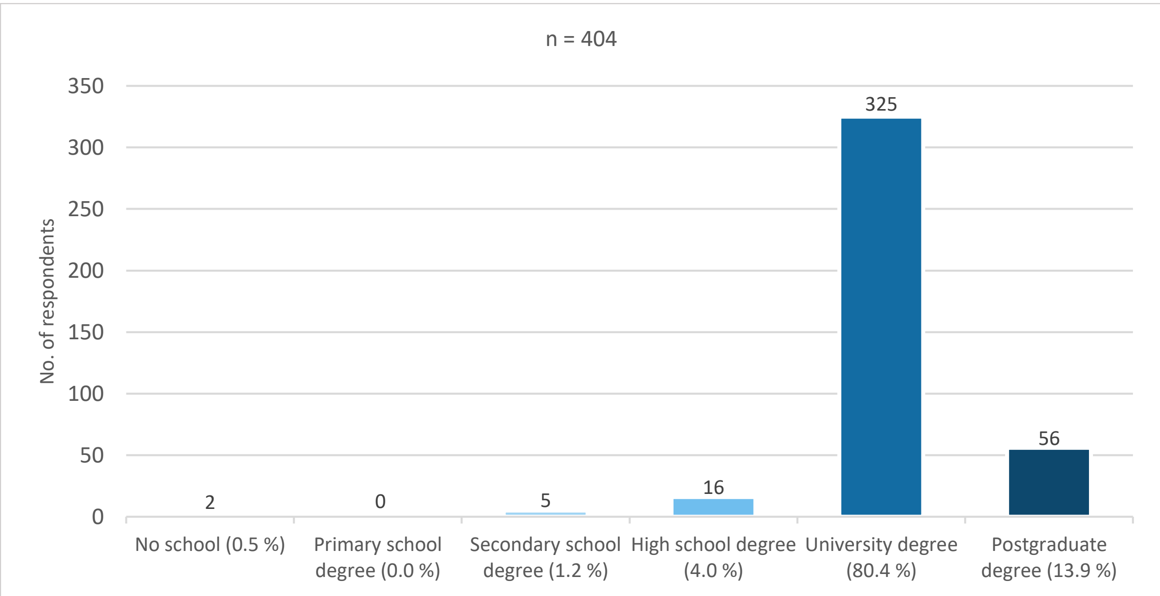

Figure 4.1-3: Education level of the respondents. Source: Author's own

4.1.3 Vehicle ownership, motorisation rate and driving licenses

The results of the survey demonstrate that motorcycles are the predominant form of transportation in HCMC. Motorcycle ownership per household excels car ownership by an impressive factor of 8.4 (Figure 4.1-4).

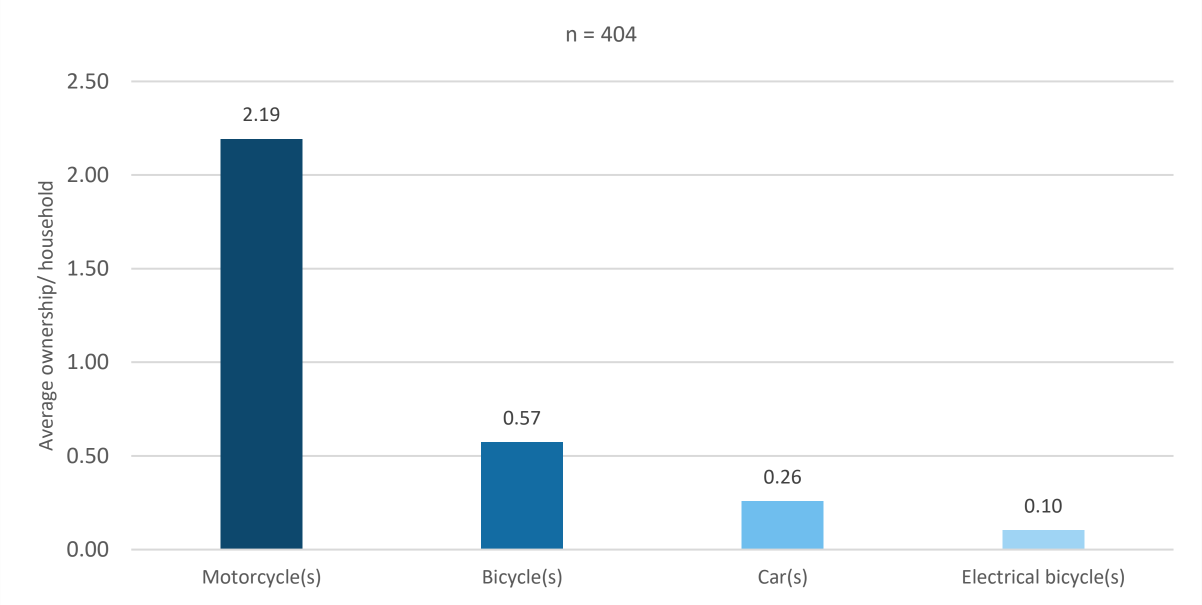

Figure 4.1-4: Average vehicle ownership per household. Source: Author's own

These results confirm the findings in the literature (Table 2.2-2) indicating that in 2017 registered motorcycles in HCMC accounted for 7.44 million units, and cars for 0.29 million units, with a total population of 8.63 million inhabitants. As described by the JICA Study Team (2015), car ownership mainly depends on the income class (

Table 2.2-3).

Furthermore, the outcome of the survey indicates that 94.6 % of households owned at least one motorcycle compared to only 23.3 % owning a car (Figure 4.1-5). This represents a ratio of approximately 4 people having access to a motorcycle to 1 having access to a car. Similar results, with motorcycle ownership of 98.6 % and car ownership of 8.2 %, were found in the METROS survey conducted in 2013 by the JICA Study Team (2015). The METROS survey includes data about the transport system and travel demand forecast in HCMC in the context of future urban railways developments in Vietnam. The higher car ownership rate in this research can be explained by two factors. First, the survey was conducted eight years after the METROS survey, and the economic growth associated with a sharp increase in household incomes, has led to a rise in car ownership. Other sources indicate that the number of registered cars in HCMC nearly doubled between 2011 and 2017 (Vietnam Registration Authority, HCMC Police, 2018). Secondly, the CAWI-method failed to reach all age groups and people with different education levels coming from different backgrounds.

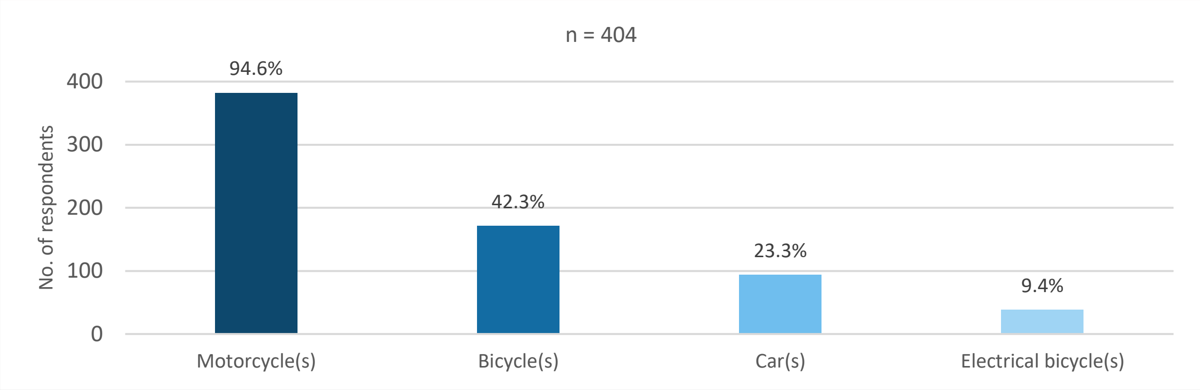

Figure 4.1-5: Percentage of households owning at least one of the following vehicles. Source: Author's own

Lastly, the number of motorcycle driving license holders is 4 times higher than the number of car driving license holders with only a small percentage not holding any driving license (Figure 4.1-6). After conducting a t-test to compare the differences between the mean values of the number of driving license holders by gender, only the number of car driving licenses held by men was significantly higher than the number of car driving licenses held by women (Figure 4.1-7). The results of the statistical analysis can be found in the appendix (Table 13.2-1 and Table 13.2-2).

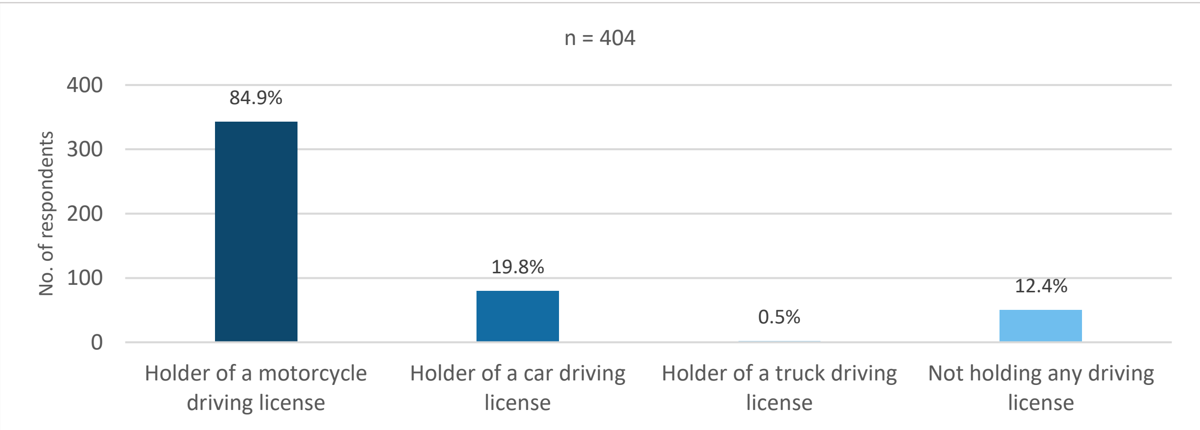

Figure 4.1-6: Holder of driving license. Source: Author's own

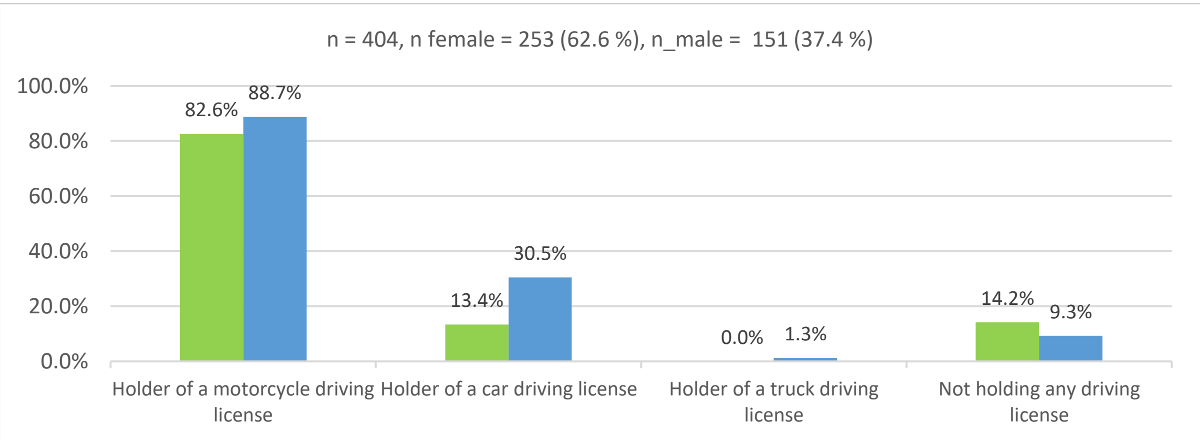

Figure 4.1-7: Holder of driving license by gender. Source: Author's own

To find out more information about the vehicle ownership distribution between the central areas and suburban areas, the respondents of the survey were split into two groups: the first group representing the people living in the Old Inner area (n = 236, 60.2 %) and the second group being the people living in the New Inner area (n = 156, 39.8 %) as previously shown in Figure 4.1-1. Since the absolute numbers of respondents greatly vary between the districts (minimum: n = 3, maximum: n = 55), a direct comparison between districts had little relevance. Nevertheless, by calculating the mean value of the vehicle ownership per household between the Old Inner areas and New Inner areas, the results illustrated in Table 4.1-1 show that the New Inner areas tend to have much higher car ownership rates (0.31) and little lower motorcycle ownership rates (2.06) in comparison to the Old Inner area having rates of (0.21) and (2.26) respectively. Despite the differences not being statistically significant, it can be assumed that this tendency may be due to the higher space scarcity which the Old Inner area faces, when compared to the New Inner area. The very densely populated tube house neighbourhoods, which appeared during the massive immigration during the times of conflicts, are defined by a dense network of narrow alleyways preventing direct car access. This car inaccessibility continues to foster the use of motorcycles in the Old Inner areas despite rising household incomes.

Table 4.1-1: Average car and motorcycle ownership in the Inner area. Source: Author's own

		Average vehicle ownership per household	
	District	**Car**	**Motorcycle**
Old Inner area n = 236	District 1	0.19	1.88
	District 3	0.47	3.00
	District 4	0.33	2.00
	District 5	0.07	1.79
	District 6	0.33	3.00
	District 8	0.15	1.85
	District 10	0.19	2.43
	District 11	0.00	2.00
	District Gò Vấp	0.22	2.06
	District Tân Bình	0.08	2.03
	District Tân Phú	0.13	2.33
	District Bình Thạnh	0.35	2.44
	District Phú Nhuận	0.06	2.59
	Subtotal	**0.21**	**2.26**
New Inner area n = 156	District Thủ Đức	0.16	2.04
	District 2	0.63	2.07
	District 7	0.27	2.00
	District 9	0.15	2.05
	District 12	0.47	2.20
	District Bình Tân	0.36	2.07
	Subtotal	**0.31**	**2.06**
HCMC	**Total**	**0.26**	**2.19**

On the contrary, more recent housing development, mainly occurring in the New Inner area and suburban areas include car amenities, such as underground parking facilities for condominiums and oversized streets with on-street parking possibilities. This car-centric design can be observed, e.g., in parts of district 2 and district 7, where most of the new neighbourhoods are being built.

4.2 What prevents people from walking [QT]

In Figure 4.2-1, the main factors preventing respondents from walking in HCMC can be observed. These factors provide the answer to the first research question (chapter 1.4). The five-point Likert Scale [-] used ranges from 1 – representing preventing people very much from walking to 5 – not preventing people at all from walking.

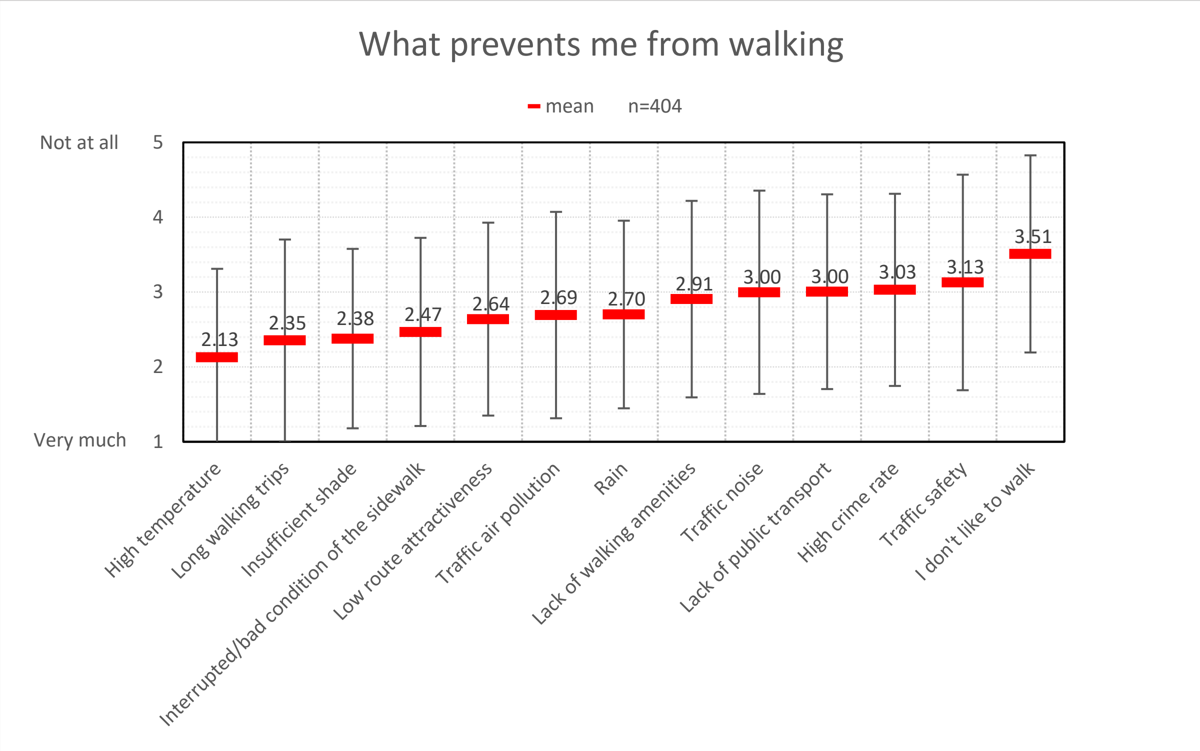

Figure 4.2-1: Main factors influencing the mode choice in the context of walking. Source: Author's own

Vietnam, being a tropical country, and the climate conditions playing a central role, "high temperature" (2.13) and "insufficient shade" (2.38) are major factors discouraging people from walking. Also "rain" (2.70) has a significantly lower importance from discouraging people to walk compared to the two previously mentioned factors. These results match the findings of the walkability study in Ho Chi Minh City done by Loc & Kim (2018), in which it is pointed out that intense sunshine can make pedestrians feel uncomfortable, or possibly harm their health. The tree canopy, which serves to strengthen community ties and physical activity by considerably lowering ground and sidewalk heat, is one of the most effective solutions to counter the negative weather influence in Ho Chi Minh City (Loc & Kim, 2018).

According to the survey, "Long walking trips" (2.35), is the second most important factor discouraging people from walking. The concept of proximity to shops of essential needs is, therefore, an important aspect in the developing process of the WETUAV.

"Interrupted sidewalk or sidewalk in bad condition" (2.47) describes the walking infrastructure such as poorly maintained walkways with missing or broken tiles, narrow sidewalks, and sidewalk availability on streets with heavy motorised traffic. It can be noticed that this factor is also negatively affecting the peoples' willingness to walk since its mean value is below the neutral value of (3.00). These results correspond to the conclusion of an interview conducted by the Asian Development Bank regarding pedestrian facilities in Asian cities, in which it was found that providing wider, levelled, and clean sidewalks were the respondents' top priority (Fabian et al., 2010).

"Low route attractiveness" (2.64) describes the attractivity of the pedestrian built environment. A vibrant neighbourhood with a lot of social and trading activities tend to make streets interesting for pedestrians. The result of the survey indicates that route attractivity plays an essential role for the majority of the respondents in the decision-making process of walking. "Lack of walking amenities" (2.91) such as public benches, public toilets, and streetlights, contribute to the convenience of walking (Fabian et al., 2010). "Lack of walking amenities" is significantly less important than the factor "low route attractiveness" but does not significantly differ from "high crime rate". As observed in the results, "high crime rate" (3.03) is a factor that is preventing less than half of the respondents from walking. Street activities are often referred to in the literature as "eyes on the street" and is contributing to a better sense of safety against crime (ITDP, 2018, p.32).

Looking at the environmental impact of motorised vehicles on pedestrians, "Traffic air pollution" (2.69) seems to affect pedestrians significantly more than "traffic noise" (3.00). According to Phan et al. (2010), HCMC residents were exposed to noise levels ranging between 75 and 83 dB, exceeding the environmental noise guidelines of 53 dB recommended by the World Health Organisation. The same study found out that, by comparing the noise annoyance responses in European cities, the Vietnamese people were less annoyed by road traffic noise by about 5 dB. These findings confirm the lower relevance of noise pollution in HCMC. This may be due to the cultural differences in terms of social conditions and habituations to road traffic noise in each country (ibid.). In contrast, the higher relevance of air pollution can be explained by the daily hospital admissions of cardiovascular and respiratory diseases (chapter 2.5). The density of $PM_{2.5}$ particles reached 40 µg/m^3 in 2017 and are 4 times higher than the recommended 10 µg/m^3 by the World Health Organisation (Vo & Vo, 2021).

"Lack of public transport" (3.00) is rather a neutral factor in the willingness to walk. This is due to the fact, that public transport is mainly used by students (JICA Study Team, 2015) and that the overall modal share remains very low (3.9 %) compared to trips done by motorcycles 86.3 % (ibid.).

Despite pedestrians accounting for 8.0 % of the fatalities of accidents in HCMC (chapter 2.6), "traffic safety" (3.13) does not seem to deter people from walking. Similar to the previous factor about public transport, due to the low modal share of pedestrians of 3.0 – 5.0 % (Emberger et al., 2013), traffic safety does not seem to concern pedestrians.

Interestingly, "not liking to walk" (3.51) seems to be the least important aspect in the decision-making process of walking.

From the outcome of the 13 factors preventing people from walking, it can be inferred that the reasons behind the low modal share of pedestrians originates mainly from unfavourable climate conditions, long walking trips, low quality of the pedestrian infrastructure, low route attractivity, traffic air pollution, and insufficient walking amenities.

To verify that the walkability factors and the resulting walkability evaluation tool work equally for female and male pedestrians, the responses were analysed by gender. The results seen in Figure 4.2-2 showed that 10 factors significantly differ by gender (circular marker) and that 3 factors did not significantly differ (square marker). Nevertheless, a correlation between the means of the factors by gender was assumed by observing the graph. Therefore, a correlation using Spearman's rho was carried out, and the results show a correlation value of 0.973, with a significance level of 0.01. This corresponds to a large effect size by Cohen (chapter 3.3). Despite a significant mean difference, a strong correlation supports the author's assumption that the order of the walkability factors relevance is very similar for both genders. Further descriptions of the statistical analysis can be found in the appendix (Table 13.2-4, Table 13.2-5 and Table 13.2-6). The JICA Study Team (2015) found out that the trip rate between genders differ in the active age group, with women making fewer trips than men on average. Another source states that land use mix influences women's walking behaviour, and that higher wealth and education, both of which are directly tied to work, appear to harm women's willingness to walk. Working women who are restricted in space and time due to household and childcare responsibilities have less freedom to explore metropolitan opportunities and modes of transportation (Leao & Kanashiro, 2021). To conclude, it seems that the limited time women tend to have at their disposal for their mobility needs makes them less likely to walk than men. Walking, opposed to motorised modes, have a much slower travel speed, thus limiting the range for a similar travel duration.

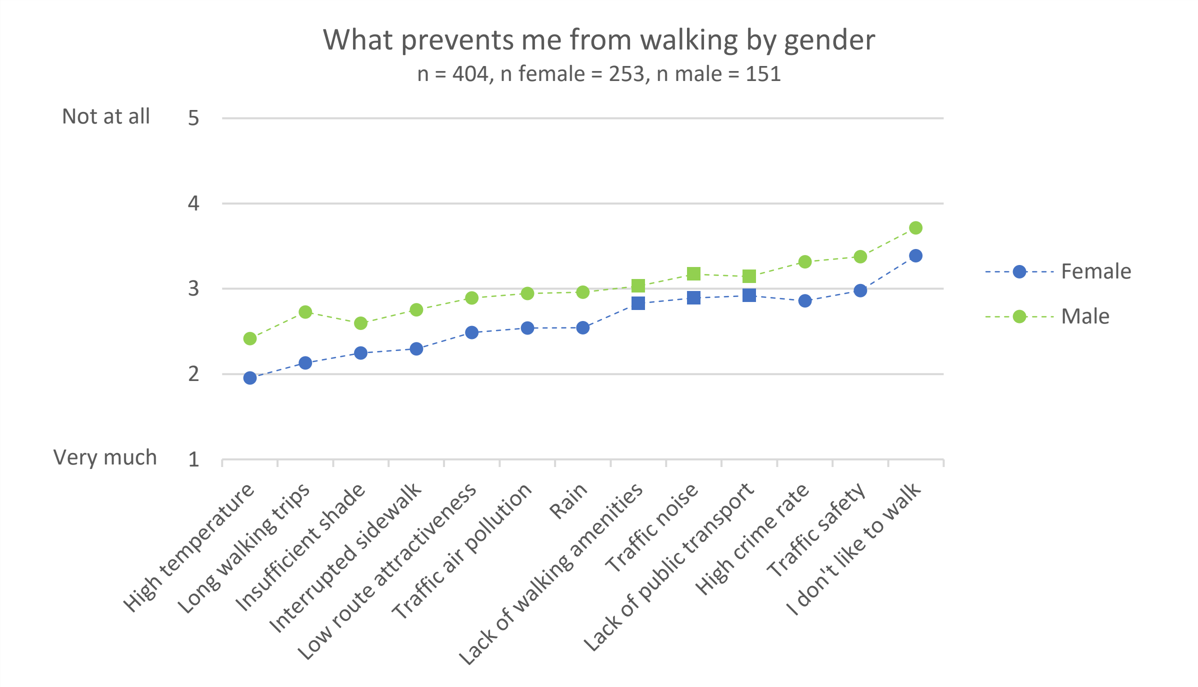

Figure 4.2-2: Main factors influencing the mode choice in the context of walking by gender (square markers, representing insignificant differences between genders and - circular markers highlighting significant differences). Source: Author's own

4.3 Travel experience & pedestrians' points of interest [AS & QT]

4.3.1 Perception of transport mode convenience

In Figure 4.3-1, the average transport mode convenience is illustrated. The results confirm the predominance of the motorcycle as the most popular choice of transportation, whereas walking is perceived as being the most inconvenient transport mode. The result of the t-test shows that the mean values of the different transport mode conveniences are all significantly different (Appendix Table 13.2-7 and Table 13.2-8). During the survey, it was found that several factors contribute to the inconvenience of walking. The main factors include poor pedestrian infrastructure, encroachment, lack of shade, high temperatures, long walking trips, air pollution (chapter 4.2). Many businesses indeed use the sidewalk in front of their shops as an extension of their selling area or even as a parking space for their customers.

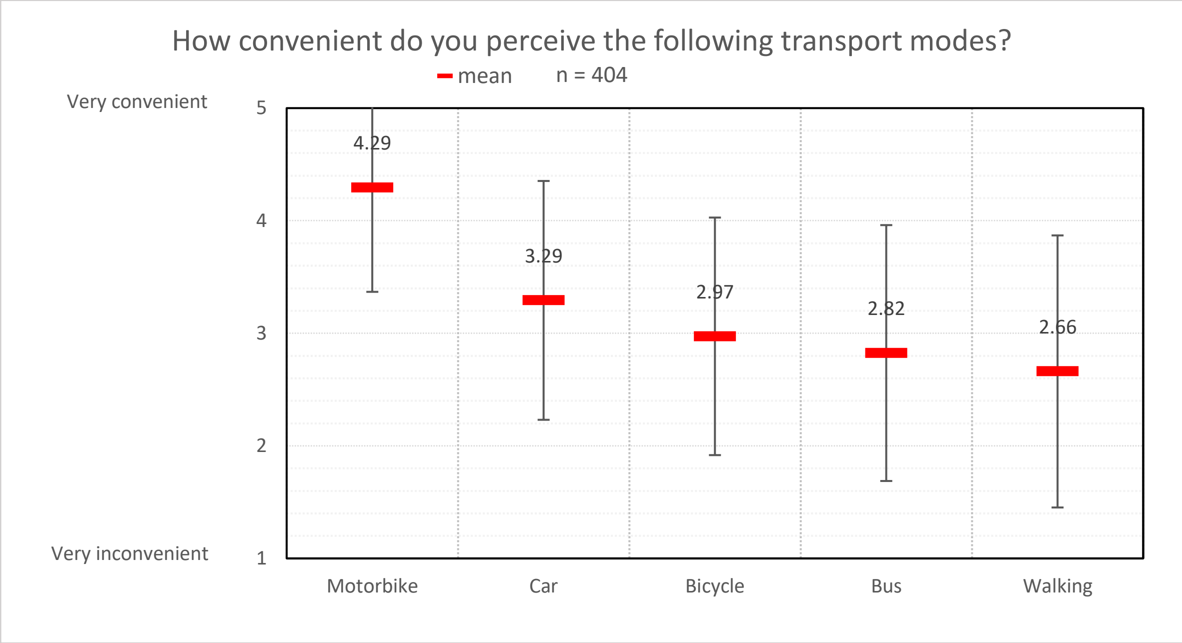

Figure 4.3-1: Average convenience of Transport modes. Source: Author's own

Another encroachment type occurring is motorcyclists using the sidewalk to bypass traffic jams during rush hours, seriously affecting pedestrian safety. This behaviour elevates the average travel speed of motorcycles, and contributes to a higher convenience for the type. These findings expose some of the many challenges that pedestrians are facing daily, and explain the poorer convenience of walking.

In the survey, 9 % of the respondents pointed out that a public transport enhancement would lead to a better walking experience. Furthermore, encroachment was also identified in the survey which led to a lower accessibility of the public transport system. Similar findings were described by the JICA Study Team (2015), where the poor perception of the actual buses is explained through the ageing bus fleet and encroached walking infrastructure preventing people from reaching public transport.

4.3.2 Street activities

As described in chapter 2.3, street activities play an important role in the Vietnamese lifestyle. Social interaction, rather than the development of building frontage, appears to be the more important part of public space (Storch et al., 2008). In the survey, participants assessed different street activities to evaluate their perception and their favourable effect on the pedestrian experience (Five-point Likert scale ranging from 1 – I strongly disagree to 5 – I strongly agree). The street activities are divided into 4 categories:

Street events:

- Street markets,
- Community events,
- Sport events,
- Street festivals, etc.

Street food vendors:

- Fruit vendors,
- Snack vendors,
- Coffee vendors,

  etc.

Street merchandise vendors:

- Hat vendors,
- Souvenir vendors,

  etc.

Street services:

- Hairdressers
- Shoeshiners,

  etc.

Source: Author's own photos, 2018

The results illustrated in Figure 4.3-2 point out, that street events (3.56) and street food vending (3.28) tend to positively influence the overall walking experience of the respondents. In contrast, street merchandise vending (2.87) and street services (2.71) are rather perceived negatively. The outcome of the statistical analysis indicates that the difference between the mean values is significant (Appendix, Table 13.2-9 and Table 13.2-10). The authors assume that street merchandise and street services are not as often used by pedestrians in comparison to street food stalls and street events. This hypothesis is backed by the findings on the main purpose of walking trips originating from the work-/school place (Figure 4.3-5). The answers "Eating out" and "Street food stalls" are, respectively, the largest and second-largest categories, pointing out that food facilities are very popular among employees and students. Street events are associated with leisure activities, and function as meeting points to hang out with friends and relatives, and are therefore positively perceived. Street merchandise vending and street services are activities that probably have a smaller customer base compared to street food vending and street events. The lower utilisation of street merchandise vending and street services may increase the perception of sidewalk encroachment, thus, negatively affecting the walking experience. No significant differences in the responses were observed between genders (Appendix Table 13.2-11 and Table 13.2-12).

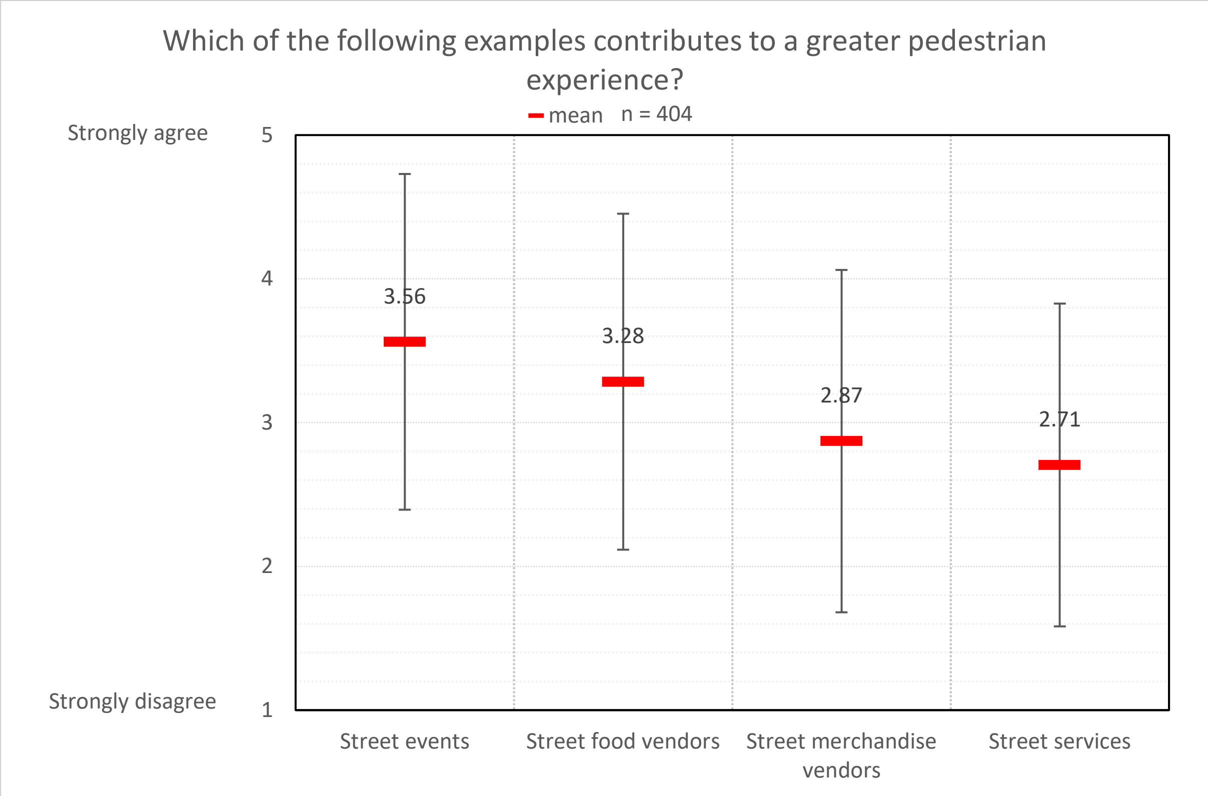

Figure 4.3-2: Perception of street activities. Source: Author's own

4.3.3 Respondents' proposals for walkability enhancement

This question was one of the three open-ended questions in the online survey, and explored the respondents' opinions to elevate the pedestrian experience. After translating the answers into English and categorising them into groups seen in Figure 4.3-3, it was possible to discern people's wishes to enhance their walkability perception. A good walking infrastructure combined with more greenery, shade, and favourable climate conditions were the most common answers. Air pollution, traffic safety, cleanliness, encroachment, and public transport enhancement have medium importance. Interestingly, the crime rate and social safety did not seem to be a major issue in the Vietnamese metropolis. In addition, "long walking trips" do not seem to be a major concern since most of the essential trips can be done within comfortable walking distance.

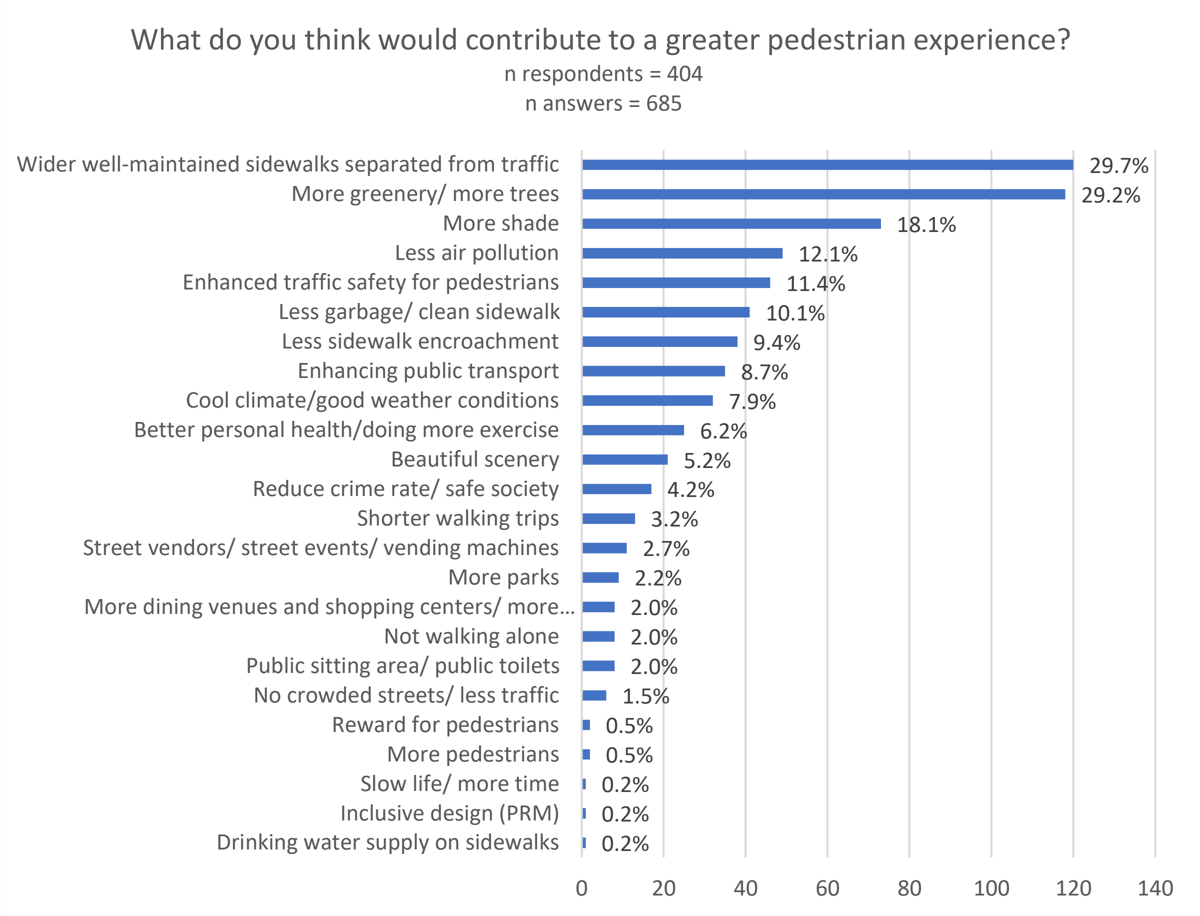

Figure 4.3-3: Respondents opinions about enhancing the pedestrian experience. Source: Author's own

4.3.4 Pedestrians' points of interest

In the survey, data about the purpose and the frequency of walking trips were collected. The idea was to define the points of interest for pedestrians and how they differ depending on their origin. Therefore, one question focused on the purpose of walking trips originating from home, another one on destinations of walking trips starting from work/school. After translating the responses into English and grouping them into categories as depicted in Figure 4.3-4 and Figure 4.3-5, it became possible to classify the most frequently encountered walking purposes. These questions were not mandatory. Participants who chose to answer, were free to provide multiple responses, as evidenced by the disparity between the number of respondents and the number of responses. The highest percentage of walking trips from home was "grocery shopping" (n = 138, 32.2 %). This highlights the significance of local centrality where shops of essential goods in residential areas are located within walking distance. Nevertheless, walks for "grocery shopping" departing from work/school (n = 41, 13.1 %) was not the predominant walking purpose. There is a tendency that people starting from work/school (n = 148, 47.3 %) are more likely to "eat out" in restaurants or street food stalls than people starting from home. "Street food stalls" (n = 45, 14.4 %) are still an important category that is frequently visited from work/school, as they are offering good and cheap alternatives to restaurants or other franchises. Further analysing Figure 4.3-4, "visit friends/family" (n = 44, 10.3 %), as well as "doing exercise" (n = 50, 11.7 %) is a common walking trip, that is preferred for those walking from home. On the opposite, these two categories starting from work/school were barely mentioned in the responses accounting for (n = 1, 0.3 %) and (n = 8, 2.6 %) respectively.

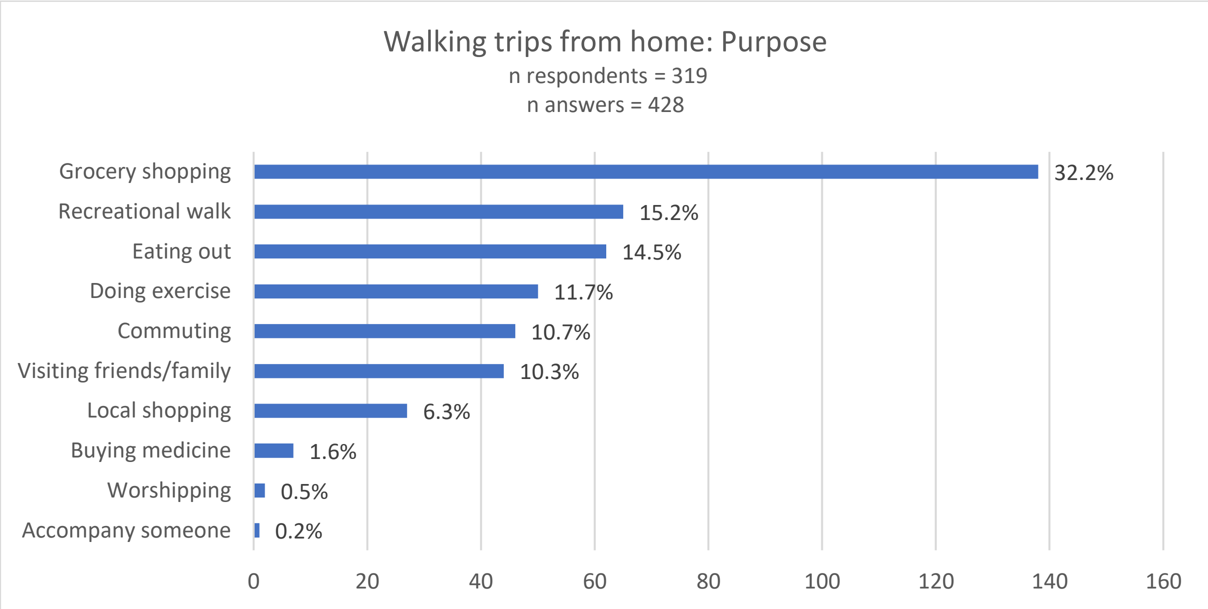

Figure 4.3-4: Number of walking trips to points of interest starting from home. Source: Author's own

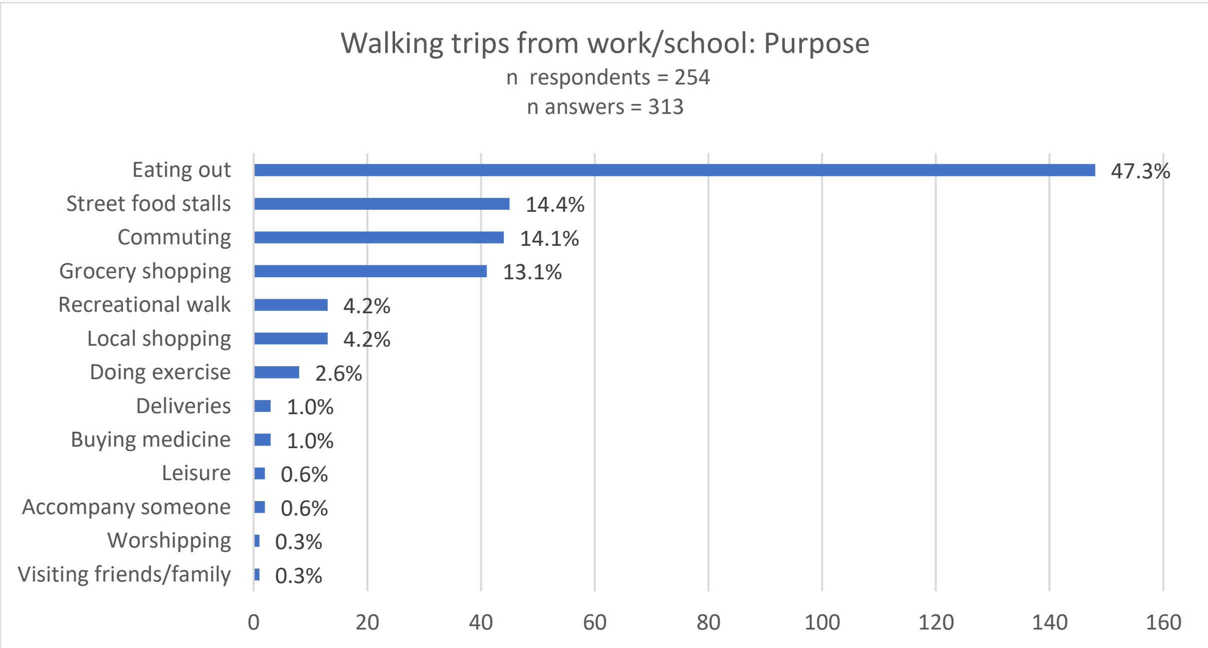

Figure 4.3-5: Number of walking trips to points of interest starting from work/school. Source: Author's own

4.4 Outcome of the online survey [AS & QT]

Based on the results of the online survey, the authors were able to determine the relevance of the walkability factors identified in the literature, as well as learn more about the mobility patterns and walking experiences of HCMC residents. The survey assisted in answering the first research question, which is about identifying the factors that discourage people from walking in HCMC.

The majority of the participants who took part in the survey live in the urban districts of HCMC (n = 392, 97.0 %) with the remaining respondents living in the rural areas of the city (n = 12, 3.0 %). Looking at the genders of the participants, a slightly higher share of female respondents compared to males was noticed. Due to the CAWI method that was used to conduct the survey, most of the participants had a high degree of education. Furthermore, the outcome of the survey indicated, that motorcycle ownership per household excels cars ownership. This outcome confirmed the information found in the literature about vehicle ownership. Moreover, the number of people who have motorcycle driving licenses is four times higher than the number of people who have car driving licenses, with only a small minority of people not having any driving license. This outcome was expected, as the import tax on cars is very high, and also most of the homes located in alleyways are only accessible by motorcycles. Additionally, the findings of the survey revealed that motorcycles are the most popular mode of transportation, particularly when compared to walking. According to the literature review, street activity is a very important aspect of HCMC. This was confirmed in the survey. Street food vending and street events are, in the respondents’ opinion, positively influencing the overall walking experience. The survey helped the authors identify the respondents’ opinions on how to enhance walkability, as well as which are the most common destinations for walking trips taken from home or work/school.

To conclude, the information and the results presented in this chapter, are helping the authors in developing the indicators which are designed for the WETUAV. Another important aspect is the weight of the indicators which must be taken into consideration. They were determined by a combination of literature reviews, the results from the survey, as well as subjective assessments of the authors.

5 Walkability Evaluation Tool for Urban Areas in Vietnam

5.1 Evaluation scheme [AS & QT]

The Walkability Evaluation Tool for Urban Areas in Vietnam is an Excel-based tool designed to rate pedestrian routes on a neighbourhood-level and street-level. The results of the WETUAV express a linear walkability score for the entire walking route and for each segment separately. Therefore, it can be used to rate the walkability between a starting point A and an endpoint B. The assessment is based on 12 indicators (Table 5.1-1) which will be further described in chapter 5.5 and chapter 5.6.

Table 5.1-1: Indicator overview of WETUAV. Source: Author’s own

Encroachment density index (EDI)
Pedestrian traffic safety index (PTSI)
Traffic air/noise pollution index (TANPI)
Sidewalk/street ratio index (SSRI)
Sidewalk condition index (SCI)
Local centrality index (LCI)
Tree canopy/-shadow index (TCSI)
Street activity index (SAI)
Social security index (SSI)
Availability of public transport (APTI)
Visual aesthetics index (VAI)
Walking amenities index (WAI)

After establishing the route's study area and defining the various route segments (chapter 5.2), the user assesses the WETUAV walkability criteria of the route using one of the three data collection methods presented in chapter 5.3. The acquired data is entered into the tool, and the WETUAV will summarise the walkability and indicator scores expressed on different scales (Table 5.1-2) in the WETUAV result table (chapter 5.4).

The first step consists of assessing the indicator scores for each segment separately. The indicator scores range from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. The walkability performance of each street segment will be evaluated by up to 12 indicator scores. The indicator score provides accurate information about the current walking conditions and intends to guide the users to identify walkability shortcomings. A walkability shortcoming occurs when the indicator score has a value below 2.50, representing the categories “not walking-friendly” and “bad walking conditions”. Furthermore, it highlights the need for walkability improvement measures.

The second step is the review of the walkability index score. The walkability index score is calculated by taking the average of the 12 indicator scores of a segment that illustrates walkability on a **street-level**. Calculating the mean value of the walkability index score for each segment results in the walkability index score of the entire route, and represent the walkability on a **neighbourhood-level**. The score is then converted into a percentage to facilitate its comparison with other walkability tools, such as, i.e., Walk Score®. The walkability index ranges from 0 % – representing bad walking conditions to 100 % – very walkable. Moreover, the walkability index score is derived into two variants:

- walkability index "raw", in which every indicator has equal importance and
- walkability index "weighted", in which indicators of higher importance have bigger weights, influencing the result.

To simplify the interpretation of the results, four colour-coded group intervals were created:

- Bad walking conditions
- Not walking-friendly
- Fairly walkable
- Very walkable

Table 5.1-2: Evaluation scheme WETUAV. Source: Author's own

WETUAV walkability scale		
	Indicator score	Walkability index score
Bad walking conditions	≥ 0.00 - < 1.25	≥ 0 - < 25 %
Not walking-friendly	≥ 1.25 - < 2.50	≥ 25 - < 50 %
Fairly walkable	≥ 2.50 - < 3.75	≥ 50 - < 75 %
Very walkable	≥ 3.75 - ≤ 5.00	≥ 75 - ≤ 100 %

5.2 Data collection [QT]

Before using the tool, it is necessary to set a walking route and define a study area. The route is then subdivided into several segments to evaluate the walkability on a street-level scale. The segment-based street-level is a more detailed analysis, and is used for walkability improvement measures. The scores of the 12 walkability indicators per segment intend to guide urban planners to identify local walkability shortcomings, and design walking-friendly solutions. The neighbourhood-level scale is used to assess the walkability around pedestrians' points of interest on a larger scope such as public transit stations, schools, shopping areas, etc. By combining the walkability scores from different routes in the same neighbourhood, a walkability map can be created. According to Huynh & Gomez-Ibanez (2017), the average pedestrian trip length in HCMC is around 1.2 km. As a result, the WETUAV is designed to cover walking routes of similar length. A segment is capable of describing the pedestrian-built environment on four different segment lengths:

- < 100 [m]
- ≥ 100 – < 250 [m]
- ≥ 250 – < 500 [m]
- ≥ 500 – < 1,000 [m]

The main objective of introducing different segment lengths was to keep a consistent data quality. Short segments will have higher accuracy and serve to rate sections having many events affecting pedestrians. Long segments are used to evaluate segments where the environment is "constant" for a longer distance, i.e., industrial zones. A segment "change" is chosen based on the occurrence of one of the following criteria:

- change of ward
- change of street name
- change in street typology
- segment exceeding 1 [km]

Street typologies used in this research are defined by the roadway width and street function (Table 5.2-1). Whereas pedestrian-only streets and alleyways have generally a good walkability score, because of its human-based design, walkability on wider streets tends to get worse when the number of lanes for motorised traffic increases. Also, estimating the width of larger roads tends to be more complicated for smaller streets. Therefore, by counting the number of lanes, the roadway width can be estimated, assuming that the average lane width is 3.5 m. For streets having more than two traffic lanes, the pedestrian-built environment is assessed for only one side of the street. The assessed street side is chosen by the study team and depend on the project goals.

Table 5.2-1: Definition of street typologies and associated assessment method. Source: Author's own

Street typologies	**Assessment method**
Pedestrian-only street [m]: • < 3.0 • ≥ 3.0 - < 10.0 • ≥ 10.0	For the street typologies "pedestrian-only street", "alleyway", "neighbourhood street" and "district street", the walking environment is assessed on <u>both sides</u> of the street.
Alleyway [m]: • < 1.0 • ≥ 1.0 - < 3.0 • ≥ 3.0	

Neighbourhood street [m]: • < 6.0 (2 lanes)	
District street [m]: • ≥ 6.0 - < 8.0 (2 lanes) • ≥ 8.0 - < 10.0 (2 lanes) • ≥ 10.0 - < 12.0 (2 lanes)	
Arterial street: • 3 lanes • 4 lanes • 5 lanes • 6 lanes	For the street typologies "arterial street" and "national road", the walking environment is assessed on <u>one side</u> of the street.
National road: • 7 lanes • 8 lanes • 9 lanes • 10 lanes • 11 lanes • 12 lanes • > 12 lanes	

5.3 Collection methods [QT]

The data collection of the Walkability Evaluation Tool for Urban Areas in Vietnam can be done by using three methods.

(1) The most basic approach is an *on-site data collection* method. Each segment is evaluated by filling out the predefined Excel input form during the on-site walk. Nevertheless, this method is not recommended by the authors since it is not efficient and would require walking the same route segment several times before collecting all of the 41 criteria. Furthermore, in case of an inappropriate segment length choice, it cannot be adapted at a later stage of the evaluation process, without surveying the route segments a second time.

(2) A much more suitable technique is the *on-site video footage* method. In this method, the built environment is recorded by walk and seems to have the highest accuracy for the following reasons:

   a. Flexibility to change the segment length after finishing the data collection process.
   b. Being able to watch the video footage several times to assess details that may have been previously overlooked.

c. Filming in a pedestrian's perspective gives an unobstructed view of the walking environment.
d. External factors which can influence the outcome of the score can be assessed (date and time of the survey, weather conditions)

(3) Another method that can be used for the data collection is the online *street imagery platforms* such as Google street view. This method is very useful for evaluating walking routes remotely. The main benefits of this method are:
a. quick access to the survey area
b. collecting the data remotely

However, street imagery providers do not cover the entire street network of a city and the data collection date greatly vary between the different street segments. Furthermore, since the data is assessed through a camera built on a motorised vehicle, pedestrian obstructions are harder to identify and may be hidden by other driving vehicles.

The sidewalk usage and activities greatly vary during the different times of the day. For having accurate data, it is preferable to compare walking routes from the same time periods. This is only possible by using on-site collection methods (on-site data collection, on-site video footage). The same route segments can also be assessed at different times of the day. The final walkability score is then expressed as the mean of the morning, noon, afternoon, and evening walkability scores. The time periods for the data collection are defined as follows:

- morning (6 am – 11 am)
- noon (11 am – 2 pm)
- afternoon (2 pm – 6 pm)
- evening (6 pm – 10 pm)

The Excel input data is then used by predefined formulas to calculate the indicator scores.

5.4 WETUAV layout in Excel [AS & QT]

The walkability evaluation tool is designed on a digital platform using Microsoft Excel software. In order to design an easy-to-use walkability evaluation tool for Urban Areas in Vietnam, it was important to keep the design as simple as possible while collecting only the necessary data. The introduction of data is assisted by colour-coded cells to support the user of the tool. As shown in Table 5.4-1, mandatory cells are coded in green, optional cells are blue and automatic generated cells are in yellow. Mandatory cells (green) include the data that needs to be recorded for calculating the walkability score. The different types of greens serve for a better orientation in the tool. It separates the collected data by topics such as, i.e., street conditions, street activity, encroachment, etc.

Optional input cells (blue) include the alleyway (and house) number of the starting and destination address of a route or segment. It can be left out for anonymity purposes.

Row indicator cells (red) are based on a Visual Basic for Applications (VBA) code. It helps the user to identify the row number of the selected cell with the matching row number of the assessment list of 41 criteria. For example, if the user is assessing the sidewalk width of segment five in cell (G21), the assessment list in cell (B21) containing the text "sidewalk width" will be shown in red. By clicking on another cell, the previous cell will become white again. This is especially useful to prevent mistakes while filling out segments characteristics that are further away from the assessment list.

Automatically generated cells (yellow) have predefined formulas. By filling out the mandatory cells, the yellow cells will automatically generate a value and do not need the intervention of the user.

Table 5.4-1: Legend of the colour codes used in the WETUAV. Source: Author's own

Mandatory input*		
Optional input*		
Row indicator		
Automatic generated		

* Depending on the number of route segments

The first part of the tool, seen below in the red frame, consists of collecting general information about the local conditions in which the on-site survey was conducted. This information includes the date of the survey, starting and ending time, survey duration, weather condition, temperature, and season (Table 5.4-2). These factors can heavily influence the pedestrian built environment, however, this information is not available when using street imagery platforms as the collection method. This information will help researchers identify the reason behind different pedestrian activities on certain days. Street activities for example vary throughout the day, and are weather-sensitive. Being able to determine the time, date, and weather conditions during the survey is crucial to trace the origin of the collected data before analysing it.

Table 5.4-2: Data input table about the date of survey, start & end time, and local weather conditions. Source: Author's own

Date of survey	2021-07-04
Start time [hh:mm]	9:30
End time [hh:mm]	9:41
Duration [min]	11
Weather conditions	Cloudy
Temperature [°C]	28
Season	Rainy season

The second part of the tool shown in the blue frame (Table 5.4-3) describes the location of the walking route. Mandatory cells (green) contain information about the district, ward, and street names. The tool can evaluate up to eight route segments with four-segment length categories (chapter 0). In densely urbanised areas, segment lengths below 500 meters are recommended due to the higher diversity of the built environment. Route segments between 500 and 1000 meters are used in industrial zones, or in street segments having very little variation of the walking infrastructure and street activities over longer distances. Adding more than eight route segments would add complexity to the general layout, and make the tool unpractical since the data collection would be too time-consuming for a single user. Adding the exact address of the starting and ending point of each segment is not mandatory. However, indicating the alleyway (and house) number can help to retrace the route on maps, and enhance the accuracy of the evaluation process.

Dividing the entire route into segments of four predefined lengths, using a drop-down list, helps to prevent too long walking segments, which would potentially lead to missing out on walkability shortcomings. Furthermore, each segment will have a separate walkability result enabling future users to identify the type, as well as the location of the shortcomings.

The population density is automatically generated depending on the selected district or ward. A higher population density is preferable to enhance proximity and mixed usage of a neighbourhood (chapter 5.6.6).

Table 5.4-3: Data input about the location of the route segments. Source: Author's own

	Street segment 1	**Street segment 2**	**Street segment 3**	**Street segment 4**
District	District 1	Select district...	Select district...	Select district...
Ward	Bến Thành	Select ward...	Select ward...	Select ward...
Street name	Đặng Trần Côn	Select street...	Select street...	Select street...
Alleyway number (optional)	Enter alleyway number...			
House number (optional)	Enter house number...			
Population density [inh./km²]	20914			

The third part of the tool, delimited by the purple frame, is the main data input table. All of the collected data are defined with drop-down lists. This section of the WETUAV collects 41 criteria that are necessary to calculate the 12 indicators (chapter 5.6). Those indicators are the backbone of the final walkability score of a chosen walking route. In Table 5.4-4, only the street characteristics and sidewalk conditions are shown to illustrate the layout of the excel sheet. The entire layout of the WETUAV can be found in the appendix (Table 13.3-1).

Table 5.4-4: Data collection table for the indicators of the WETUAV per segment. Source: Author's own

Route segment ID number		**1**	**2**
Street characteristics & sidewalk conditions	Segment length [m]	< 100	≥ 100 – < 250
	Street typology	Alleyway	District street
	Roadway width [m] or number of lanes	2.5 – 6.0	10.0 – 12.0 (2 lanes)
	Does the street have a sidewalk?	No, not necessary	Sidewalk on both sides
	Sidewalk/alleyway surface conditions	Good conditions	Moderate conditions
	Sidewalk width [m]	0.0	3.0 – 4.0
	Sidewalk cleanliness	Clean	Moderate

After developing each indicator according to the result of the survey and the literature review in chapter 5.6, further explanations about the relevance of the collected data and associated walkability enhancement recommendations of a route are summarised in Table 5.4-5.

Table 5.4-5: Relevance of collected data regarding walkability. Source: Author's own

Relevance of collected data regarding walkability	
Street characteristics & sidewalk condition	
Segment length	A higher segment length leads to a lower density of observed events, those events consist mainly of observed street activity events and encroachment events per route segment length. Lastly, it allows the user to estimate the total trip length. Starting a new segment at a change of street name, ward, street typology or when a segment exceeds a length of 1 km helps to mitigate that problem.
Street segment typology	Street typologies give information about the design concept of public space. Is it a human-scaled street design based on pedestrians or is it a street that is designed focusing on prioritising motorised vehicles?
Roadway width or number of lanes	Further developing the concept of street typologies, roadway width and number of lanes indicates the ease and safety for pedestrians to cross a street. The wider, the more challenging it becomes to safely cross a street. Besides, reducing the compactness of buildings in a neighbourhood leads to increased trip length to reach points of interest from the pedestrian's point of view. These issues are addressed in the pedestrian traffic safety and sidewalk/street ratio indicator.
Does the street segment have a sidewalk?	As soon as a street contains lanes reserved for motorised vehicles, the availability of sidewalks becomes essential to guarantee a pleasant and safe trip for pedestrians. Exceptions are Pedestrian-only streets and alleyways.
Sidewalk/alleyway surface conditions	The sidewalk/alleyway surface conditions heavily affect people's willingness to walk. Walking surfaces having holes and bumps makes walking difficult and increase the risk of falling and, as a result, injuries.
Sidewalk width	Sidewalk width indicates the space reserved for pedestrians in a street section. A narrow sidewalk would force pedestrians to walk on the street, exposing them to the risk of collision with motorised traffic. If the sidewalk is wide enough, other activities not related to walking but benefiting pedestrians such as trading, leisure or social spaces can be considered.

Sidewalk cleanliness	A clean environment is not only benefiting the well-being of pedestrians but also the whole neighbourhood. Waste is not only smelly and an eyesore to many people, but it also illustrates how strong the sense of community is to keep their surroundings clean.
Sidewalk/alleyway encroachment type affecting my walking trajectory encountered in this route segment	
Parked vehicles	Parked vehicles are the most common obstacles a pedestrian needs to encounter while walking in HCMC's streets. Increasing parking fares, only allowing parking on the streets, or distributing parking fines to people encroaching on sidewalks could be part of the solution.
Driving motorcycles on sidewalks	Driving motorcycles on sidewalks are mainly occurring during rush hour and are the most dangerous encroachment type identified in HCMC. High speeds combined with the legitimate perceived sense of pedestrian safety on sidewalks can lead to major conflicts and accidents.
Businesses encroaching on the sidewalk	Business spillovers are part of the lifestyle of HCMC and enrich the neighbourhood. Nevertheless, spillovers taking over most of the pedestrian space should be advised to reduce their encroachment.
Street vendors	Street vendors are socially and economically the most vulnerable public space users and are causing low encroachment compared to parked vehicles. If they are causing severe encroachment, nearby dedicated spaces with clean water access to improve the hygiene condition of their businesses should be considered.
Advertising signs	Advertisement signs blocking the flow of pedestrians should be removed.
Trees/plants	Trees and plants are generally very beneficial for pedestrians by creating a cool climate with shade. Since they are often put close to the curb, pedestrians should have clear access to pass between the trees and the building.
Bus stations/ metro entrances	Bus stations and metro entrances should be designed in a way to not fully occupy the section of a sidewalk.
Utility poles	Utility poles disturbing the pathway of pedestrians should be put in places where more space is available.
Type of urban neighbourhood	
Built environment	The type of neighbourhood is indicating the type of built environment in which the walking segment is located. Tube house neighbourhoods are historically not designed for cars; therefore, most shops of essential needs are within a walking distance. On the contrary, newly built single-use residential neighbourhoods consisting of separate houses are heavily reliant on cars to access daily necessities because of the induced additional distances.
Street activity index	
Trading activities	
Street food vendors	Trading activities are contributing to creating vibrant neighbourhood communities, the benefits towards walking being, the variation of functions throughout the day, increasing the diversity of a place as well as improving proximity. Eyes on the street increase the sense of safety from crime and enhance the overall attractiveness of a place by proposing many retail facilities. From a social perspective, tolerating street vendors provide a social safety net to the poor and prevents the gentrification of a place.
Street market	
Street merchandise vendors	
Street services	
Businesses expanding on the sidewalk	
Restaurant/Coffee/teashop spillover	
Social activities	
Street events	Social activities are indicating to who the public space is accessible by walk, a particular focus should be put on more vulnerable groups such as children,
Children playing	

People playing cards or board games	people with disabilities and the elderly. Is it safe for children to play outside? Is it convenient to exercise in the public space? Is it safe for the elderly to spend time outside? A place where neighbours socialise in front of their houses contributes to enhancing the sense of community and therefore also the sense of safety from crime.
People eating out or having drinks together	
People relaxing outside	
Public transport	
Is there a bus station in a 400m vicinity?	Access to public transport acts as a pedestrian feeder and a well-developed transport system with high reliability and frequency has the potential of greatly increasing the range of pedestrians on a city-wide level. As seen in many cities around the world, transit-oriented development can help to curb the use of private motorised vehicles.
Number of stations	A high density of stations in the vicinity is indicating a better connection to the public transport network.
Tree canopy/-shadow index	
Type of shadow	The type of shadow affects the temperature and the local climate. Shadows generated from greenery has the benefit of slightly cooling down the walking environment.
Shadow coverage	The shadow coverage indicates how much a pedestrian is exposed to direct sunlight. Vietnam being a tropical country, limiting sun exposure on sidewalks is very important to increase the willingness to walk.
Visual aesthetics	
Domestic plants/flowers in public space	Domestic plants in alleyways and flowers are enhancing the overall charm of the street, making it interesting for pedestrians.
Visually active frontage	"Visually active frontage promote safety from crime in walkable areas through informal observation and surveillance by people inside buildings." (ITDP, 2018, p.32). In this thesis, visually active frontage describes the visual interactions between people inside buildings and pedestrians outside in the public space.
Physically permeable frontage	"Sidewalks that are lined with continuous ground-floor activity and services have fewer zones of inactivity, thereby creating a more attractive walking environment that is safer from crime." (ITDP, 2018, p.32). In this research, frontage permeability describes the possibility of physical interactions between the public space and the private space. Buildings that are accessible by the general public are defined as physically permeable.
Street lighting	Street lighting not only serves comfort purposes but also increase security during the nighttime.
Landmarks (churches/pagodas/squares/rivers)	Landmarks such as places of worship, squares, parks, riverfronts are major points of interest for pedestrians, especially for leisure purposes.
Walking amenities	
Public sitting	Public sitting is an important amenity for pedestrians to rest without being forced to consume as is nowadays the case on privately owned stools.
Public garbage bin	Providing garbage bins helps maintain a clean and pleasant walking environment.
Public toilet	Public toilets enable people to accomplish longer trips by walking. This is especially true for recreational walking.
Rain shelter	Any type of shelter, protecting pedestrians from rain, is especially useful during brief rain showers occurring in the rainy season.
Traffic congestion of motorised vehicles	
Level of service	The level of service of motorised vehicles is a major factor that can be used to evaluate pedestrian traffic safety, as well as air and noise pollution of the walking environment.

The last section of the WETUAV, marked in green frame, shows the result of the whole walking route (Table 5.4-6). Each column represents a route segment. Per route segment, the lines include the scores of the 12 indicators [from 0.00 - representing bad walking conditions to 5.00 - very walkable]. Those results are critical when comparing the different route segments. Walkability shortcomings, occurring when an indicator score is below 2.50 (bad walking conditions, not walking-friendly), help users to identify the type and location of walkability problems. At the bottom of each column, the walkability index "raw" and the walkability index "weighted" is displayed. Further details about the weighting procedure will be discussed in chapter 5.7. The purpose of the average walkability index, illustrated in the last column, consists of the average of every segment score and enable a comparison with the results of other walkability tools such as Walk Score®. A route segment, having several walkability shortcomings are more likely to prevent people from walking and favour motorised transport modes. It can be seen that the scores of the indicators are divided into three categories; category A describes conflicts between pedestrians and other street users; category B describes physical walking space and infrastructure, and category C describes pedestrian comfort and convenience. To avoid incoherent comparisons between sections of the routes, each segment needs to have a minimum of eight indicators. This number was set by the authors to give the tool enough flexibility, in case of missing data while keeping a high data quality. Route segments not having sidewalks, cannot determine the encroachment density index. In this case, the maximum possible number of indicators for segments is 11. If a segment possesses data for less than eight indicators, the walkability index score will automatically not be calculated, and an error message "insufficient number of indicators" will be displayed as shown in Table 5.4-6.

Table 5.4-6: Example of result table illustrating the walkability and indicator scores of the WETUAV for a route with 2 segments. Source: Author's own

Indicators	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average
Category A: Conflicts between pedestrian and other street users									**91%**
Encroachment density index	5.0	5.0							5.0
Pedestrian traffic safety index	4.6								4.6
Traffic air/noise pollution index	4.0								4.0
Category B: Physical walking space and infrastructure									**69%**
Sidewalk/street ratio index	3.0								3.0
Sidewalk condition index	3.8								3.8
Local centrality index	3.5								3.5
Category C: Pedestrian comfort and convenience									**53%**
Tree canopy/-shadow index	4.0								4

Street activity index	0.0	0.0							0
Social security index									
Availability of public transport index	4.0								4
Visual aesthetics index									
Walking amenities index									
Walkability index raw	**64%**	**Insufficient number of indicators***							**64%**
Walkability index weighted	**73%**	**Insufficient number of indicators***							**73%**
*Number of valid indicators	9	2	0	0	0	0	0	0	

5.5 Indicator extraction process [AS & QT]

In the literature review, factors and indicators describing walkability in cities around the world were investigated. Opposed to Western countries, which are mainly car-dominated, Vietnam is a motorcycle-dependent country and has therefore a very different urban structure and modal split. This fact needed to be taken into account while searching for indicators that are suiting Vietnam's walking challenges. Consequently, the literature research mainly focused on South-East Asian cities, which had similar features to Vietnamese urban centres. The built environment and challenges of pedestrians in Ho Chi Minh City were analysed and walkability factors that seemed to address these issues were selected and summarised in a preliminary walkability factor list. This list was then included in the questionnaire to study their relevance for the residents of HCMC (chapter 4.2). Based on the preliminary list, described in (chapter 2.7) and the outcome of the survey, a total of 12 walkability indicators were developed for the Walkability Evaluation Tool for Urban Areas in Vietnam (WETUAV). These indicators were selected or adapted based on the respondents' opinion and their relevance in the Vietnamese metropolis. To cover all major pedestrian hurdles that were mentioned in the questionnaire efficiently, the indicators describe different aspects of walkability such as environment perception, convenience, and well-being of pedestrians in HCMC. This chapter addresses the second research question relating to the creation of suitable walkability indicators in the context of HCMC (chapter 1.4 for more details).

The indicators will assess the potential conflicts between pedestrians and other road users, the quality of the pedestrian infrastructure and the perception of the built environment. The requirement of the Walkability Evaluation Tool for Urban Areas in Vietnam was to measure the pedestrian-friendliness of a neighbourhood in three steps. First, a walking route is selected by the user, which is then divided into different segments. Collecting the data through the input form of the Evaluation Tool in Excel, automatically leads to the second step, without any intervention of the user. The input data is processed through the predefined formulas in Excel and calculates the indicator scores. Some indicators have overlapping input data but have slightly different formulas.

The list of 12 indicators is classified into 3 categories (A, B, C) and are briefly described in Table 5.5-1. The indicators and categories are further described in the following subchapters. It should be noted that the creation of the indicator list and categories is a complex process since some indicators overlap in different categories or influence each other. Therefore, the following categorisation should be understood as a recommendation from the authors' subjective perspective.

Table 5.5-1: List of indicators. Source: Author's own

Category A: Conflicts and impairment potential
A1 Encroachment density index
A2 Pedestrian traffic safety index
A3 Traffic air/noise pollution index
Category B: Space and infrastructural conditions
B1 Sidewalk/street ratio index
B2 Sidewalk condition index
B3 Local centrality index
Category C: Pedestrian comfort
C1 Tree canopy/-shadow index
C2 Street activity index
C3 Social security index
C4 Availability of public transport
C5 Visual aesthetics index
C6 Walking amenities index

In chapters 5.5.1, 5.5.2 & 5.5.3, the indicators of the three categories are briefly summarised and will be further described afterwards.

5.5.1 Category A: Conflicts between pedestrians and other street users

Category A describes physical interactions negatively affecting the well-being of pedestrians. A high occurring rate of conflictual events leads to a bad walkability score. One of the most critical problems pedestrians are enduring are conflicts with motorised vehicles. The higher mass and speed of motorised vehicles make pedestrians particularly vulnerable to accidents.

In Vietnam, sidewalk encroachment is occurring daily. Parked motorcycles, businesses, invading in some cases the entire cross-section of a sidewalk, are forcing pedestrians to step down on the street and expose them to the risk of being hit by a vehicle. As a result, the main purpose of sidewalks, which is to protect pedestrians from motorised vehicles, is not anymore guaranteed. This problem is assessed by the encroachment density index (chapter 5.6.1).

Pedestrian traffic safety is another source of conflict between motorised vehicles and pedestrians. Generally, a congested road will cause more motorcyclists to use the sidewalks to bypass traffic jams. Furthermore, the availability of sidewalks is a necessity in streets with a high share of motorised vehicles and high driving speeds. On the other hand, alleyways and pedestrian-only streets, both having very low or no motorised traffic at all, are not requiring sidewalks. Lastly, the number of lanes indicate the distance a pedestrian needs to overcome to cross the street and is critical since most car/motorcycle drivers tend to not respect pedestrians' priority at crosswalks. This attitude of motorists affects pedestrians traffic safety (chapter 5.6.2).

Heavy motorised traffic is the main source of air and noise pollution. Bad air quality is a major source of cardiovascular and respiratory diseases and affects public health whereas noise pollution is impacting the pedestrians' well-being by making their conversations inaudible. Since traffic is the main origin of both, air and noise pollution, it was possible to merge it into a single indicator (chapter 5.6.3).

5.5.2 Category B: Physical walking space and infrastructure

Category B describes the built environment in which pedestrians travel. This includes the physical space allocated for walking such as the sidewalk characteristics and the surrounding urban structure.

The sidewalk/street ratio defines the space shared between the different transport modes. A higher ratio indicates that there is more space in a street cross-section reserved for pedestrians than for motorised vehicles resulting in a pedestrian-friendly space distribution (chapter 5.6.4).

Sidewalk condition is another indicator documenting the quality of the existing walking infrastructure. This includes the smoothness of the walking surface, the availability of sidewalks when higher volumes and speed of motorised vehicles makes it necessary, the width and cleanliness of sidewalks (chapter 5.6.5).

The physical walking space can also be understood as the urban structure of a neighbourhood and its associated proximity. A compact urban environment limits land consumption, creates diverse neighbourhoods with a wide variety of uses and shortens walking trips (Storch et al., 2008). Walking is a much more common mode of transportation over shorter distances (ITDP, 2018). To maintain walking-friendly neighbourhoods, the neighbourhood type and residential density are used to describe the proximity (chapter 5.6.6).

5.5.3 Category C: Pedestrian comfort and convenience

Lastly, category C contains the indicators that have positive effects on walkability and contribute to higher pedestrian comfort and convenience. A higher density of the features defining these indicators will therefore positively influence the outcome of the final walkability score.

The outcome of the survey and the results from Loc & Kim (2018) show that the presence of tree canopies and shadows was an indicator of high importance for the comfort and welfare of pedestrians in Ho Chi Minh City. A high shadow coverage and greenery are helping to reduce the temperature of the environment (chapter 5.6.7).

Street activities, such as street food vending, enhance the appeal of streets by diversifying the use of public spaces. Furthermore, it provides temporary jobs to more vulnerable social groups, acting as a social safety net for many immigrants with lower education levels (chapter 0).

In addition, their presence is often referred to as "eyes on the street" during the night or early morning hours, when the streets tend to be empty, enhancing the perception of safety against crime (chapter 5.6.9).

Accessibility to public transport plays a major role as a pedestrian feeder since it greatly extends the range of pedestrians without the need of private vehicles. The proximity to the bus station and the number of bus stations are used to describe the quality of the public transport (chapter 5.6.10).

Visual aesthetics represent another aspect of the streets' appeal from the pedestrians' point of view. This includes plants and flowers decorating the public space. The rate of the visually active frontage of buildings, which is defined by visually penetrable areas, such as windows or wide-open areas, that enable eye contact between the interior and exterior of buildings. Physically permeable frontage is a similar factor as the visually active frontage but, is defined by the accessibility of storefronts and restaurants. Lastly, street lighting is not only enhancing walking comfort during nighttime but is also having an important influence on people's safety perception (chapter 0).

Another argument regarding comfort is the availability of walking amenities, such as benches and public toilets, enabling pedestrians to increase their walking range. This is especially true for recreational walking (chapter 5.6.12).

5.6 Developed indicators & formulas [QT]

Each indicator in this chapter evaluates every segment separately and have scores ranging from 0.00 - representing bad walking conditions to 5.00 – very good walking conditions.

5.6.1 A1 – Encroachment density index (EDI)

As derived from the survey with inhabitants of HCMC, "Less sidewalk encroachment" (9 %) and "Wider well-maintained sidewalks separated from traffic" (30 %), are accounting for 39% of the respondent's opinions about enhancing the pedestrian experience (Figure 4.3-3). Similar results were found in a study of the Asian Development Bank (ADB) analysing walkability and pedestrian facilities in Asian cities. In their study, 21 % of the respondents were from Vietnam with Hanoi and HCMC each having a share of 500 respondents. "Wider, levelled and clean sidewalks/footpaths" and "Removal of obstacles/parking from footpaths" were the first and second highest priority of the respondents for improving pedestrian facilities (Fabian et al., 2010, p.30). However, not every street needs a sidewalk. A relatively low motorised traffic flow and strict enforcement of driving speeds below 20 km/h encourage pedestrians to share the space (ibid.). In HCMC, having a network of 5,000 km of alleyways (Huynh & Gomez-Ibanez, 2017), these conditions are often met. The length of the alleyways limit the maximum speed of motorised vehicles as seen in the example illustrated in Figure 5.6-1. As a result, the encroachment density index is not applicable in alleyways and pedestrian-only streets.

Figure 5.6-1: Typical alleyway network in District 5, HCMC. Source: Author's own based on a cadastral map of HCMC

Since encroachment regularly occurs on HCMC’s sidewalk infrastructure, thus threatening pedestrians’ safety and convenience by forcing them to step down on the motorised traffic lane, the encroachment density index is vital for evaluating the current walking conditions. An encroachment event is defined as follows:

- less than 1.5 [m] clearance on the sidewalk or,
- pedestrians are forced to step down on the street to avoid obstacles or,
- motorised vehicles driving on the sidewalk to bypass traffic jams.

The encroachment density index evaluates eight kinds of different encroachment types which restrict the accessibility and usability of existing pedestrian infrastructure. Before determining an encroachment event, the users need to remember the definition of encroachment mentioned above. I.e., parked vehicles not obstructing pedestrians by leaving a minimum gap on the sidewalk of one meter, is not considered as encroachment. The input data for the encroachment density index is assessed by counting the number of encroachment events per segment for the eight following categories:

(1) Parked vehicles obstructing the sidewalk [No. of vehicles/segment]
(2) Motorised vehicles driving on sidewalks [No. of vehicles/segment]
(3) Businesses encroaching the sidewalk [No. of businesses/segment]
(4) Street food/merchandise stalls obstructing the sidewalk [No. of stalls/segment]
(5) Advertising signs obstructing the sidewalk [No. of signs/segment]
(6) Trees obstructing the sidewalk [No. of trees/segment]
(7) Bus stations/ metro entrances obstructing the sidewalk [No. of stations/segment]
(8) Utility poles obstructing the sidewalk [No. of items/segment]

The sum of the total number of encroachment events and the number of encroachment categories [1 - 8] are rated as scores ranging from 0.00 - representing bad walking conditions to 5.00 – very good walking conditions (Table 5.6-1 and

Table 5.6-2). The higher the number of total encroachment events is, the lower the result of the “Number of events score” will be. The “Number of categories score” is calculated the same way. The evaluation matrix is dependent on segment length, and is defined by four distance ranges:

- < 100 [m]
- ≥ 100 – < 250 [m]
- ≥ 250 – < 500 [m]
- ≥ 500 – < 1,000 [m]

Table 5.6-1: Number of events per street segment length and resulting encroachment events score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author’s own

	Segment length			
Number of events	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
None	5.00	5.00	5.00	5.00
1	4.00	4.25	4.50	4.75
2	3.00	3.50	4.00	4.50
3	2.00	2.75	3.50	4.25
4	1.00	2.00	3.00	4.00
5 or more	0.00	0.00	0.00	0.00

Table 5.6-2: Number of categories per street segment length and resulting encroachment categories score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author’s own

	Segment length			
Number of categories	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
None	5.00	5.00	5.00	5.00
1	4.00	4.25	4.50	4.75
2	3.00	3.50	4.00	4.50
3	2.00	2.75	3.50	4.25
4	1.00	2.00	3.00	4.00
5 or more	0.00	0.00	0.00	0.00

The mean value of the encroachment events score and encroachment categories score results in the final encroachment density index (Equation 5.6-1).

$$\text{Encroachment density index (EDI)} = \frac{\text{Encroachment events score} + \text{Encroachment categories score}}{2}$$

Equation 5.6-1: Encroachment density index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author’s own

Example

Table 5.6-3: Example of a segment evaluation for defining the encroachment density index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

<table>
<tr><td colspan="2">Encroachment density in segment 1 (≥ 100 – < 250 [m])</td></tr>
<tr><td>Encroachment category:
• Parked vehicles obstructing the sidewalk (5 or more [vehicles/segment])
Number of encroachment events = 5</td><td></td></tr>
<tr><td>Encroachment category:
• Parked vehicles obstructing the sidewalk (2 [vehicles/segment])
• Utility items obstructing the sidewalk (1 [item/segment])
Number of encroachment events = 3</td><td></td></tr>
<tr><td colspan="2"><u>Encroachment density in segment 1 (≥ 100 – < 250 [m])</u>
8 events and segment length (≥ 100 – < 250 [m]) → (Table 5.6-1)
2 categories and segment length (≥ 100 – < 250 [m]) → (
Table 5.6-2)
Encroachment events score = 0.00
Encroachment categories score = 3.50
Encroachment density index for segment 1: $EDI_{S1} = \frac{0.00 + 3.50}{2}$ = 1.75 (not walking-friendly)</td></tr>
</table>

5.6.2 A2 - Pedestrian traffic safety index (PTSI)

The pedestrian traffic safety index is defined as the exposure of pedestrians to conflicts with other motorised transport modes and ranges from 0.00 - representing bad walking conditions to 5.00 – very good walking conditions. It contains five evaluation criteria (Table 5.6-5).

The *first criterion* is the traffic volume (TV) which is described by the level of service (LOS) for motorised vehicles as defined in the Highway Capacity Manual of the Transport Research Board (TRB, 2016). The qualitative measurement scale of the LOS is shown in Table 5.6-4. A higher volume of motorised traffic leads to an increased likelihood that people will drive on the sidewalk or close to the curb, thus increasing the risk of a collision in case of sidewalk encroachment. Furthermore, a high traffic volume increases the risk of collision at pedestrian crosswalks.

Table 5.6-4: Level of Service. Source: TRB, 2016

LOS A	Free Flow
LOS B	Reasonably free flow
LOS C	Stable flow
LOS D	Approaching unstable flow
LOS E	Unstable flow
LOS F	Forced or breakdown flow

The *second criterion* assesses the sidewalk encroachment density (ED). The assumption is that a higher encroachment density on sidewalks forces pedestrians to walk on the street to bypass obstacles. This does not only lead to inconvenience but also create conflicts between slow-moving pedestrians and faster driving motorised vehicles. The encroachment, already assessed in the encroachment density index (A1), is integrated into the pedestrian traffic safety equation (Equation 5.6-3).

The *third criterion* is the availability of sidewalks (SAVAL). Sidewalks are not necessary for pedestrian-only streets and alleyways, since the inexistent or low traffic volume, and limited vehicle speed enables safe space sharing. For street typologies having lanes reserved for motorised vehicles, thus enabling higher speeds, the availability of sidewalks in the surveyed route segments is vital to maintain a high degree of pedestrian safety.

The *fourth criterion* impacting pedestrians' well-being is driving motorised vehicles on the sidewalk (DVOS). This encroachment type is associated with higher speeds and is one of the most hazardous threats to pedestrians. Therefore, it is assessed separately from the other encroachment types.

The *fifth criterion* is the street typology described by the roadway width or the total number of lanes (RWNL). A higher roadway width or a high number of lanes lead to a longer crossing distance for pedestrians. Hence, the city needs main arteries to cope with the high traffic volume and to establish a high-quality bus network. Therefore, street sections having 6 lanes or less still have a value above 2.50, which leaves them in the walking-friendly spectrum of the WETUAV walkability scale.

Table 5.6-5: Evaluation of pedestrian traffic safety criteria resulting in the criteria score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Pedestrian traffic safety criteria		**Criteria score**
1. Traffic volume (TS) [LOS]	LOS A	5.00
	LOS B	4.00
	LOS C	3.00
	LOS D	2.00
	LOS E	1.00
	LOS F	0.00
2. Encroachment density (ED)	Encroachment density index score	

3. Sidewalk availability (SAVAL)	Sidewalk on both sides	5.00
	Sidewalk on one side	3.00
	No sidewalk	0.00
4. Driving vehicles on the sidewalk (DVOS) [number]	0	5.00
	1	4.00
	2	3.00
	3	2.00
	4	1.00
	5	0.00
5. Roadway width or number of lanes (RWNL)		
5.1. Pedestrian-only street or alleyway	-	5.00
5.2. Neighbourhood street [roadway width, m]	< 6.0 (2 lanes)	5.00
5.3. District street [roadway width, m]	6.0 - 7.9 (2 lanes)	4.80
	8.0 - 9.9 (2 lanes)	4.60
	10.0 - 12.0 (2 lanes)	4.40
5.4. Arterial Street [No. of Lanes]	3 Lanes	4.00
	4 Lanes	3.50
	5 Lanes	3.00
	6 Lanes	2.50
5.5. National road [No. Of Lanes]	7 Lanes	2.00
	8 Lanes	1.50
	9 Lanes	1.00
	10 Lanes	0.50
	11 Lanes	0.00
	12 Lanes	0.00

If the sidewalk availability is "No sidewalk" for street typologies including lanes reserved for motorised vehicles, the pedestrian traffic safety index is 0.00 -representing bad walking conditions, as indicated in Equation 5.6-2.

$$\text{Pedestrian traffic safety index (PTSI)} = 0$$

Equation 5.6-2: Pedestrian traffic safety index for streets not providing sidewalks [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

The average of the five criteria is calculated to give the pedestrian traffic safety index as shown in Equation 5.6-3:

$$\text{Pedestrian traffic safety index (PTSI)} = \frac{\text{TV} + \text{ED} + \text{SAVAL} + \text{DVOS} + \text{RWNL}}{5}$$

Equation 5.6-3: Pedestrian traffic safety index for streets providing sidewalks [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

5.6.3 A3 - Traffic air/ noise pollution index (TANPI)

Ho Chi Minh City is notorious for its chronic congestion issues and its poor air quality due to exhaust fumes. About 70 % of the city's total emissions are emitted by traffic (Hoi, 2020). Similarly, traffic is the main source of urban noise pollution, the measured daily average noise levels exceed 72 dB (Phan et al., 2010). In order to optimise and reduce the number of indicators in the WETUAV, the traffic air pollution indicator and noise pollution indicator were merged and assessed as one. Based on the statistics of 2020, there are more than 9 million motorcycles and 500 thousand cars of all kinds registered in Ho Chi Minh City for a total population of 9 million (Hoi, 2020), making the city private motorised vehicles dependent. Therefore, it was assumed that by qualitatively measuring the LOS (Level of Service) for motorised vehicles for each segment, using the same scale as described in the pedestrian traffic safety index (A2) (Table 5.6-4) and the street typology, the air and noise pollution of the walking environment could be determined. The assumption taken in this research was that combining the LOS with the street typology, describing roadway width or the number of lanes, would approximately indicate the number of motorised vehicles in the surveyed segment. A 12-lane national road with a LOS F has, because of its bigger capacity, more motorised vehicles than a 2-lane neighbourhood street with a LOS F. As a result, the bigger amount of traffic will result in a lower score for the traffic air/noise pollution index. The evaluation matrix used for this index is shown in Table 5.6-6. Alleyways were defined in three categories based on their cross-section width; < 1.0 [m] represent alleyways only accessible on foot; 1.0 – 3.0 [m] characterise alleyways accessible by pedestrians and motorcycles and > 3.0 [m] are alleyways accessible by pedestrians, motorcycles, and cars. Since pedestrian-only streets and alleyways have no or very little capacity regarding motorised vehicles, the traffic air/noise pollution index remains at 5 for these street types.

Table 5.6-6: Traffic air/ noise pollution index depending on roadway width and LOS [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

		LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
Pedestrian-only street [cross-section width, m]	< 3.0	5.00	5.00	5.00	5.00	5.00	5.00
	3.0 – 10.0	5.00	5.00	5.00	5.00	5.00	5.00
	> 10.0	5.00	5.00	5.00	5.00	5.00	5.00
Alleyways [cross-section width, m]	< 1.0	5.00	5.00	5.00	5.00	5.00	5.00
	1.0 – 3.0	5.00	5.00	5.00	5.00	5.00	5.00
	> 3.0	5.00	5.00	5.00	5.00	5.00	5.00
Neighbourhood street [roadway width, m]	2 lanes (< 6.0)	5.00	4.65	4.30	3.95	3.60	3.25
District street [roadway width, m]	2 lanes (6.0 – 7.9)	5.00	4.60	4.20	3.80	3.40	3.00
	2 lanes (8.0 – 9.9)	5.00	4.55	4.10	3.65	3.20	2.75
	2 lanes (10.0 – 12.0)	5.00	4.50	4.00	3.50	3.00	2.50
Arterial street [No. of lanes]	3 lanes	5.00	4.45	3.90	3.35	2.80	2.25
	4 lanes	5.00	4.40	3.80	3.20	2.60	2.00

	5 lanes	5.00	4.35	3.70	3.05	2.40	1.75
	6 lanes	5.00	4.30	3.60	2.90	2.20	1.50
National road [No. of lanes]	7 lanes	5.00	4.25	3.50	2.75	2.00	1.25
	8 lanes	5.00	4.20	3.40	2.60	1.80	1.00
	9 lanes	5.00	4.15	3.30	2.45	1.60	0.75
	10 lanes	5.00	4.10	3.20	2.30	1.40	0.50
	11 lanes	5.00	4.05	3.10	2.15	1.20	0.25
	12 lanes	5.00	4.00	3.00	2.00	1.00	0.00
	> 12 lanes	5.00	3.95	2.90	1.85	0.80	0.00

5.6.4 B1 - Sidewalk/street ratio index (SSRI)

The sidewalk/street ratio index is used to rate the space allocated to pedestrians. By reducing the amount of space allocated to motorised modes of transportation, more room is available for pedestrian infrastructure, such as sidewalks, and car speeds and volumes are reduced, resulting in a sheltered and more suitable walking environment (ITDP, 2018). Less than 15.0 % of the total area should be devoted to motorised transport modes with the remaining 85.0 % shared between active modes of transport (ibid.). The Institute for transportation and development policies (ITPD) developed the *Pedestrians First* tool to interpret walkability and measure the features promoting walkability in cities throughout the world.

In this study, the authors' methodology to evaluate the sidewalk/street ratio slightly differs from the methodology used by ITDP (2018). As the other transport modes besides walking were not considered in this research, the optimal sidewalk/street ratio was lowered and set at 60.0 % space reserved for pedestrians. Furthermore, the economic growth of HCMC puts immense pressure on the existing road network, and the current public transport system cannot substitute the majority of trips currently done by private motorised vehicles, thus limiting alternatives for longer trips.

The sidewalk/street ratio index used in WETUAV consists of two sub-indices illustrated in Table 5.6-7 and Table 5.6-8. The sidewalk/street ratio is calculated by forming in a defined street segment the ratio [%] of the width [m] for pedestrians (sidewalk) and the total cross-section width [m]. The resulting resulting score is, ranging from 0.00 - representing bad walking conditions to 5.00 - very good walking conditions. The sidewalk/street ratio score reaches the highest score (5.00) when it exceeds 60.0 % space for pedestrians.

Table 5.6-7: Sidewalk/street [%] of a street cross-section and associated sidewalk/street score ranging from 0.00 - representing bad walking conditions to 5.00 - very good walking conditions. Source: Author's own

Sidewalk/street ratio [%]	Sidewalk/street ratio score
> 60	5.00
> 54 - ≤ 60	4.50
> 48 - ≤ 54	4.00
> 42 - ≤ 48	3.50
> 36 - ≤ 42	3.00
> 30 - ≤ 36	2.50
> 24 - ≤ 30	2.00
> 18 - ≤ 24	1.50
> 12 - ≤ 18	1.00
> 6 - ≤ 12	0.50
≤ 6	0.00

The authors assume that a high width of the street segment, and a high number of traffic lanes, the distance between buildings increases and negatively affects the walking experience. For example, a 60 m wide street, fully pedestrianised would result in a 100.0 % sidewalk/street ratio. This would incorrectly lead to a very high score and erroneously influence positively the overall walkability score. To counteract this trend, the authors decided to introduce the street typology index as seen in Table 5.6-8. If the surveyed street segment is a pedestrian-only street or an alleyway, the sidewalk/street ratio cannot be calculated because of the inexistent sidewalk infrastructure. In such a case, the tool will indicate "Not applicable (N/A)" and only considers the street typology index for expressing the sidewalk/street ratio index.

Table 5.6-8: Street typology score based on the type of street segment ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Street typology	Street typology score
Pedestrian-only street	5.00
Alleyway	4.50
Neighbourhood street	4.00
District street	3.00
Arterial street	2.00
National road	0.00

The sidewalk/street ratio index is calculated as the mean of the street typology score and the sidewalk/street ratio score as illustrated in Equation 5.6-4:

$$\text{Sidewalk/street ratio index (SSRI)} = \frac{\text{Street typology score} + \text{Sidewalk/street ratio score}}{2}$$

Equation 5.6-4: Sidewalk/street ratio index ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

5.6.5 B2 - Sidewalk conditions index (SCI)

Complete, continuous, and safe walkway networks that give clear protection from motorised vehicles which are accessible to all people, including those with impairments, are the most basic aspects of urban walkability (ITDP, 2018). Even though the authors acknowledge the importance of an inclusive sidewalk design in modern-day mobility, in this study, the authors decided not to consider evaluating the inclusive design for people with disabilities in the WETUAV. Although Vietnam has acceded to the United Nations Convention on persons with disabilities, including the design and construction of public transport works in urban areas, in practice, a large part of the city's infrastructure still does not support the needs of the disabled (Truong et al., 2017). For this reason, it makes little sense to assess and evaluate the infrastructure for disabled people. In addition, sidewalks at-grade would in today's situation be making the sidewalk even more accessible for motorcycles, thus worsening pedestrians' safety. The sidewalk condition index in the WETUAV considers four evaluation criteria (Table 5.6-9) and are defined as follows.

The *first criterion* is sidewalk availability (SAVAL). Streets not requiring sidewalks, for instance, pedestrian-only streets and alleyways, are only evaluated based on the condition of the sidewalk surface and the cleanliness. Sidewalk availability and sidewalk width are getting the result "Not applicable (N/A)".

The *second criterion* is the sidewalk/alleyway surface conditions (SCOND) and it assesses the surface quality of the walking areas (Figure 5.6-2). A well-maintained sidewalk surface increase walking comfort and avoids injuries by preventing pedestrian from stumbling.

Good sidewalk surface condition

Moderate sidewalk surface condition

Bad sidewalk surface condition

Figure 5.6-2: Examples of sidewalk conditions in HCMC. Source: Author's own, 2019

The *third criterion* represents sidewalk width (SWW). Contrary to Western countries, where the sidewalks' primary function is to cater only for pedestrians, in HCMC the sidewalk life diversify the use of walkways, as described in chapter 2.3. These functions include:

- Walking,
- space reserved for tree planting,
- street vending,
- motorcycle parking,
- leisure activities, outdoor exercise
- business spillovers.

As a result, a more generous sidewalk width is preferable to preserve those features which foster street activities and benefit the overall walkability (Figure 5.6-3).

Sidewalk width 3 – 4 [m]

Observed sidewalk usage:

motorcycle parking, business spillover, tree, utility pole

Sidewalk width > 5 [m]

Observed sidewalk usage:

Juice shop spillover, motorcycle parking, tree

Figure 5.6-3: Example of sidewalk cross-sections and the diversity of sidewalk usage. Source: Author's own, 2018

The *fourth criterion* addresses sidewalk cleanliness (SCL). The survey results indicate that 10.1 % of the respondents expressed their wish for a cleaner sidewalk (Figure 4.3-3). The findings of the study about pedestrian facilities in Asian Cities confirmed that clean sidewalks are one of the pedestrians' top priorities (Fabian et al., 2010).

Table 5.6-9: Sidewalk conditions criteria and associated score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

		Score
Sidewalk availability (SAVAL)	Sidewalk on both sides	5.00
	Sidewalk on one side	3.00
Sidewalk/alleyway surface conditions (SCOND)	Good conditions	5.00
	Moderate conditions	3.00
	Bad conditions	0.00
Sidewalk width [m] (SWW)	> 5.0	5.00
	> 4.0 - ≤ 5.0	4.50
	> 3.0 - ≤ 4.0	4.00
	> 2.0 - ≤ 3.0	3.50
	> 1.0 - ≤ 2.0	2.00

	≤ 1.0	0.50
Sidewalk/alleyway cleanliness (SCL)	Clean	5.00
	Moderate	3.00
	Dirty	0.00

If the street typology is "alleyway" or "pedestrian-only street", sidewalks are not necessary because of the pedestrian-friendly nature of their design. Alleyway layouts are mostly narrow and short in distance, often ending in dead ends, limiting the maximum possible speed of motorised vehicles. Pedestrian-only street layouts reserve the available public space exclusively for walking, therefore removing the conflicts between pedestrians and motorised vehicles. As a result, the sidewalk conditions index for alleyways and pedestrian-only street typologies are calculated without considering the sidewalk availability (SAVAL) and sidewalk width (SWW) (Equation 5.6-5).

$$\text{Sidewalk conditions index (SCI)} = \frac{\text{SCOND} + \text{SCL}}{2}$$

Equation 5.6-5: Sidewalk conditions index for alleyways & pedestrian-only streets [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

If the street segment includes lanes for motorised vehicles leading to higher traffic volumes and driving speeds, sidewalks become a necessity for protecting pedestrians from other road users. Consequently, if the sidewalk availability (SAVAL) is set as "no sidewalk", the sidewalk condition index gets the score of 0.00 - representing bad walking conditions (Equation 5.6-6).

$$\text{Sidewalk conditions index} = 0.00$$

Equation 5.6-6: Sidewalk conditions index for streets having higher volumes of motorised traffic without providing sidewalks [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Since the sidewalk width (SWW) is representing the space allocated for pedestrian mobility in a motorised environment, a sufficient width is essential to offer a safe travel experience. Therefore, the authors decided to add a weighting factor of 2 in the sidewalk conditions index formula (Equation 5.6-7).

$$\text{Sidewalk conditions index (SCI)} = \frac{\text{SAVAL} + \text{SCOND} + (2 * \text{SWW}) + \text{SCL}}{5}$$

Equation 5.6-7: Sidewalk conditions index for streets with sidewalks [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Example

Table 5.6-10: Example of a segment evaluation for defining the sidewalk conditions index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own, 2018

Sidewalk conditions index in segment 1	
Sidewalk availability (SAVAL): sidewalk on both sides = 5.00 Sidewalk/alleyway surface conditions (SCOND): good condition = 5.00 Sidewalk width (SWW): > 2.0 - ≤ 3.0 [m] = 3.50 Sidewalk cleanliness (SCL): clean = 5.00	
Sidewalk conditions index result for segment 1 (SCI_{S1}) $SCI_{S1} = \frac{SAVAL+SCOND+(2*SWW)+SCL}{5}$ = 4.40 (very walkable)	

5.6.6 B3 - Local centrality index (LCI)

First of all, the distinction between local centrality and large-scale centrality should be made. On one hand, local centrality refers to providing goods, working places and services to people living or working in a neighbourhood, positively affecting the walkability of an area. Long commutes in the city centre can be avoided due to the proximity of living and working, which is sometimes merged within one house, and the high density of different types of usage (Storch et al., 2008). On the other hand, large-scale centrality, like central business districts or shopping malls, points to high densities of jobs and businesses at one place attracting people from very far away. This increases the average trip length, and as a result, also the dependence on motorised vehicles. In addition, condominiums and high-rise office towers put a lot of pressure on the already saturated transport infrastructure in HCMC. The local centrality was designed as an expression for the land-use mix index frequently found in the walkability literature. Assessing the land-uses, without a digital GIS data-based support tool, turned out to be inconvenient. Therefore, to keep the WETUAV simple and practical, it was decided to use data that was easily available. The two components defining the local centrality index are (i) the type of neighbourhood and (ii) the district residential density.

Type of neighbourhood

In this study, it was assumed that the type of neighbourhood influences the diversity of land use and the proximity to shops of essential needs. Therefore, the type of neighbourhood can serve as a proxy for trip distances.

The following types of neighbourhoods are distinguished:

- Shophouse/ tube houses,
- Historic/ French Colonial,
- Condominium,
- Highrise office towers or central business district (CBD) and
- Separate houses.

“Shophouse” neighbourhood, often reinterpreted today as the “tube house” neighbourhood, is a low-rise urban form that allows very high residential densities giving street access to a maximum of residents. In Ho Chi Minh City, 85.0 % of the city dwellers still live in an urban network of alleyways typically defined by tube houses (Gibert & Pham, 2016). The narrow front of the ground floor, which is open to the public street space, becomes a hub of activity and social exchange and is still the source of income for many families today (Storch et al., 2008). To support the author's assumption, it was found in the literature that 54.7 % of trips, including intra zonal trips, were done by motorcycles that were less than 1 km long (JICA Study Team, 2015). This dense urban fabric is ideal to promote walkability regarding distances. The extensive network of alleyways arose mostly out of the city dwellers’ pragmatism during the uncertain times of war. Historically, the format of urban dwellings in Vietnam has been shaped by trading functions. As a result, alleyways that are directly connected to commercial routes are the most valuable (Gibert & Pham, 2016).

Having shops or services of essential needs within walking distance enables more of these trips to be done by walk (ITDP, 2018). Self-organised communities are another feature of Vietnamese alleyways. Alleyway neighbourhoods are subdivided into 50-to-100-person resident groups (tổ dân phố). Each group is led by a head person, who represents the neighbourhood at the ward level (Gibert & Pham, 2016). This kind of neighbourhood positively influences the social equity and social security of the local community. As those unplanned neighbourhoods were built around the concept of local centrality, inherited from the ancient frame of rural paths, it offers a huge variety of services within a walking distance. As a result, it is given a maximum score of 5.00 (Table 5.6-11).

Table 5.6-11: Type of neighbourhoods in HCMC and an associated score ranging from 0 – representing bad walking conditions to 5 – very good walking conditions. Source: Author’s own

Type of neighbourhood	Score
Shophouses/ Tube houses	5.00
Historic buildings/ French colonial	4.50
Condominium	3.00
Highrise office towers or CBD	2.00
Separate houses	0.00

Figure 5.6-4: Example of shophouse neighbourhoods'. Source: Author's own, 2019

"Historical buildings/French colonial" neighbourhood is a low-rise mix of office buildings, tube houses and French colonial-style buildings such as villas, churches, schools. The main characteristic, being the grid-shaped street network with its large sidewalks and huge century-old trees providing a lot of shade for pedestrians. The traditional family-run shophouse businesses are more and more replaced by franchises, separating the home and workplace and, as a result, generating more commuter traffic. Shopping malls are responsible for centralising shopping activities and increasing average trip length. Nevertheless, a huge network of convenience stores provides access to groceries within a walking distance and also the beautiful architecture enhances the walking experience. Therefore, this category is given a score of 4.50 (Table 5.6-11).

Figure 5.6-5: Example of historical buildings/ French colonial neighbourhoods'. Source: Author's own, 2019

"Condominium" neighbourhoods are defined by high-rise residential buildings containing a number of individually owned apartments. This kind of building sometimes includes retail spaces on the ground floors run by franchises. These buildings often include underground parking garages stimulating the use of private motorised vehicles. In addition, street vending is often not tolerated in front of these buildings and the high-end shops inside these buildings often lead to segregation and gentrification of the society. Due to car/motorcycle centric design, limitation of street activities and gentrification of society, the final score of this category is 3.00, despite short walking distances (Table 5.6-11).

Figure 5.6-6: Example of condominium neighbourhoods’. Source: Author’s own, 2019

“Highrise office towers or CBD (Central Business District)” neighbourhoods are designed to centralise thousands of jobs at the same place, therefore generating intense commuter traffic often coming from far away. Without an efficient MRT (Mass Rapid Transit) system in place, this type of urban form is unsustainable regarding walkability. The amount of motorised traffic generated at peak hours puts a lot of pressure on the already jammed city transport infrastructure, heavily affecting air quality and noise pollution. There are still many amenities that can be reached by walking around those office buildings. Many office workers still prefer going to local restaurants or street food stalls over food courts available inside the building, supporting social equity. Based on the strong centralisation of activities, the average trip length significantly increases across the city, rising the commuter’s dependence on motorised modes of transport. As a result, traffic jams are negatively affecting the walking experience. Thus, the score of this category is 2.00 (Table 5.6-11).

Figure 5.6-7: Examples of high-rise office towers/ central business district neighbourhoods’. Source: Author’s own, 2019

“Separate houses” neighbourhoods are high-end real estate areas that have been recently developed, only having the function for residential use. Vietnam's market-oriented reforms in the 1980s paved the way for a modern consumer society (Storch et al., 2008). The lack of land-use mix creates de facto long trip distances between the several destinations and make the use of automobiles nearly inevitable. The low density is also preventing the implementation of an efficient public transport network since its operation would be uneconomical. Changed mobility patterns reflect this growth; housing and workplace are separated from one another; family members and friends live on the opposite side of town (Storch et al., 2008). Slum-upgrading projects and the effect of highly-paced developments of new buildings are often destroying economic and social networks. This leads to gentrification, in which low-income groups are pushed to relocate further from the city centre and can only reclaim their living by travelling long distances to family and jobs (Storch et al., 2008). In some cases, the high-end neighbourhoods are built-in forms of gated communities guarded 24/7, which heavily impacts social life and access to streets, consequently excluding the poorer. Considering these findings, and the fact that Ho Chi Minh City cannot rely on private cars as the dominant transport system due to its limited street density, the score of that category is 0.00 (Table 5.6-11).

Figure 5.6-8: Example of separate house neighbourhoods'. Source: Author's own, 2010

__District residential density__

Complementary to the "type of neighbourhood", the "district residential density" indicates the average number of inhabitants/km² per district (Table 5.6-12). A ward level residential density database would be preferable, but updated data was not found by the authors. As written in many other walkability papers, a dense neighbourhood enhance the walkability of an area regarding proximity (i.e., ITDP 2018, Storch et al. 2008). This is expressed through more schools, pharmacies, hospitals, etc., thus reducing the overall trip length between destinations. A greater weighted residential density can serve as a proxy to describe the potential for street activities (ITDP, 2018). After analysing the existing densities in HCMC, the scores were defined as illustrated in Table 5.6-12.

Table 5.6-12: Residential density scale for HCMC and an associated score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

District residential density index	Score
> 25,000	5.00
> 20,000 - ≤ 25,000	4.50
> 15,000 - ≤ 20,000	4.00
> 10,000 - ≤ 15,000	3.00

> 5,000 - ≤ 10,000	1.00
> 0 - ≤ 5,000	0.00

The local centrality index is calculated as the mean of the type of neighbourhood and district residential density (Equation 5.6-8).

$$\text{Local centrality index (LCI)} = \frac{\text{Type of neighbourhood} + \text{District residential density}}{2}$$

Equation 5.6-8: Local centrality index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

5.6.7 C1 - Tree canopy/shadow index (TCSI)

As one result of the survey with the inhabitants of HCMC, high temperatures and lack of greenery are the main reasons preventing people from walking in the tropical climate of Ho Chi Minh City (Figure 4.2-1, Figure 4.3-3). In the encroachment density index (A1), trees obstructing the sidewalk were negatively assessed. Therefore, it is important to reserve enough space on sidewalks for tree planting, forming a tree canopy providing shade for pedestrians while avoiding sidewalk obstruction.

In HCMC or cities with similar climate conditions, people's willingness to walk can be considerably increased by improving the overall walking environment and building overhead canopies or shades (Fabian et al., 2010). Furthermore, shade and shelter contribute to enhancing the comfort of the walking environment by protecting pedestrians from heat, rain, and other elements (ITDP, 2018).

The tree canopy/shadow index indicates the coverage and the type of shadow available on the street. It is defined by (i) the type of shadow and (ii) shadow coverage occurring on the street segment selected (Table 5.6-13). "Shadow from greenery and buildings" has a slightly higher score than "shadow from buildings" since greenery helps to mitigate the heat island effect in urban environments and therefore contributes to local temperature reduction. The coverage categories are defined as follows:

- "High coverage" corresponds to a shadow coverage rate of > 75.0 %,
- "Moderate coverage" describes a shadow coverage rate of 50.0 % - 75.0 %,
- "Low coverage" represents shadow coverage rates of 25.0 – 49.9 %,
- "No shadow at all" designate shadow coverage rates of < 25.0 %.

Table 5.6-13: Tree canopy/shadow criteria and associated score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

		Score
Shadow coverage	High coverage	5.00
	Moderate coverage	3.00
	Low coverage	1.00
	No shadow at all	0.00
Type of shadow	Shadow from greenery and buildings	5.00
	Shadow only from buildings	3.00
	N/A	0.00

If the shadow coverage is "no shadow at all", the type of shadow is not applicable, and the tree canopy/shadow index is given the lowest score of 0.00 (bad walking conditions). The tree canopy/shadow index is measured as the mean of the type of shadow score and the shadow coverage score (Equation 5.6-9).

$$\text{Tree canopy/shadow index (TCSI)} = \frac{\text{Type of shadow score} + \text{Shadow coverage score}}{2}$$

Equation 5.6-9: Tree canopy/shadow index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Example

Table 5.6-14: Example of the tree canopy/shadow index for a route of 4 segments ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own, 2019

• Segment 1 Shadow coverage: "High coverage" (> 75.0 %) = 5.00 Type of shadow: "Shadow from greenery and buildings" = 5.00 Tree canopy/shadow index for segment 1: $TCSI_{S1} = \frac{5.00+5.00}{2}$ = 5.00 (very walkable)	
• Segment 2 Shadow coverage: "Moderate coverage" (50.0 % - 75.0 %) = 3.00 Type of shadow: Shadow only from buildings = 3.00 Tree canopy/shadow index for segment 2: $TCSI_{S2} = \frac{3.00+3.00}{2}$ = 3.00 (fairly walkable)	

• <u>Segment 3</u> Shadow coverage: "Low coverage" (25.0 % - 49.9 %) = 1.00 Type of shadow: Shadow only from buildings = 3.00 Tree canopy/shadow index for segment 3: $TCSI_{S3} = \frac{1.00+3.00}{2}$ = 2.00 (not walking-friendly)	
• <u>Segment 4</u> Shadow coverage: "No shadow at all" (< 25.0 %) = 0.00 Type of shadow: N/A Tree canopy/shadow index for segment 4: $TCSI_{S4} = \frac{0.00+\text{N/A}}{2}$ = 0.00 (bad walking conditions)	
Tree canopy/shadow index for the entire route = $\frac{TCSI_{S1}+TCSI_{S2}+TCSI_{S3}+TCSI_{S4}}{4}$ **= 2.50 (fairly walkable)**	

5.6.8 C2 - Street activity index (SAI)

Compared to other walkability tools such as Walk Score®, in which street activities are not assessed, the WETUAV is designed to rate the benefits and drawbacks of street activities. As previously mentioned in chapter 5.6.1, street activities contribute to sidewalk encroachment. However, their presence increases the overall street attractivity and social safety. Therefore, the right balance between encroachment and street activity needs to be found. As described in the literature (chapter 2.3), street life and street activities are deeply embedded in the Vietnamese culture and lifestyle. Even though, street vendors are often considered to be obstructing sidewalks, Leung & Le (2019) found in their research that street vendors are positively correlated with district-level active travel frequency. In this context, new sidewalk designs should include spaces for informal street vending in such a way that it does not encroach on the movement of pedestrians. Complimentary amenities, such as clean tap water access and public trash bins, will also help to improve the sanitary image of street vendors. In the questionnaire discussed in chapter 4.3.2, it was noticed that street events and street food vendors are contributing to a better walking experience whereas street merchandise vendors and street services have a lower acceptance rate. In Kim's (2015) study, most of sidewalk spaces are in the French historic centre of HCMC (district 1, district 3) used for motorcycle parking and in the Chinatown of Cholon (district 5, district 6 and district 11) for storeowners' spillovers of merchandise. However, sidewalk vendors are the focus of sidewalk clearance policies and debates.

The main benefit of street vendors is their rotation throughout the day. As shown in the study of Kim (2015), the sidewalk spaces used fluctuate throughout the day. During mealtimes, space used for selling food is extended with stools and chairs, which are later stacked up against the wall to free up some public space. After school, relaxation and leisure activities start to take over the space over other sidewalk activities. These changes of uses of the sidewalk greatly contribute to the economic and social diversity of the public place, reducing walking distances and responding to the needs of pedestrians. Hence, the importance of defining the date and time during the data collection process is apparent. As found in the survey, most walking trips departing from an education facility or workplace led to street food stalls and local restaurants, again highlighting the importance of preserving that cultural asset as a major point of interest for pedestrians (chapter 4.3.4).

In the WETUAV, the street activity index consists of two main parts. The *first part* assesses the occurrence rate of street activities by counting the number of events. An event is defined as a street activity that takes place in the surveyed route corresponding to one of the street activity categories. The *second part* evaluates the diversity of street activities by counting the number of categories. The street activity categories are defined as trading and social activities as follows:

(1) Existence of trading activities such as:
   a. Street food vendors [No. of vendors/segment]
   b. Street market vendors [No. of vendors/segment]
   c. Street merchandise vendors [No. of vendors/segment]
   d. Street services [No. of vendors/segment]
   e. Shop using the sidewalk as a selling area [No. of shops/segment]
   f. Restaurant/coffee/teashop spillover [No. of businesses/segment]

(2) Existence of social activities such as:
   a. Children playing in the public space [No. of people/segment]
   b. People playing cards or board games [No. of people/segment]
   c. People eating out or having drinks together [No. of people/segment]
   d. People relaxing outside [No. of people/segment]

The street activity index is calculated using a similar evaluation method as in the encroachment density index (A1). The activity density and diversity are described by counting the number of street activity events and the number of street activity categories. Both factors are segment length-dependent and a high density and diversity of street activities lead to a high score (Table 5.6-15, Table

5.6-16). Contrary to the encroachment density index (A1), which only assesses street activities encroaching the sidewalk by obstructing the entire cross-section, the street activity index collects both, encroaching and non-encroaching street activities.

Table 5.6-15: Number of events per street segment length and resulting street activity events score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

	Segment length index			
Number of street activity events	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
5 or more	5.00	5.00	5.00	5.00
4	5.00	5.00	5.00	4.00
3	5.00	5.00	3.75	3.00
2	5.00	3.33	2.50	2.00
1	2.50	1.67	1.25	1.00
None	0.00	0.00	0.00	0.00

Table 5.6-16: Number of categories per street segment length and resulting street activity categories score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

	Segment length index			
Number of street activity categories	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
5 or more	5.00	5.00	5.00	5.00
4	5.00	5.00	5.00	4.00
3	5.00	5.00	3.75	3.00
2	5.00	3.33	2.50	2.00
1	2.50	1.67	1.25	1.00
None	0.00	0.00	0.00	0.00

Those two intermediate scores are segment length-dependent, and their results are part of the final street activity index as illustrated in Equation 5.6-10.

$$\text{Street activity index (SAI)} = \frac{\text{Street activity events score} + \text{Street activity categories score}}{2}$$

Equation 5.6-10: Street activity index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Table 5.6-17: Example of the street activity index for a route of 2 segments ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own, 2018

Street activities in segment 1 (≥ 100 – < 250 [m])

Street activity category:
- People eating out (4 [people/segment])
- Restaurant spillover (1 [business spillover/segment])

Number of street activity events = 5

Street activity results in segment 1

5 events and segment length (≥ 100 – < 250 [m]) → (Table 5.6-15)

2 categories and segment length (≥ 100 – < 250 [m]) → (Table 5.6-16)

- Street activity events score = 5.00
- Street activity categories score = 3.33

Street activity index for segment 1: $SAI_{S1} = \frac{5.00 + 3.33}{2} = 4.17$ (very walkable)

Street activities in segment 2 (< 100 [m])

Street activity category:
- Street services (1 [vendor/segment])

Number of street activity events = 1

Street activity category:
- Children playing outside (3 [Children/segment])

Number of street activity events = 3

Street activity results in segment 2

4 events and segment length (< 100 [m]) → (Table 5.6-15)

2 categories and segment length (< 100 [m]) → (Table 5.6-16)

- Street activity events score = 5.00
- Street activity categories score = 5.00

Street activity index for segment 2: $SAI_{S2} = \frac{5.00+5.00}{2} = 5.00$ (very walkable)

Street activity index for the entire route = $\frac{SAI_{S1} + SAI_{S2}}{2}$ = 4.59 (very walkable)

5.6.9 C3 - Social security index (SSI)

The social security index was designed to evaluate the perception of security from crime in a route segment. A higher residential density increases the likelihood of not walking alone to nearby amenities. During the nighttime, when street activities decrease and shops are closing, good street lighting increases the sense of security. In this research, the street light quality is assessed by estimating the distance between street light poles. All the indicators mentioned above are making it harder for criminals to remain unnoticed. The presence of continuous ground-floor activity and services means that there are fewer zones of inactivity on sidewalks, resulting in a more desirable pedestrian environment that is also safer against crime (ITDP, 2018). The indicators of the social security index come from several other indices of the WETUAV. The combination of these indicators enabled the creation of an evaluation of the local security conditions from crime in particular street segments. As can be seen in Table 5.6-18, residential density comes from the local centrality index; street lighting, visually active frontage and physically permeable frontage are parts of the visual aesthetics index and finally, the score of the street activity index is used.

Table 5.6-18: Social security criteria and associated score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Social security criteria		**Score**
Residential density (RD) [inhabitants/km²]	> 25,000	5.00
	> 20,000 - ≤ 25,000	4.50
	> 15,000 - ≤ 20,000	4.00
	> 10,000 - ≤ 15,000	3.00
	> 5,000 - ≤ 10,000	1.00
	> 0 - ≤ 5,000	0.00
Street lighting density (SLD) Street light interval [m]	Streetlight pole distance < 25	5.00
	Streetlight pole distance ≥ 25 - < 50	4.00
	Streetlight pole distance ≥ 50 - < 75	2.50
	Streetlight pole distance ≥ 75 - < 100	1.00
	No street lighting at all	0.00
Street activity (SAI) [-]	Street activity index score	
Visually active frontage (VAF) [%]	> 75.0	5.00
	≥ 50.0 - < 75.0	4.00
	≥ 25.0 - < 50.0	2.00
	< 25	0.00
Physically permeable frontage (PPF) [%]	> 75.0	5.00
	≥ 50.0 - < 75.0	4.00
	≥ 25.0 - < 50.0	2.00
	< 25	0.00

The calculation method used for the social security index is measured by the mean of the residential density, streetlight density, street activity, visually active frontage and physically permeable frontage (Equation 5.6-11).

$$\text{Social security index (SSI)} = \frac{\text{RD} + \text{SLD} + \text{SAI} + \text{VAF} + \text{PPF}}{5}$$

Equation 5.6-11: Social security index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

5.6.10 C4 - Availability of public transport index (APTI)

Public transport plays a major role in walking-friendly cities. By creating safe, active, continuous, and well-connected pedestrian areas within dense, mixed, and accessible neighbourhoods interconnected by public transportation, land uses, and urban forms should be organised to facilitate walking as the dominant mode of transportation (ITDP, 2018). Cities adopting the concept of transit-oriented development (TOD), is a type of urban planning that focuses on maximising the amount of residential, commercial, and recreational areas within walking distance of the public transport system. The main benefit of a TOD city is that it can free up space previously used by private vehicles, thus, using it for public transport, walking or public space for economic or social activities. In addition, it helps reduce local air and noise pollution since most Mass Rapid Transit systems (MRT) nowadays are powered by electricity. The main disadvantages are that they are often costly to build and operate, and most of the current bus lines in HCMC needs to be subsidised. The low implementation speed and huge investment costs of MRT projects are discouraging private investors.

The planning of the functional areas of HCMC is not clear and as a result, the residential, economic, and industrial zones are spread out. This directly affects the organisation of public transport because it is difficult to connect different functional areas and thus meet the mobility requirements of people. This is why the city's bus system does not work efficiently (Truong et al., 2017).

In order to address this issue, the "availability of public transport index" was developed. The following type of public transport was assessed:

- Bus stops
- Metro stations
- Train stations

A distance describing the accessibility of a public transport station needed to be set. The authors assumed, that a public transport station should be in a 5-minute walking range to remain competitive to individual motorised vehicles. According to the Highway Capacity Manual (Transport Research Board, 2016), the average speed of a person with a Pedestrian Level of Service of A (free flow) lies at

1.32 m/s for uninterrupted pedestrian facilities. At this speed, a public transport station in the vicinity of 400 m can be reached within a 5-minute walk. The method used to calculate the reach of public transport station includes the following steps:

(i) draw a circle with a radius of 400 meters in the midpoint of each segment,

(ii) count the number of public transport stations that lie within the circle

It is assumed that a higher density of public transport stations would lead to a higher quality of public transport (Table 5.6-19).

Table 5.6-19: Public transport station density and the resulting availability of public transport index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Number of public transport stations in a 400 m vicinity	**Availability of public transport index**
3 or more	5.00
2	4.00
1	3.00
0	0.00

5.6.11 C5 - Visual aesthetics index (VAI)

The visual aesthetics index is defined by five evaluation criteria that are described below.

The particularity of Vietnamese alleyways is that there is no strict separation between private and public spaces. Therefore, shop owners tend to use the public space in front of their homes for their business activities; people sometimes cook and eat in small alleyways and others put some flowerpots or plants in front of their gate. This increases the visual attractiveness of the street since those activities change throughout the day and trigger pedestrians' curiosity. This criterion is described by the domestic plants/flowers density (Table 5.6-20).

Table 5.6-20: Number of domestic plants/flowers per street segment length and resulting domestic plants/flowers score (DPF) [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

	Segment length index			
Number of domestic plants/flowers in the public space	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
5 or more	5.00	5.00	5.00	5.00
4	5.00	5.00	5.00	4.00
3	5.00	5.00	3.75	3.00
2	5.00	3.33	2.50	2.00
1	2.50	1.67	1.25	1.00
None	0.00	0.00	0.00	0.00

According to the guidelines from the institute for transportation and development policy (2018), the aesthetics of the buildings and permeability play major roles in creating attractive as well as safe neighbourhoods. The two following statements are issued from their list of indicators:

<u>*Visually active frontage (VAF)*</u>

"Visually active frontages promote safety from crime in walkable areas through informal observation and surveillance by people inside buildings. This is often described as "eyes on the street" (Pedestrians first, ITDP, 2018, p.32). This thesis defines visually active frontages as buildings that enable visual contact between people inside buildings and pedestrians outside in the public space. It is assessed by estimating the surface percentage of building frontages per segment that is visually penetrable. The ratio is divided into the following four categories (< 25 %; ≥ 25 % - < 50 %; ≥ 50 % - < 75 %; > 75 %).

<u>*Physically permeable frontage (PPF)*</u>

"Sidewalks that are lined with continuous ground-floor activity and services have fewer zones of inactivity, thereby creating a more attractive walking environment that is safer from crime". (Pedestrians first, ITDP, 2018, p.32). In this research, frontage permeability describes the physical interactions between the public space and the private space. Buildings that are accessible by the general public are defined as physically permeable. This mainly includes retail spaces such as stores, restaurants, cafés, shopping malls, markets but also educational or recreational facilities like museums, parks, squares, plazas, etc. It is assessed by estimating the number of buildings penetrable by the public per segment divided by the total number of buildings per segment. The ratio is divided into the following four categories (25 %; ≥ 25 % - < 50 %; ≥ 50 % - < 75 %; > 75 %).

Examples of visual active and physically permeable frontage rates are illustrated in Table 5.6-21.

Table 5.6-21: Examples illustrating visual active and physically permeable frontage [%] in HCMC. Source: Author's own, 2018

VAF: > 75 % PPF: < 25 %	 *Source: Image data ©2019 Google Street View*	VAF: < 25 % PPF: < 25 %	

VAF: > 75 % PPF: > 75 %		VAF: < 25 % PPF: < 25 %	

Alongside evaluating building frontages, good street lighting at regular intervals is another measure to raise the overall perceived safety from crime during nighttime. These three visual aesthetics criteria are illustrated in Table 5.6-22.

Table 5.6-22: Visual aesthetics criteria and associated score [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Visual aesthetics criteria		**Score**
Visually active frontage (VAF) [%]	> 75.0	5.00
	≥ 50.0 - < 75.0	4.00
	≥ 25.0 - < 50.0	2.00
	< 25.0	0.00
Physically permeable frontage (PPF) [%]	> 75.0	5.00
	≥ 50.0 - < 75.0	4.00
	≥ 25.0 - < 50.0	2.00
	< 25.0	0.00
Street lighting density (SLD) [m]	Streetlight pole distance < 25	5.00
	Streetlight pole distance ≥ 25 - < 50	4.00
	Streetlight pole distance ≥ 50 - < 75	2.50
	Streetlight pole distance ≥ 75 - < 100	1.00
	No street lighting at all	0.00

Small squares, parks, pagodas, churches, etc, are monuments contributing to the identity of the neighbourhood. For people coming there for the first time, these monuments visible from longer distances can serve as orientation. Furthermore, parks and squares are bigger areas reserved for pedestrians and promote leisure activities. The method used to calculate the densities of landmarks in a neighbourhood is identical to the method used to calculate the density of transport stations and include the two following steps (Table 5.6-23).

(i) draw a circle with a radius of 400 meters in the midpoint of each segment

(ii) count the number of landmarks that lies within that circle

Table 5.6-23: Landmark density and associated landmark density score (LMD) [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

Number of landmarks (LMD) (churches/pagodas/squares/parks/museums) in a 400 m vicinity	Score
None	0.00
1	3.00
2	4.00
3 or more	5.00

The visual aesthetics index is calculated as the mean of domestic plants/flowers score (DPF), visually active frontage score (VAF), physically permeable frontage score (PPF), street lighting density (SLD), landmark density (LMD) (Equation 5.6-12).

$$\text{Visual aesthetics index (VAI)} = \frac{\text{DPF} + \text{VAF} + \text{PPF} + \text{SLD} + \text{LMD}}{5}$$

Equation 5.6-12: Visual aesthetics index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author's own

5.6.12 C6 - Walking amenities index (WAI)

Poor infrastructures are often blamed to discourage people from walking and shifting to motorcycles and cars instead. To enhance the walking experience, providing amenities designed specifically for pedestrian needs can help to make walking a more pleasant experience. Public sitting is one amenity often requested by pedestrians. Indeed, some respondents of the survey complained that the seating facilities were owned by private businesses and resting without any consumptions was therefore impossible. Furthermore, public garbage bins can aid in the preservation of the environment by lowering the amount of litter produced. Since recreational walking can last for a longer time, providing a good network of clean and functioning public toilets is essential. During the rainy season, heavy rain is occurring on a daily basis. Fortunately, in HCMC, these events are often brief, lasting less than one hour. Rain shelters could be the solution for a pedestrian being trapped in heavy rain. The chosen approach to evaluate the walking amenities for pedestrians was to rate the availability of different kinds of walking amenities (Table 5.6-24).

Table 5.6-24: Number of facilities per street segment length and resulting facility scores for the different types of walking amenities [-] ranging from 0.00– representing bad walking conditions to 5.00 – very good walking conditions. Source: Author’s own

		Segment length index			
	Number of facilities	< 100 [m]	≥ 100 – < 250 [m]	≥ 250 – < 500 [m]	≥ 500 – < 1,000 [m]
Public sitting facilities (PSF)	4 or more	5.00	5.00	5.00	5.00
	3	5.00	4.50	4.00	3.50
	2	5.00	4.00	3.00	2.00
	1	5.00	3.50	2.00	0.50
	None	0.00	0.00	0.00	0.00
Public garbage bin (PGB)	4 or more	5.00	5.00	5.00	5.00
	3	5.00	4.50	4.00	3.50
	2	5.00	4.00	3.00	2.00
	1	5.00	3.50	2.00	0.50
	None	0.00	0.00	0.00	0.00
Public toilet facilities (PTF)	4 or more	5.00	5.00	5.00	5.00
	3	5.00	4.50	4.00	3.50
	2	5.00	4.00	3.00	2.00
	1	5.00	3.50	2.00	0.50
	None	0.00	0.00	0.00	0.00
Rain shelter (RS)	4 or more	5.00	5.00	5.00	5.00
	3	5.00	4.50	4.00	3.50
	2	5.00	4.00	3.00	2.00
	1	5.00	3.50	2.00	0.50
	None	0.00	0.00	0.00	0.00

The walkability amenities index is expressed as the mean of public sitting facility score, public garbage bin score, public toilet facility score, and rain shelter score (Equation 5.6-13).

$$\text{Walking amenities index (WAI)} = \frac{\text{PSF} + \text{PGB} + \text{PTF} + \text{RS}}{4}$$

Equation 5.6-13: Walking amenities index [-] ranging from 0.00 – representing bad walking conditions to 5.00 – very good walking conditions. Source: Author’s own

5.7 Indicator weights [AS & QT]

To evaluate the indicators based and their relevance for walking-friendly neighbourhoods, different indicator weights were introduced. The weights are classified into four categories, ranging from low importance to very strong importance (Table 5.7-1). The weighting factors allow to increase the importance of indicators of very strong importance and therefore have a bigger influence on the overall walkability score. The indicators are given a weighting factor of 1.0; 1.5; 3.0 or 5.0.

Table 5.7-1: Weighting importance categories. Source: Author's own

Weighting		
Very strong importance	**Weighting factors**	**Weighting [%]**
Encroachment density index	5.0	18.5%
Sidewalk condition index	5.0	18.5%
Tree canopy/-shadow index	5.0	18.5%
Strong importance		
Street activity index	3.0	11.1%
Moderate importance		
Traffic air/noise pollution index	1.5	5.6%
Pedestrian traffic safety index	1.5	5.6%
Low importance		
Sidewalk/street ratio	1.0	3.7%
Local centrality index	1.0	3.7%
Social security index	1.0	3.7%
Availability of public transport	1.0	3.7%
Visual aesthetics	1.0	3.7%
Walking amenities	1.0	3.7%

The chosen weights are the result of the combination of literature research, the outcome of the survey and the subjective assessment of the authors. The chosen weights should be understood as a proposal and can be adapted through further research or other weighting methodologies. The weighting hierarchy used for the different types of indicators is illustrated in Figure 5.7-1.

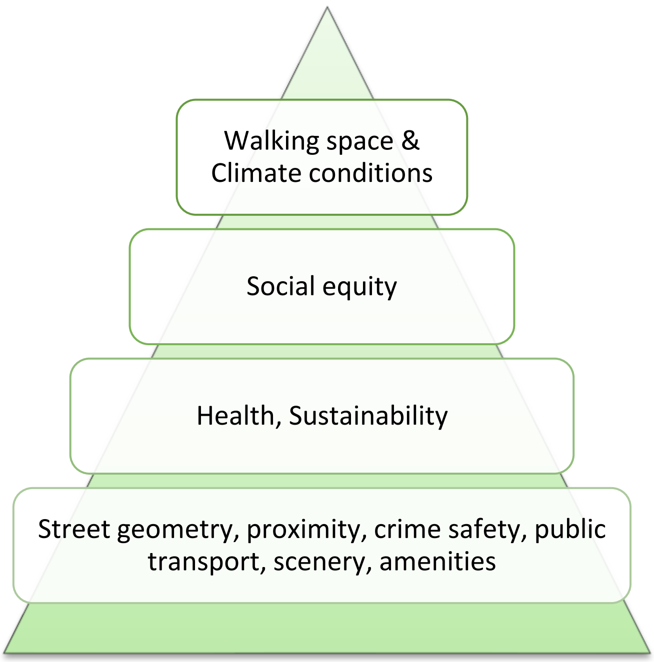

Figure 5.7-1: Weighting hierarchy adopted in this study. Source: Author's own

Through the findings of the survey, lack of shade, high temperatures, sidewalk encroachment and bad walking infrastructure were the most recurrent answers discouraging people from walking in the city. Therefore, the indicators covering these issues, being the encroachment density index, sidewalk condition index and tree canopy/-shadow index, have the strongest importance with a combined weight of 55.5% of the total walkability score. In the study of Loc et al. (2018), the walkability factor describing temperature in HCMC was doubled because of the high influence it has on walking.

Street activities are the main cultural and social features of Ho Chi Minh City differentiating it from other cities throughout the world. Findings in the literature indicated the importance of the preservation of these activities for several reasons. Enhanced social safety and security (ITDP, 2018), meeting place for neighbours increasing the sense of neighbourhood community (Gibert & Pham, 2016), mix-use of public space (ITDP, 2018), are all benefitting the well-being of pedestrians. Nowadays, where public space is mainly reserved for transport, particularly motorised transport, creating dedicated spaces for street vending and community activities helps diversify the use of public space by creating space for social interactions and trading functions. Furthermore, new spaces for street vending may reduce the impact of sidewalk encroachment. Leung & Le (2019), researching about factors associated with adolescent active travel in HCMC, find out that the presence of street vendors in neighbourhoods or near schools has a positive impact on active travel. Based on this knowledge, the authors of this thesis allocated strong importance to the street activity index.

Both air and noise pollution, as well as pedestrians' perceptions of their own safety in traffic, are detrimental to their health. According to the survey, air pollution in Ho Chi Minh City seems to have a more significant impact on people’s willingness to walk than noise pollution. Nevertheless, since most air and noise pollution are both generated by traffic, they are assessed and evaluated through the same indicator. Good air quality, low noise pollution and a safe walking environment are essential parts of a design to create sustainable neighbourhoods. Consequently, those indicators are weighted according to category moderate importance.

Lastly, street geometry, proximity, crime safety, public transport, scenery, and walking amenities are given equal importance in the Walkability score. All of the indicators in this group are generally enhancing the pedestrian friendliness of a place but are not the main reasons preventing people from walking in the context of Ho Chi Minh City.

To further explore the effect of the indicator weights, a sensitivity analysis was conducted by introducing diverse category weight factors depending on the prioritisation settings (chapter 6.3). Three different scenarios were created representing diverging priorities that depend on the stakeholders. Examples of these stakeholders could be parents worrying about their childrens’ traffic safety on their way to school, putting high importance on safety, thus increasing the weighting factor of category A: "Conflicts and impairment potential". Stakeholders representing a small neighbourhood community may consider category B: "Space and infrastructural conditions" of higher importance, willing to improve their pedestrian built environment and proximity to local points of interest in walking range. If the accessibility of public transit stations is the main focus point, public transport providers would assign heavier importance to category C: "Pedestrian comfort" aiming to attract new customers. The sum of all weight factors must equal 100 % and should be understood as a subjective example of the authors.

Summarising the evaluation scores of the WETUAV and associated purposes, it includes:

- *indicator score* ranging from – 0.00 representing bad walking conditions to 5.00 very walkable. Indicator scores under 2.50 are considered as a walkability shortcoming on a segment level.
- *walkability index "raw" score* ranging from – 0.0 % representing bad walking conditions to 100.0 % very walkable, serve as a reference value for the walkability index "weighted".
- *walkability index "weighted"* score ranging from – 0.0 % representing bad walking conditions to 100.0 % very walkable, is the final walkability score which is used for comparison with other walkability tools such as Walk Score®.

Before comparing the different routes, the different evaluation methods of both tools should be discussed. The WETUAV is distinguished between four categories. A higher indicator score respectively walkability score implies higher walkability. Furthermore, an indicator of the WETUAV was defined as being a shortcoming, when its score was lower than 2.5, respectively 50%. Such values are defined by the categories "not walking-friendly" and "bad walking conditions" (Table 5.7-2). The walkability index score ranges from 0 % – representing bad walking conditions to 100 % – very walkable and it is colour coded. In contrast to WETUAV, Walk Score® has five categories that are not linear (Table 5.7-3). Walk Score® describes the walkability result that indicates how car-dependent a neighbourhood is. Another difference was that the WETUAV has a linear evaluation method using route segments, while Walk Score® has a punctual evaluation method that is based on an address. For this reason, to compare the results with the segments of the WETUAV, the addresses of the Walk Score® were chosen at the midpoint of a WETUAV segment.

Table 5.7-2: Evaluation scheme WETUAV. Source: Author's own

WETUAV walkability scale		
	Indicator score	Walkability index score
Bad walking conditions	≥ 0.00 - < 1.25	≥ 0 - < 25 %
Not walking-friendly	≥ 1.25 - < 2.50	≥ 25 - < 50 %
Fairly walkable	≥ 2.50 - < 3.75	≥ 50 - < 75 %
Very walkable	≥ 3.75 - ≤ 5.00	≥75 - ≤ 100 %

Table 5.7-3: Evaluation scheme Walk Score®. Source: Walk Score®, 2021

Walk Score®	**Description**	
90-100%	Walker's Paradise	Daily errands do not require a car.
70-89%	Very Walkable	Most errands can be accomplished on foot
50-69%	Somewhat Walkable	Some errands can be accomplished on foot
25-49%	Car-Dependent	Most errands require a car.
0-24%	Car-Dependent	Almost all errands require a car.

6 Application

The application of the WETUAV in Ho Chi Minh City serves to test the tools' behaviour in various urban environments and investigates the WETUAVs' ability to rate the overall walkability of a route on a street-level and neighbourhood-level. Moreover, the indicator scores of each evaluated route segment are compared with the on-site observations. After the evaluation of the five test routes, the results of the WETUAV will be compared with the results of Walk Score® (chapter 6.2). Lastly, a sensitivity analysis consisting of several scenarios with different prioritisation of the walkability indicator categories (A, B, C) is conducted to explore the influence of the weighting factors on the walkability index scores (chapter 6.3).

6.1 Testing the WETUAV and Walk Score® in HCMC [AS & QT]

The purpose was to test the WETUAV in different neighbourhood types of Ho Chi Minh City. The results are analysed and verified if they managed to evaluate walkability and identify shortcomings occurring during a walking trip. Moreover, the application will prove if the WETUAV can deliver information that will help answer the three research questions. Lastly, this application will prove the enhanced capability of the WETUAV of describing the walkability in Vietnamese urban areas compared to existing walkability evaluation tools such as Walk Score®. Five different walking routes were selected based on their different urban settings and evaluated with the WETUAV, as well as the Walk Score®. The five test routes are located in district 10, Bình Thạnh district, district 5, district 2 and district 1 (Figure 6.1-1 and Figure 6.1-2). The input data for the WETUAV was collected using two different methods.

- *on-site video footage* recorded by a pedestrian walking the route
- *street imagery platforms* (Image data ©2019 Google Street View)

The benefits and disadvantages of these methods will be further discussed in chapter 6.2. Route 1, 2, 3 and 5 were all assessed through the *street imagery platforms* data collection method. Route 4 was the only route tested using the *on-site video footage* collection method. The criteria for choosing the five test routes were based on neighbourhood typologies and trip purposes. Route 1 and route 4 are describing trips between home and grocery shopping. Both routes are replicating real shopping trips of the author's acquaintances. However, the acquaintances were using motorcycles to reach the grocery markets despite being within walking distance. These two routes being located in two different neighbourhood types ("shophouse" and "separate houses") turned out to be ideal to test the WETUAV. Route 2 was chosen because it is located in a recently developed "condominium neighbourhood" based on Western car-oriented designs with very wide sidewalks. A trip between the closest bus station to a park was simulated. Despite some segments having large, clean and well-maintained sidewalk infrastructure, the number of observed pedestrians did not seem to be higher than in the other routes.

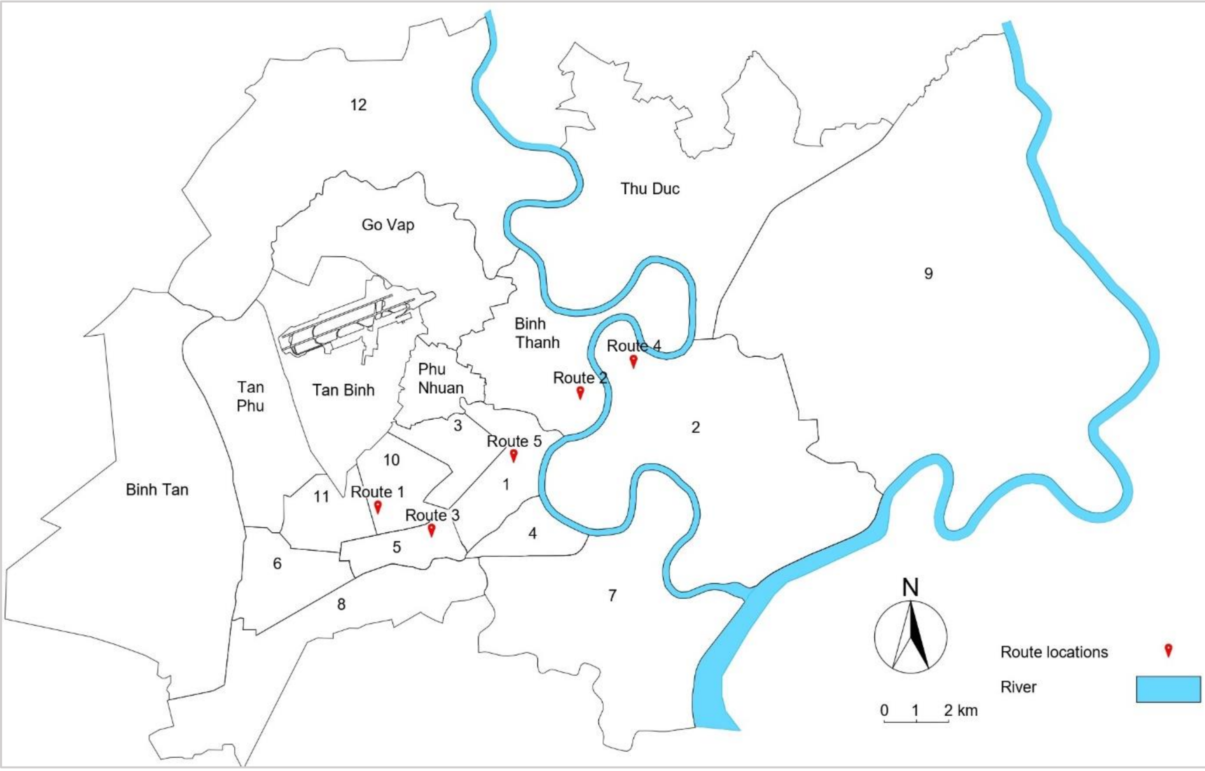

Figure 6.1-1: Location of the 5 test routes. Source: Author’s own based on map data ©2021 Google

Figure 6.1-2: Evaluated routes in HCMC. Source: Author’s own

Route 3 is located in a "shophouse neighbourhood" in the old inner areas of the city and replicated a trip done by the authors' between a shophouse in an alleyway and a public square for recreational purposes. This area is marked by boulevards with century-old tree canopies inherited from the French Colonial period surrounded by dense shophouse neighbourhoods. Lastly, route 5 located in district 1 covers a route connecting several touristic attractions including the Nguyễn Văn Bình pedestrian-only street, the Notre-Dame cathedral, the city hall and Nguyễn Huệ walking street. In the following subchapters of the evaluated routes, all the results of the WETUAV and the Walk Score® were summarised and illustrated in tables. Route 1 "Traditional market" is the only route that has a detailed description of the evaluation procedure using WETUAV. Figures of the route segments, the result of WETUAV and the results of Walk Score® of the remaining routes (2 to 5) can be found in the appendix (chapter 13.4).

6.1.1 Route 1: Traditional market

Route 1 is located in district 10 and replicates a 600 m long trip for grocery shopping between a residential complex and a Vietnamese traditional food market. The map in Figure 6.1-3 gives information about the chosen path of the first route with the corresponding segments. The urban structure consisted mainly of shophouses with alleyways surrounded by 2 major arterial roads (Lý Thường Kiệt, Ba Tháng Hai "3/2"). it is divided into 5 segments. The input data was collected based on street imagery platforms (Image data ©2019 Google Street View).

Figure 6.1-3: Map overview of route 1. Source: Author's own based on Map data ©2021 Google, CNES/Airbus, Maxar Technologies

Figure 6.1-4: Route 1 segment 1, hẻm 666 Ba Tháng Hai, ward 14, District 10. Source: Image data ©2019 Google Street View

The second segment is very short and describes the crossing of the 6-lanes Ba Tháng Hai arterial street. This connection between ward 14 and ward 6 seem to be challenging due to the wide roadway increasing the overall crossing length and resulting in no shadow coverage. Furthermore, the high traffic volume generates heavy air and noise pollution and the street typologies lead to higher driving speeds (Figure 6.1-5).

Figure 6.1-5: Route 1 segment 2, Ba Tháng Hai, ward 14, District 10. Source: Image data ©2019 Google Street View

Segment 3 shows a short section of Nguyễn Kim street (ward 6). Despite having only 2 lanes the roadway is very large. Therefore, the chosen street typology was "District street 2-lanes" with a roadway width ranging between 10 m and 12 m. As a result, the shadow coverage was low despite the presence of trees. The combination of narrow sidewalk width and encroachment originating from business spillovers and parked motorcycles made sidewalks unusable.

Figure 6.1-6: Route 1 segment 3, Nguyễn Kim, ward 6, District 10. Source: Image data ©2019 Google Street View

Segment 4 is situated in Bà Hạt street in ward 6. Similarly to segment 1, the narrow roadway width and presence of narrow sidewalks characterise this segment as a "neighbourhood street". Many street activities and retail spaces were observed. The shading coverage was low and the width of the sidewalks was insufficient for being used by pedestrians.

Figure 6.1-7: Route 1 segment 4, Bà Hạt, ward 6, District 10. Source: Image data ©2019 Google Street View

Segment 5 marks the end of this walking route and is located in front of the Nguyễn Tri Phương traditional market. Trading activities are seen on nearly all available sidewalk spaces around the main market building. This encroachment forced pedestrians to walk on the roadway which was acceptable due to the low volume of motorised traffic.

Figure 6.1-8: Route 1 segment 5, Nguyễn Tri Phương, ward 6, District 10. Source: Image data ©2019 Google Street View

Table 6.1-1 summarises the indicator scores of route 1 with an overall WETUAV walkability index weighted score of 60 % (fairly walkable). Looking at the mean walkability indicator scores evaluating the entire route on a neighbourhood-level, the column “average” shows the performance of the 12 indicators. Encroachment density index (0.88), walking amenities (0.68) are both highlighting “bad walking conditions” whereas the sidewalk/street ratio index (2.40) indicate the category “not walking-friendly”. The walkability indicators that positively influence the walkability of route 1 were pedestrian safety index (2.96), sidewalk conditions index (2.84), tree canopy/shadow index (3.00) reaching the category “fairly walkable”. Furthermore, traffic air/noise pollution index (4.13), local centrality index (4.80), street activity index (4.75), social security index (3.79), availability of public transport index (5.00) and visual aesthetics index (4.10) achieved very high scores entering the category “very walkable”.

Table 6.1-1: Walkability index and indicator scores of WETUAV for route 1. Source: Author's own

Route 1	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average
Category A: Conflicts between pedestrian and other street users									**53%**
Encroachment density index	0.00	1.00	1.00	N/A	1.50				**0.88**
Pedestrian traffic safety index	3.60	2.90	4.00	0.00	4.30				**2.96**
Traffic air/noise pollution index	4.30	2.20	4.50	4.65	5.00				**4.13**
Category B: Physical walking space and infrastructure									**67%**
Sidewalk/street ratio index	3.25	2.00	2.25	0.00	4.50				**2.40**
Sidewalk conditions index	2.80	3.60	2.80	0.00	5.00				**2.84**
Local centrality index	4.50	4.50	5.00	5.00	5.00				**4.80**
Category C: Pedestrian comfort and convenience									**71%**
Tree canopy/shadow index	5.00	0.00	3.00	3.00	4.00				**3.00**
Street activity index	5.00	5.00	3.75	5.00	5.00				**4.75**
Social security index	3.80	3.80	3.75	3.60	4.00				**3.79**
Availability of public transport index	5.00	5.00	5.00	5.00	5.00				**5.00**
Visual aesthetics index	4.60	4.00	4.10	4.20	3.60				**4.10**
Walking amenities index	0.00	1.25	0.00	0.88	1.25				**0.68**
Walkability index raw	**77%**	**63%**	**68%**	**63%**	**85%**				**71%**
Walkability index weighted	**64%**	**49%**	**58%**	**51%**	**78%**				**60%**
*Number of valid indicators	12	12	12	11	12	0	0	0	

Indicators performing under 2.50 are defined as walkability shortcomings (chapter 5.1). A total of 16 indicators were identified as negatively influencing the overall walkability of all the segments (Table 6.1-2). The main shortcomings include heavy sidewalk encroachment and a lack of walking amenities impacting every segment of the route. The WETUAV walkability index weighted scores ranged from "not walking-friendly" in segment 2 to "very walkable" in segment 5. Segment 2 turned out to be the worst-performing section of the route with a walkability score of 49 % (not walking-friendly). As seen in Figure 6.1-5, a busy 6-lane arterial road needed to be crossed for connecting ward 14 with ward 6. The high traffic volume leads to heavy air and noise pollution in the walking environment, negatively affecting the well-being of pedestrians. The wide street design contributes to low shadow coverage and as a result to intense sun exposure. This is believed to be perceived as a physical barrier. The low sidewalk/street ratio index is indicating that the roadway for motorised vehicles is very wide compared to the space allocated for pedestrians. Segment 5, reaching the highest overall score of this route, is located in front of the traditional market. Motorcycles parking on the sidewalks and lack of walking amenities were the only identified issues.

Table 6.1-2: Interpretation of the WETUAV results per segment, route 1. Source: Author's own

WETUAV Route 1: Traditional market	
Segment 1	**Walkability index weighted = 64 %**
Street name, ward	Hem 666 Ba Thang Hai, ward 14
Identified shortcomings	Heavy sidewalk encroachment
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment and lack of walking amenities.
Segment 2	**Walkability index weighted = 49 %**
Street name, ward	Ba Thang Hai, ward 14
Identified shortcomings	Heavy sidewalk encroachment
	High traffic air/noise pollution
	Unfavourable sidewalk/street ratio for pedestrians
	Tree canopy providing insufficient shade
	Lack of walking amenities
Description	This street is **not walking-friendly**; identified shortcomings include heavy encroachment, high air/noise pollution, motorised vehicles favourable space distribution, intense sun exposure and lack of walking amenities.
Segment 3	**Walkability index weighted = 58 %**
Street name, ward	Nguyen Kim, ward 6
Identified shortcomings	Heavy sidewalk encroachment
	Unfavourable sidewalk/street ratio for pedestrians
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment, motorised vehicles favourable space distribution and lack of walking amenities.
Segment 4	**Walkability index weighted = 51 %**
Street name, ward	Ba Hat, ward 6
Identified shortcomings	Low pedestrian traffic safety
	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include, low pedestrian traffic safety, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure and lack of walking amenities.
Segment 5	**Walkability index weighted = 78 %**
Street name, ward	Nguyen Lam, ward 6
Identified shortcomings	Heavy sidewalk encroachment
	Lack of walking amenities
Description	This street is **very walkable**; identified shortcomings include encroachment and lack of walking amenities.

In contrast to the results of the WETUAV-tool, Walk Score® shows a very high walkability score for the entire route (Table 6.1-3). All 5 segments reached the score "Walker's Paradise" (Table 6.1-4). Walk Score® mainly evaluates the walkability by measuring distances between an address and its nearby amenities, as well as the density of the amenities in the neighbourhood. As a result, it failed to identify the features preventing people from walking, which is essential to address the walkability of a neighbourhood.

Table 6.1-3: Walk Score® results for route 1. Source: Author's own

Route 1	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average Walk Score®
Walk Score®	**90%**	**98%**	**98%**	**98%**	**99%**				**97%**
Number and street	Hẻm 666 Đường 3/2	664 Đường 3/2	198 Nguyễn Kim	626 Bà Hạt	68 Nguyễn Lâm				
Ward	Ward 14	Ward 14	Ward 6	Ward 6	Ward 6				
District	District 10	District 10	District 10	District 10	District 10				

Table 6.1-4: Walk Score® results, route 1. Source: Author's own based on Walk Score®

Walk Score® Route 1: Traditional market	
Segment 1	**Walk Score = 90 %**
Description	Hẻm 666 Ba Tháng Hai has a Walk Score of 90 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn cây, VK Cactus Garden and Công viên Lãnh Binh Thăng.
Segment 2	**Walk Score = 98 %**
Description	664 Đường 3/2 has a Walk Score of 98 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn cây, VK Cactus Garden and Công viên Dạ Trạch.
Segment 3	**Walk Score = 98 %**
Description	198 Nguyễn Kim has a Walk Score of 98 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn cây, VK Cactus Garden and Công viên Dạ Trạch.
Segment 4	**Walk Score = 98 %**
Description	626 Bà Hạt has a Walk Score of 98 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn cây, Công viên Dạ Trạch and Văn Lang.
Segment 5	**Walk Score = 99 %**
Description	68 Nguyễn Lâm has a Walk Score of 99 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn cây, Công viên Dạ Trạch and Văn Lang.

6.1.2 Route 2: Condominiums

The second test route is located in Bình Thạnh district. As seen in Figure 6.1-9, the route started at a bus stop along the 10-lane wide Nguyễn Hữu Cảnh street. The total length of the walking trip is about 950 m and includes 4 segments. The input data was collected based on street imagery platforms (Image data ©2019 Google Street View).

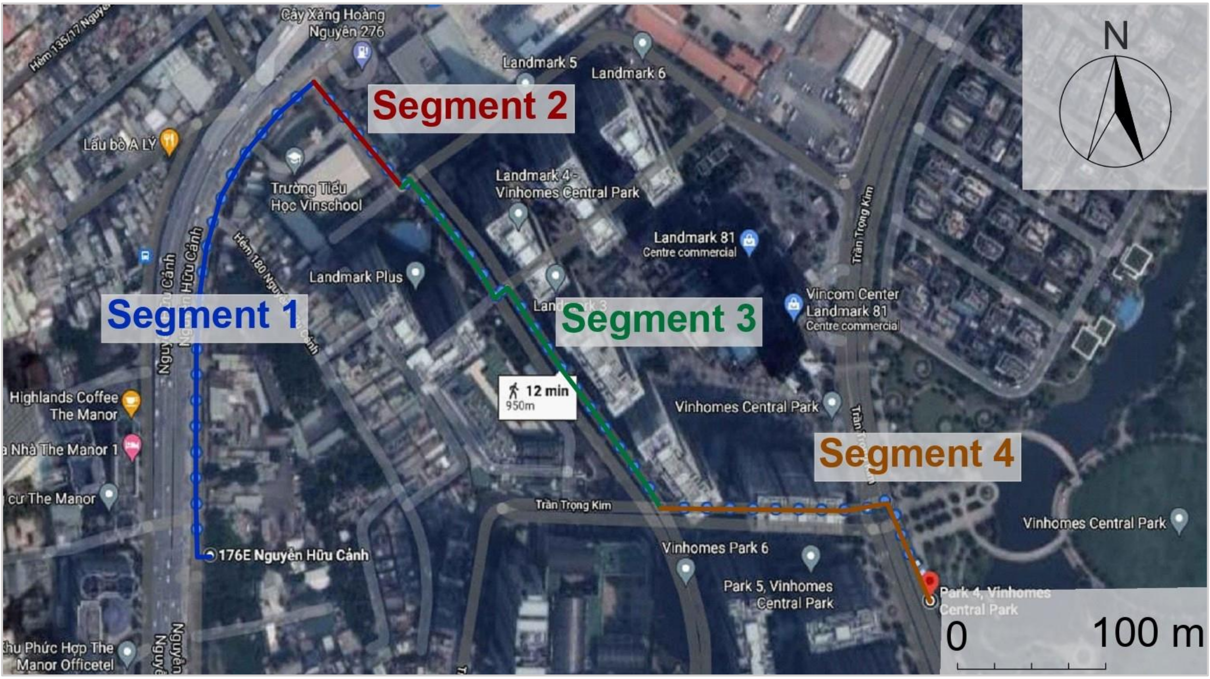

Figure 6.1-9: Map overview of route 2. Source: Author's own based on Map data ©2021 Google, CNES/Airbus, Maxar Technologies

In Figure 6.1-10, as one example, segment 2, having a WETUAV score of 28 % is pictured. For understanding the reasons for this low score, it is worth noticing that this segment is one of the very few links connecting the condominiums neighbourhood with the surrounding neighbourhood. The main issues that can be observed are that this small street has a very high volume of motorised traffic and no sidewalk. This design completely ignores the basic needs of pedestrians and expose them, without protection, to motorised traffic. As a result, the low safety and inadequate walking infrastructure prevent people from walking.

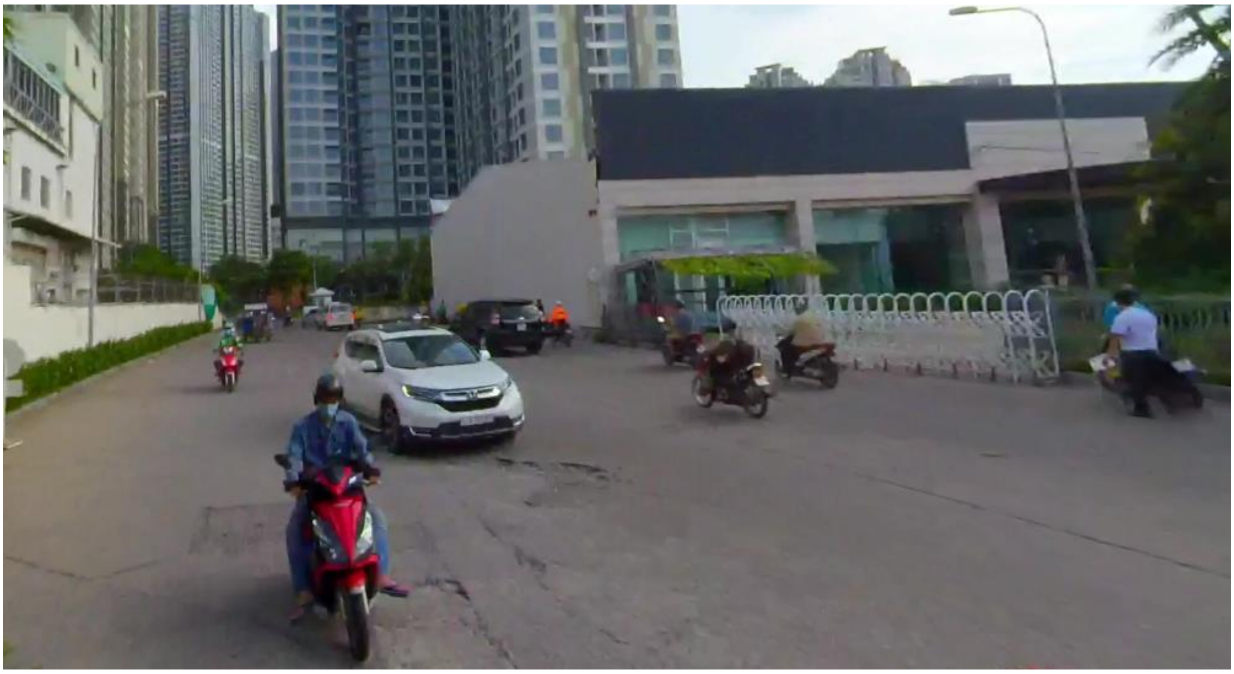

Figure 6.1-10: Route 2 segment 2, Nguyễn Hữu Cảnh, ward 22, Bình Thạnh district. Source: Image data ©2019 Google Street View

Route 2 has an overall WETUAV walkability index weighted score of 62 % (fairly walkable). This score is very similar to route 1, 60 % (fairly walkable). When comparing the two overall weighted scores, it can be noticed, that only a general overview of the walking conditions is described. This is not accurate enough to identify what is making a route walkable or not. Therefore the walkability index score weighted of the different route segments or average indicator scores is preferred for the interpretation of the walkability results of an area.

Category A "Conflicts between pedestrian and other street users" is performing well with a category score of 76 % (very walkable) (Appendix Table 13.4-1). This is mainly due to the last two segments (number 3 and 4) which are located in the newly developed high-rise condominiums neighbourhood. Wide sidewalks and heavily regulated public space limits sidewalk encroachment (3.83) and provide a strict separation between motorised traffic and pedestrians, thus increasing pedestrian traffic safety (3.10). However, removing most street activities has its drawbacks. At nighttime, a reduced street activity (2.03) can lead to an increased feeling of insecurity (1.91). Furthermore, banning street activities lead to gentrification of a neighbourhood and removes a social safety net for the vulnerable social classes.

Table 6.1-5 indicates that the WETUAV was able to identify 15 shortcomings throughout the walking route. The main shortcomings for this route are low sidewalk/street ratios, low street activities, low social security and lack of walking amenities.

Table 6.1-5: Interpretation of the WETUAV results per segment, route 2. Source: Author’s own

WETUAV Route 2: Condominium	
Segment 1	**Walkability index weighted = 54 %**
Street name, ward	176 Nguyễn Hữu Cảnh, ward 22
Identified shortcomings	Heavy sidewalk encroachment
	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Low social security
	Poor visual aesthetics
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy sidewalk encroachment, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure, low social security, unattractive visual aesthetics and lack of walking amenities.
Segment 2	**Walkability index weighted = 28 %**
Street name, ward	208 Nguyễn Hữu Cảnh, ward 22
Identified shortcomings	Low pedestrian traffic safety
	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Missing street activities
	Low social security
	Poor visual aesthetics
	Lack of walking amenities
Description	This street is **not walking-friendly**; identified shortcomings include low pedestrian traffic safety, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure, missing street activities, low social security, unattractive visual aesthetics and lack of walking amenities.
Segment 3	**Walkability index weighted = 80 %**
Street name, ward	208 Nguyễn Hữu Cảnh, ward 22
Identified shortcomings	Missing street activities
Description	This street is **very walkable**; identified shortcomings include missing street activities.
Segment 4	**Walkability index weighted = 84 %**
Street name, ward	Trần Trọng Kim, ward 22
Identified shortcomings	Low public transport availability
Description	This street is **very walkable**; identified shortcomings include lack of public transport.

Table 6.1-6 is showing that this route is generally “walking-friendly”. Only two segments reached the highest walkability score, whereas the first segment has the score of very walkable. Interestingly, segment 4 which is the last segment leading to the Vinhomes central park achieves the lowest score. This is probably due to the low density of daily amenities close to the park. Walk Score® was not able to discover any of the shortcomings discussed in Table 6.1-5.

Table 6.1-6: Walk Score® results, route 2. Source: Author's own based on Walk Score®

Walk Score® Route 2: Condominium	
Segment 1	**Walk Score = 88 %**
Description	176 Đường Nguyễn Hữu Cảnh has a Walk Score of 88 out of 100. This location is **Very Walkable** so most errands can be accomplished on foot. Nearby parks include Van Thanh Park, Công viên and SAIGONLAND.
Segment 2	**Walk Score = 93 %**
Description	208 Đường Nguyễn Hữu Cảnh has a Walk Score of 93 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Van Thanh Park, SAIGONLAND and Công viên
Segment 3	**Walk Score = 93 %**
Description	208 Đường Nguyễn Hữu Cảnh has a Walk Score of 93 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Van Thanh Park, SAIGONLAND and Công viên
Segment 4	**Walk Score = 66 %**
Description	Trần Trọng Kim has a Walk Score of 66 out of 100. This location is **Somewhat Walkable** so some errands can be accomplished on foot. Nearby parks include Công viên, Van Thanh Park and Cửa Hàng Hoa Kiểng Sa Đéc

6.1.3 Route 3: Shophouse

The third test route is located in district 5 and the map of this route is shown in Figure 6.1-11. This route is located in a shophouse neighbourhood in the old inner district of the city. It evaluates the walkability between a shophouse in an alleyway and a small square. The trip purpose of this route is similar to route 2, the only difference is the type of neighbourhood. The total length of the walking trip is about 1000 m and includes 5 segments. The input data was collected through street imagery platforms (Image data ©2019 Google Street View).

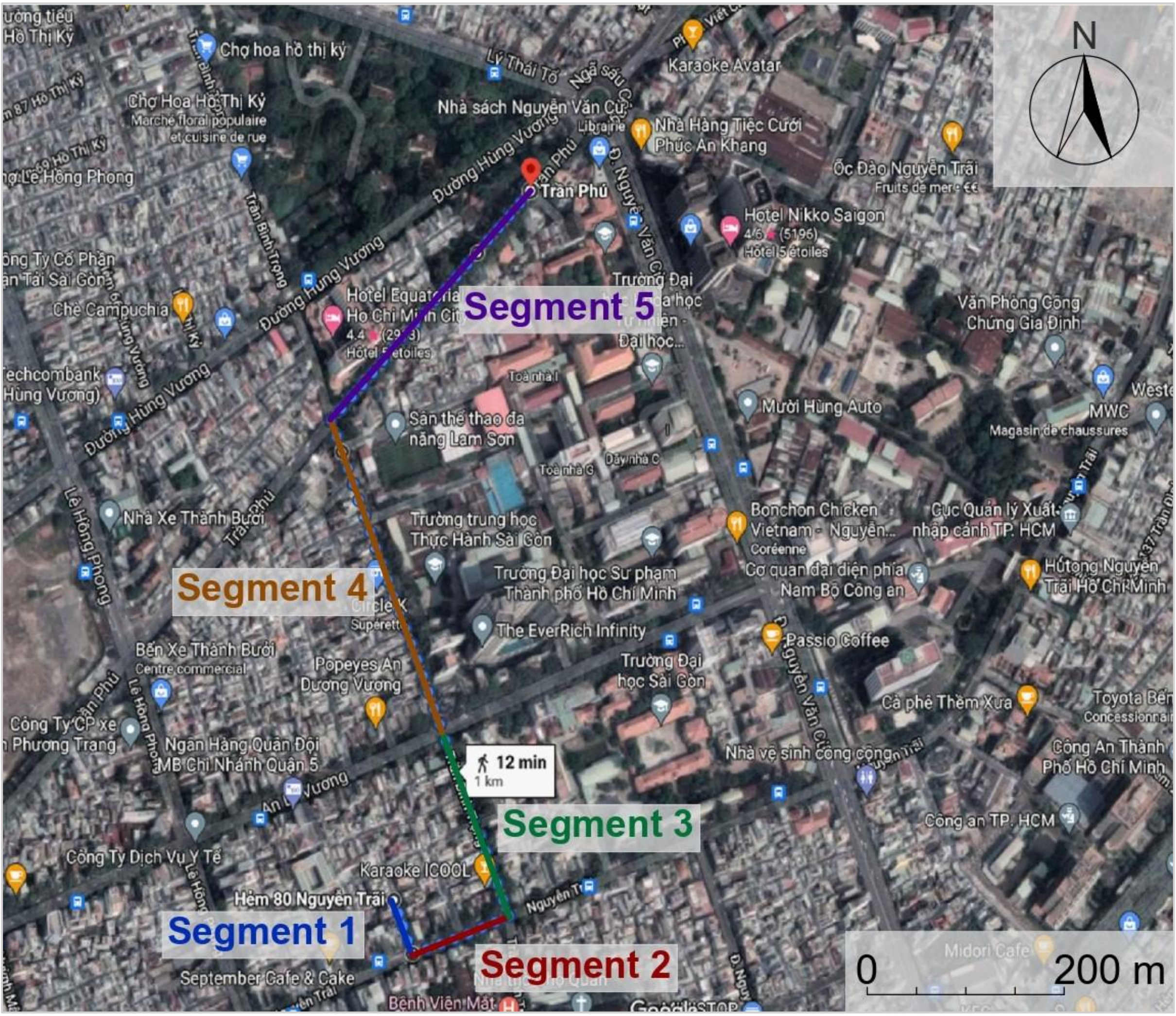

Figure 6.1-11: Map overview of route 3. Source: Author's own based on Map data ©2021 Google, CNES/Airbus, Maxar Technologies

Figure 6.1-12 shows an illustrative cross-section of segment 1. The WETUAV walkability index weighted of this segment is 87 % (very walkable). This figure underlines the assumption that alleyways do not need a sidewalk for a pedestrian to safely move in the public space. The photography shows children and elderly people, which indicate that they probably feel safe in the street space (Figure 6.1-12). The observed street activity corresponds to the results of the WETUAV.

Figure 6.1-12: Route 3 segment 1, hẻm 80 Nguyễn Trãi, ward 3, District 5. Source: Author's own

The entire route is located in one of the central districts and is characterised by typical Vietnamese settlement structures with an extremely high density of living. The overall WETUAV walkability index weighted score is 64 % (fairly walkable) (Appendix Table 13.4-3). Similarly to route 1 "Traditional market" the indicators performing poorly in every segment include encroachment density index (0.00) and walking amenities index (0.48). Segment 1 achieved a score of "very walkable". This segment is an alleyway, where sidewalk encroachment is not considered since this street typology generally does not need sidewalks. It is usually a shared space between pedestrians and other road users. The high walkability index weighted score for this segment is 87 % (very walkable). It seems plausible since the number of observed pedestrians outnumbers motorised vehicle drivers. Furthermore, century-old tree canopies offer generous shading (4.20) and street activities are numerous (4.88). The mix-use and density of shophouse neighbourhoods benefit the local centrality index (5.00). Several bus stops were observed in a 400 m vicinity of the route resulting in high availability of public transport index (4.80).

A total of 12 shortcomings were identified throughout the entire route (Table 6.1-7). The main shortcomings of this route are encroachment and lack of walking amenities. The indicator scores range between the segment from "fairly walkable" to "very walkable". The next 4 segments have quite similar scores and street typologies, where sidewalk encroachment and a bad sidewalk infrastructure are the main flaws. Parked motorcycles, advertising signs as well some street vendors are forcing pedestrians to walk on the street, which leads to lower pedestrian traffic safety. More images of the route segments can be found in the appendix (in Figure 13.4-4, Figure 13.4-5, Figure 13.4-6 and Figure 13.4-7).

Table 6.1-7: Interpretation of the WETUAV results per segment, route 3. Source: Author’s own

WETUAV Route 3: Shophouse	
Segment 1	**Walkability index weighted = 87 %**
Street name, ward	Hẻm 80 Nguyễn Trãi, ward 3
Identified shortcomings	Lack of walking amenities
Description	This street is **very walkable**; identified shortcomings include a lack of walking amenities.
Segment 2	**Walkability index weighted = 62 %**
Street name, ward	Nguyễn Trãi, ward 3
Identified shortcomings	Heavy sidewalk encroachment
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment and lack of walking amenities.
Segment 3	**Walkability index weighted = 60 %**
Street name, ward	Trần Bình Trọng, ward 3
Identified shortcomings	Heavy sidewalk encroachment
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment and lack of walking amenities.
Segment 4	**Walkability index weighted = 55 %**
Street name, ward	Trần Bình Trọng, ward 4
Identified shortcomings	Heavy sidewalk encroachment
	Low pedestrian traffic safety
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment, low pedestrian traffic safety, bad/inexistent walking infrastructure and missing walking amenities.
Segment 5	**Walkability index weighted = 57 %**
Street name, ward	Trần Phú, ward 4
Identified shortcomings	Heavy sidewalk encroachment
	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure and lack of walking amenities.

The results of Walk Score® shows a very high walkability score for the entire route (Table 6.1-8). All segments for this route reached the score “Walker’s Paradise”. Daily errands do not require a car. Here again, it becomes clear that the indicators used by Walk Score® are not sufficient to describe the walkability situation in Ho Chi Minh City.

Table 6.1-8: Walk Score® results, route 3. Source: Author’s own based on Walk Score®

Walk Score® Route 3: Shophouse	
Segment 1	**Walk Score = 96 %**
Description	Hẻm 80 Nguyễn Trãi has a Walk Score of 96 out of 100. This location is a **Walker’s Paradise** so daily errands do not require a car. Nearby parks include Hoa Binh Park, Công viên Âu Lạc and Công viên Chung cư Nguyễn Thiện Thuật
Segment 2	**Walk Score = 96 %**
Description	70 Nguyễn Trãi has a Walk Score of 96 out of 100. This location is a **Walker’s Paradise** so daily errands do not require a car. Nearby parks include Công viên Âu Lạc, Hoa Binh Park and Công viên Chung cư Nguyễn Thiện Thuật.
Segment 3	**Walk Score = 97 %**
Description	184 Trần Bình Trọng has a Walk Score of 97 out of 100. This location is a **Walker’s Paradise** so daily errands do not require a car. Nearby parks include Công viên Âu Lạc, Hoa Binh Park and Công viên Chung cư Nguyễn Thiện Thuật
Segment 4	**Walk Score = 97 %**
Description	273 Trần Bình Trọng has a Walk Score of 97 out of 100. This location is a **Walker’s Paradise** so daily errands do not require a car. Nearby parks include Công viên Âu Lạc, Hoa Binh Park and Công viên Chung cư Nguyễn Thiện Thuật
Segment 5	**Walk Score = 96 %**
Description	3D Trần Phú has a Walk Score of 96 out of 100. This location is a **Walker’s Paradise** so daily errands do not require a car. Nearby parks include Công viên Âu Lạc, Công viên Chung cư Nguyễn Thiện Thuật and Hoa Binh Park.

6.1.4 Route 4: Separate houses

The fourth test route is located in district 2. As seen in Figure 6.1-13, most houses located along the routes are separate houses. Similarly to route 1, this journey also replicates a grocery shopping trip and evaluates the walkability between a house located close to DALALAND Saigon Coffee and An Phú supermarket. The total length of the walking trip is about 1000 m and includes 4 segments. The input data was collected using the on-site video footage collection method. Segment 4 (Figure 6.1-14) is located after the supermarket but its inclusion turned out to be beneficial for this research as described later.

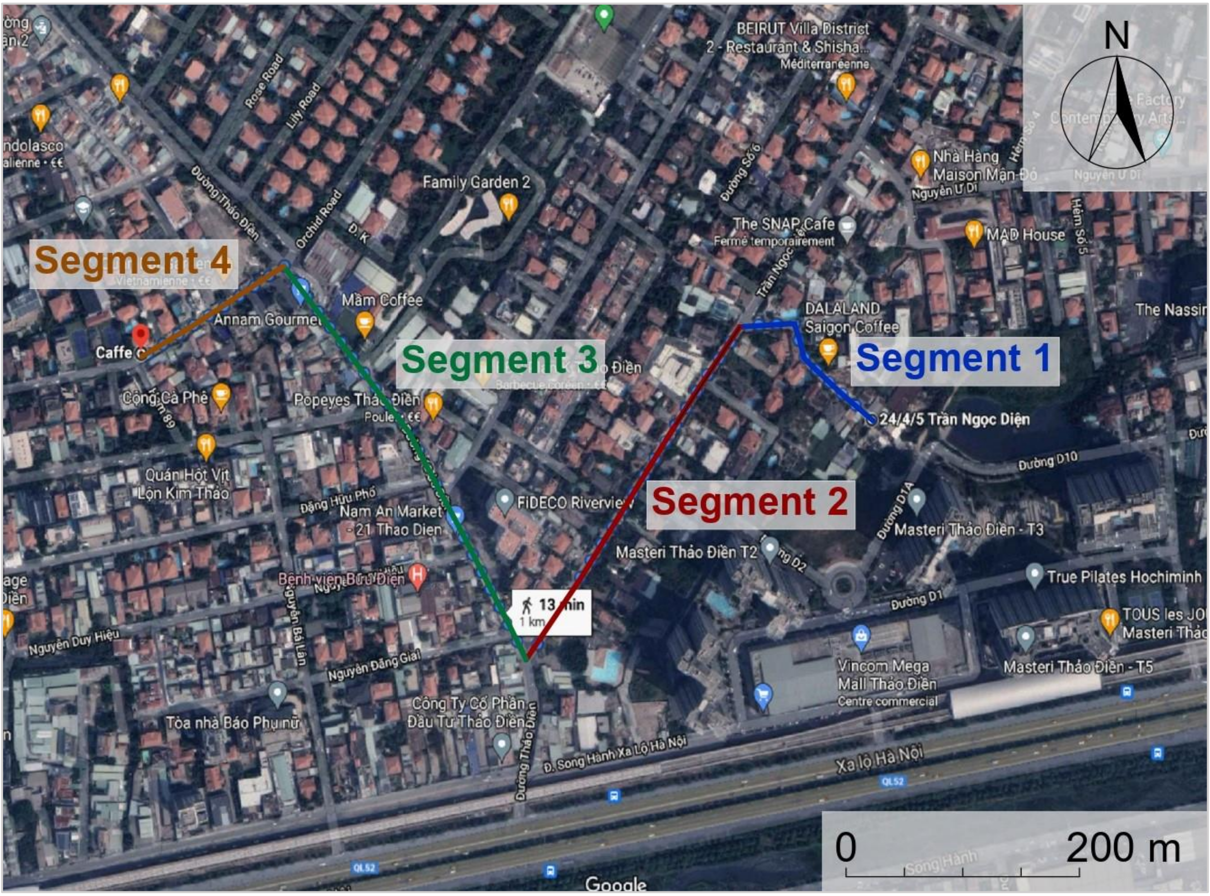

Figure 6.1-13: Map overview of route 4. Source: Author's own based on Map data ©2021 Google, CNES/Airbus, Maxar Technologies

Figure 6.1-14: Route 4 segment 4, Ngô Quang Huy, District 2. Source: Author's own

The overall WETUAV walkability index weighted score for route 4 lies at 45 % and is the street with the lowest walkability score of the five testing routes (Appendix Table 13.4-5). However, not every segment of route 4 present a low walkability index. Segment 1 reaches a walkability index weighted score of 73 % (fairly walkable). The street typology of this segment is an alleyway; thus, the encroachment density index is not applicable. The local centrality index has the lowest value possible, due to its low residential density of 2,282 inhabitants/km^2 and a limited number of shops. The closest public transport station is 700 m away, making the use of public transport unattractive (1.50). The second and third segments have the street typology of a district street and include sidewalks on both sides. A limited sidewalk width combined with parked motorcycles and utility poles leads to serious encroachment (1.75). This affects the walking trajectory, forcing pedestrians to bypass the obstacle on the roadway. Street activities (1.98) were absent for the entire route. Walking amenities (0.66) such as public toilets or public sitting facilities are absent. The only indicator performing well for this route is the traffic air/noise pollution index (4.90). This is due to the low density and the peninsula shape of this ward surrounded by the Saigon River to the west, north and east, thus, excluding through traffic from neighbouring districts. The last segment of this route (number 4) has the worst assessment. The street typology is a neighbourhood street, corresponding to a two-lane street, less than 6 m wide. There is no sidewalk available, affecting pedestrian traffic safety, but because of the street's narrow typology and the low amount of traffic, the exposure of conflicts between pedestrians and motorised vehicles was limited. This segment achieves a score of 8 % representing a street with "bad walking conditions". The only positive aspect of this segment was the low volume of motorised traffic with a Level of Service A, enhancing the traffic air and noise pollution index.

Table 6.1-9: Interpretation of the WETUAV results per segment, route 4. Source: Author's own

WETUAV Route 4: Separate houses	
Segment 1	**Walkability index weighted = 73 %**
Street name, ward	Hẻm Trần Ngọc Diện, ward Thảo Điền
Identified shortcomings	Unfavourable local centrality due to low density single-use separate houses
	Low social security
	Low public transport availability
	Poor visual aesthetics
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include low land-use mix/ low residential density, low social security, lack of public transport, unattractive visual aesthetics and lack of walking amenities.
Segment 2	**Walkability index weighted = 42 %**
Street name, ward	Trần Ngọc Diện, ward Thảo Điền
Identified shortcomings	Heavy sidewalk encroachment
	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Unfavourable local centrality due to low density single-use separate houses
	Missing street activities
	Low social security
	Poor visual aesthetics
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure, low land-use mix/ low residential density, lack of street activities, low social security, unattractive visual aesthetics and lack of walking amenities.
Segment 3	**Walkability index weighted = 59 %**
Street name, ward	Thảo Điền, ward Thảo Điền
Identified shortcomings	Heavy sidewalk encroachment
	Unfavourable local centrality due to low density single-use separate houses
	Low social security
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include heavy encroachment, low land-use mix/ low residential density and lack of street activities, low social security and lack of walking amenities.
Segment 4	**Walkability index weighted = 8 %**
Street name, ward	Ngô Quang Huy, ward Thảo Điền
Identified shortcomings	Low pedestrian traffic safety

	Unfavourable sidewalk/street ratio for pedestrians
	Poor sidewalk conditions
	Unfavourable local centrality due to low density single-use separate houses
	Tree canopy providing insufficient shade
	Missing street activities
	Low social security
	Low public transport availability
	Poor visual aesthetics
	Lack of walking amenities
Description	This street has **bad walking conditions**; identified shortcomings include low pedestrian safety, motorised vehicles favourable space distribution, bad/inexistent walking infrastructure, low land-use mix/ low residential density, intense sun exposure, missing street activities, low social security, lack of public transport, unattractive visual aesthetics and missing walking amenities.

Table 6.1-10 shows that Walk Score® attributes good walkability scores for this route. While the first segment has a score of "very walkable", the rest of the segments achieve the highest score possible. All the daily errands can be accomplished on foot.

Table 6.1-10: Walk Score® results, route 4. Source: Author's own based on Walk Score®

Walk Score® Route 4: Separate	
Segment 1	**Walk Score = 76 %**
Description	24 Đường Trần Ngọc Diện has a Walk Score of 76 out of 100. This location is **Very Walkable** so most errands can be accomplished on foot. Nearby parks include Công viên Thảo Điền, Sparkle park and AAVN Park.
Segment 2	**Walk Score = 90 %**
Description	15 Đường Trần Ngọc Diện has a Walk Score of 90 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Công viên Thảo Điền, Công viên Thanh Niên and Rửa xe AutoFine.
Segment 3	**Walk Score = 92 %**
Description	16 Đường Thảo Điền has a Walk Score of 92 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Công viên Thảo Điền, Công viên Thanh Niên and AD FURNITURE CORP.
Segment 4	**Walk Score = 91 %**
Description	55 Ngô Quang Huy has a Walk Score of 91 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Công viên Thảo Điền, AD FURNITURE CORP and Công viên Thanh Niên.

6.1.5 Route 5: Historic centre

The fifth test route is located in district 1 (Figure 6.1-15) and starts in a fully pedestrianised street in the historic centre of Ho Chi Minh City. This route was chosen because it is one successful example of pedestrianisation in Ho Chi Minh City. Following the pedestrian-only street, the route passes next to the Notre-Dame cathedral in the Đồng Khởi street, which is a famous shopping street in the city centre. It ends in front of the city hall. The total length of the walking trip is about 700 m and includes 4 segments. The input data was collected using street imagery platforms (Image data ©2019 Google Street View).

Figure 6.1-15: Map overview of route 5. Source: Author's own based on Map data ©2021 Google, CNES/Airbus, Maxar Technologies

In Figure 6.1-16, the segment with the highest WETUAV score can be seen. It reached a walkability score of 97 % and was also the segment where most pedestrians were observed. The WETUAV identified no shortcomings and walkers are not confronted with any other street user. The narrow street design with its aligned trees forms an ideal canopy, protecting pedestrians from intense sun exposure. The absence of motorised vehicles limits air and noise pollution and enable comfortable social interactions.

Figure 6.1-16: Route 5 segment 1, Nguyễn Văn Bình, ward Bến Nghé, District 1. Source: Image data ©2019 Google Street View

Route 5 achieved overall the highest walkability score (Table 6.1-11). Generous shading, well-maintained street and amenities, inexistent encroachment, are all set to satisfy pedestrians' expectations. The only shortcomings are identified in segments 3 and 4. For these segments, the street activities, low social security and insufficient walking amenities are the only things that are missing, for fulfilling pedestrian needs.

Table 6.1-11: Interpretation of the WETUAV results per segment, route 5. Source: Author's own

Route 5: Historic Centre	
Segment 1	**Walkability index weighted = 97 %**
Street name, ward	Nguyễn Văn Bình, ward Bến Nghé
Identified shortcomings	None
Description	This street is **very walkable**; with no shortcomings identified.
Segment 2	**Walkability index weighted = 89 %**
Street name, ward	Công Xã Paris, ward Bến Nghé
Identified shortcomings	Unfavourable sidewalk/street ratio for pedestrians
	Lack of walking amenities
Description	This street is **very walkable**; identified shortcomings include motorised vehicles favourable space distribution and lack of walking amenities.
Segment 3	**Walkability index weighted = 74 %**
Street name, ward	Đồng Khởi, ward Bến Nghé
Identified shortcomings	Low social security

	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include low social security and lack of walking amenities.
Segment 4	**Walkability index weighted = 73 %**
Street name, ward	Lê Thánh Tôn, ward Bến Nghé
Identified shortcomings	Missing street activities
	Low social security
	Lack of walking amenities
Description	This street is **fairly walkable**; identified shortcomings include missing street activities, low social security and lack of walking amenities.

According to Walk Score®, all segments receive a score of 100 %, meaning it's a "Walker's Paradise" (Table 6.1-12). A further comparison between the results from WETUAV and Walk Score® will be explained in the following chapter. Since this route benefitted from well-maintained infrastructure and very few shortcomings, lower differences between the WETUAV and Walk Score® could be noticed.

Table 6.1-12: Walk Score® results, route 5. Source: Author's own based on Walk Score®

Route 5: Historic Centre	
Segment 1	**Walk Score = 100 %**
Description	7 Đường Nguyễn Văn Bình has a Walk Score of 100 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Cafe Bệt, Coffee bệt nhà thờ đức bà. and Công viên 30-4
Segment 2	**Walk Score = 100 %**
Description	Công xã Paris has a Walk Score of 100 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Cafe Bệt, Coffee bệt nhà thờ đức bà. and Công viên 30-4
Segment 3	**Walk Score = 100 %**
Description	229 Đồng Khởi has a Walk Score of 100 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn Chi Lăng, Công viên Bách Tùng Diệp and Cafe Bệt
Segment 4	**Walk Score = 100 %**
Description	Lê Thánh Tôn has a Walk Score of 100 out of 100. This location is a **Walker's Paradise** so daily errands do not require a car. Nearby parks include Vườn Chi Lăng, Công viên Bách Tùng Diệp and Phố đi bộ Nguyễn Huệ.

6.2 Comparison of the results of WETUAV and Walk Score® [AS & QT]

This chapter focuses on the comparison between the results from the WETUAV and Walk Score®, thereby answering the third research question which is: "How will the Walkability Evaluation Tool for Urban Areas in Vietnam perform in comparison with Walk Score®?". Two different methods were used to collect input data for the evaluation of the walkability for the five routes. One route, the fourth, was assessed using the *on-site video footage collection* method, provided by a friend of the authors. The other routes were assessed using the *online street imagery platform* method (Image data ©2019 Google Street View). When using video footage, the walking behaviour of pedestrians could be assessed. For example, the authors discovered that throughout the video footage, pedestrians would choose to go on the street rather than the sidewalk because of the recurrent sidewalk obstacles. The users of the tool can look at things from the perspective of a pedestrian, which makes it simpler to assess the 41 input criteria of the WETUAV. However, the drawback of using this method is that it takes longer to record the data.

On the other hand, Image data from Google Street View (©2019) offers the advantage of being available fast and from a remote place. The most significant drawbacks are that the data is not available in every street and that there is no clear information regarding the day and time of the recording, among other things.

As shown in Table 6.2-1, all routes have a total length of less than 1 km which represents walking trips of less than 15 minutes. There is no significant difference between the Raw Walkability score and the Weighted Walkability result of the Walkability Evaluation Tool for Urban Areas Vietnam (WETUAV). Nonetheless, a slightly greater difference can be noticed in routes 1 and 3. These two routes are located in typical Vietnamese shophouse neighbourhoods where sidewalks are usually heavily encroached.

Table 6.2-1: Differences between the results from Walk Score® and the "raw" and "weighted" WETUAV results for the 5 test routes. Source: Author's own

			WETUAV walkability index [%]		Walk Score® [%]	Difference Walk Score®- WETUAV [% - points]	
Type of neighbourhood	**Route length [m]**		Raw	Weighted		Raw	Weighted
Traditional market	**Route 1**	600	71	60	97	-26	-37
Condominiums	**Route 2**	950	55	62	85	-30	-23
Shophouse	**Route 3**	1,000	67	64	96	-29	-32
Separate houses	**Route 4**	1,000	38	45	87	-49	-42
Historic centre	**Route 5**	700	72	83	100	-28	-17
	Total	**850**	**61**	**63**	**93**	**-32**	**-30**

Walk Score® measures the walkability of any address using algorithms to analyse hundreds of walking routes to nearby amenities (Walk Score® 2021). Points are awarded depending on the proximity to amenities and measures pedestrian friendliness by analysing population density, road metrics (block length, intersection density) (ibid.). As a result, the final score is mostly composed of an evaluation of the walking distances between an address and its surrounding amenities, as well as the density of daily amenities in the surrounding area. Nevertheless, Walk Score® is often used as a reference in the literature to describe the walkability of a neighbourhood. In Asia, Koohsari et. al (2021) and Ting-fu et al. (2019) analysed the relation between the Walk Score® and the perceived walkability in study areas in Japan and Taiwan respectively. The study conducted by Koohsari et al. (2021) concluded, that there was a medium correlation between Walk Score® and the overall perceived walkability of ultra-high-density areas in Koto City (Tokyo prefecture) and Matsuyama City (Ehime prefecture), Japan. The nine indicators used in that study are very similar to the ones used in WETUAV and included: (1) population density, (2) access to shops, (3) access to public transport, (4) presence of sidewalks, (5) presence of bike lanes, (6) access to recreational facilities, (7) aesthetics, (8) traffic safety, (9) safety from crime. In Taiwan, Ting-Fu et al. (2019) found out, that Walk Score® appears to be a valid measurement tool for evaluating the walkability of neighbourhoods. Despite the different methodologies of Walk Score® and WETUAV, both tools are designed to describe the walkability of a neighbourhood which makes it suitable for comparison.

When comparing the WETUAV assessment results with the results from Walk Score®, all of the analysed routes had a lower result when WETUAV is used. There is an average difference of 32 percentage points between WETUAV "raw" and Walk Score® and 30 percentage points between WETUAV "weighted" and Walk Score®. A smaller difference can be noticed in routes 2 and 5. These two routes have more a car-oriented design based on western standards, as well as wider sidewalks, which are heavily regulated by the authorities, therefore diminishing street activity and as a result also reducing sidewalk encroachment.

Following a comparison of the two tools, the authors conclude that WETUAV has greater accuracy in assessing the walking conditions in an area. It is also capable of recognising punctual shortcomings occurring during the assessment of a walking route. More importantly, the instrument has been developed to measure walkability while still preserving the Vietnamese traditional usage of public space. The downside of the WETUAV is, that it is more time-consuming than tools based on algorithms and requires the support of trained observers to limit the subjectivity of the results (chapter 6.4). Despite this, the tool was primarily developed for Vietnamese urban environments and will require further adaptation before it can be used elsewhere.

In contrast to WETUAV, the key advantage of Walk Score® is its ability to deliver quick and objective results without requiring prior training by the user. All that is required to get a walkability score, is a street address. This tool is intended for usage on a global scale, making it easy to compare the walkability of cities all around the world. However, it is designed for car-dependent cities and does not assess sidewalk infrastructure or encroachment, nor does it consider social and cultural aspects.

Figure 6.2-1 shows the differences between the WETUAV score raw/weighted, and the Walk Score®. In addition, the Local centrality index (LCI) from the WETUAV is displayed. The local centrality index used a simplified formula to describe the proximity to amenities based on neighbourhood typologies and residential densities and corresponds to the Walk Score® evaluation of distances to nearby amenities. This made the authors want to compare the local centrality index and Walk Score® separately. As can be seen in Figure 6.2-1, the scores for route 1 (96 %) and route 3 (100 %) are very similar, matching the results of Walk Score® (96 %, 97 %). Both routes are located in dense shophouse neighbourhoods defined by small businesses offering a wide variety of goods and services. The LCI results of route 2 (65 %) and 5 (55 %) may be biased by the outdated population densities of those wards, where the most recent population census found dated from 1999. Walk Score® rated these routes with walkability scores of 85 % and 100 % respectively. However, route 4 describes a neighbourhood dominated by separate houses. For this route, the results are not corresponding at all. The authors want to point out that the simplified formula of the LCI used in WETUAV does not directly assess the number of amenities and is based on assumptions describing the efficiency of a neighbourhoods' structure regarding trip lengths and population densities. In this case, the structure of separate low-density houses highlights the inefficiency of the urban design regarding travel distances between home and daily necessities and resulted in a very low score (0 %). On the contrary, Walk Score® using a different assessment method detected several amenities such as restaurants, bars, cafés, schools and parks in the vicinity of route 4, giving it a high score (87 %). To conclude, the LCI performs as expected but the results describing proximity diverge from the result from Walk Score® due to the different assessment methodologies.

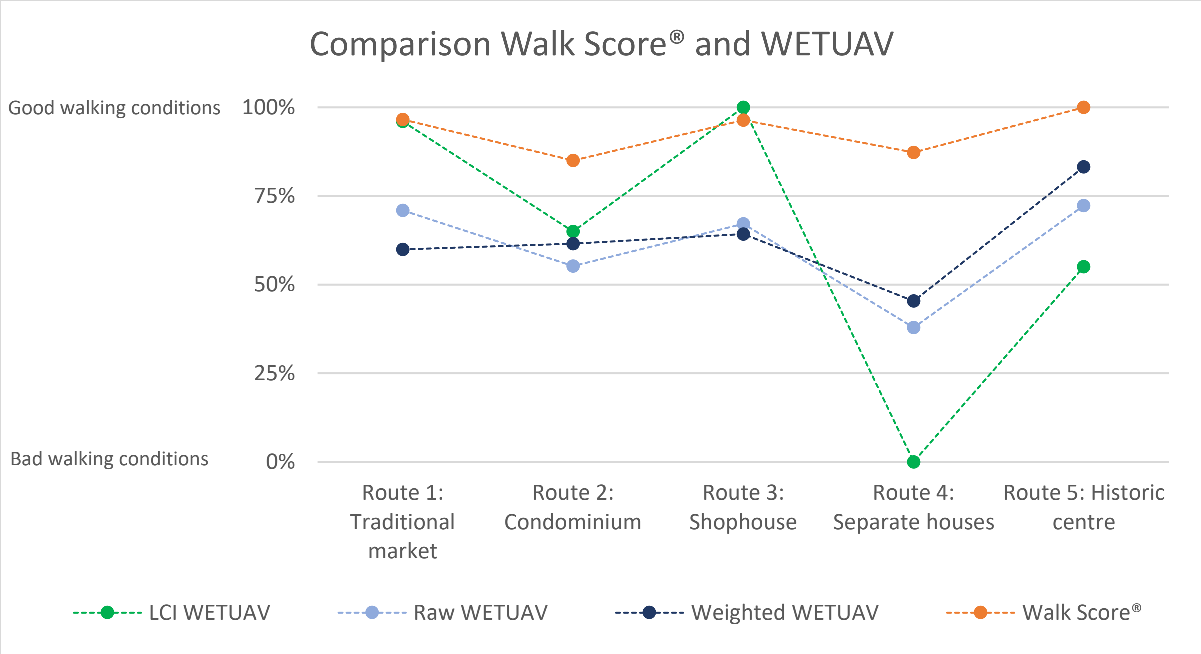

Figure 6.2-1: Comparison of Walk Score® and WETUAV based on 5 test routes in HCMC. Source: Author's own

In general, walkability scores of the WETUAV are lower than the results from Walk Score®. The authors argue that the high scores obtained by Walk Score® are wrongly indicating very high walkability in most of HCMC's neighbourhoods. This is confirmed by the very low modal share of pedestrians observed during the test route evaluations. One explanation is that Walk Score® does not include the three most relevant walkability indicators which were discovered in this research including sidewalk encroachment, sidewalk conditions and tree canopy/-shadow coverage.

The only route reaching the highest walkability category "very walkable" of the WETUAV is route 5, located in the touristic centre of Ho Chi Minh City. Throughout our evaluation process using video footage and online imagery from Google Street View (Image data © 2019), this route, was the only one where most pedestrians were observed. Though, further studies comparing the WETUAV score and the walking frequency needs to be done to confirm the accuracy of the tool.

Finally, by comparing the results from WETUAV "raw" with the WETUAV "weighted", slightly bigger differences can be noticed in the first and third routes. These routes are severely impacted by encroachment, and due to the high weight factor of the encroachment density index, the difference in the results is more important.

6.3 Sensitivity analysis for different category weight scenarios [AS & QT]

A sensitivity analysis was conducted for four different weighting scenarios. The examples are extracted from the five evaluated test routes (chapter 6.1). In addition to the indicators, the categories are weighted depending on their prioritisation. This is done to represent and compare the interests of different stakeholders. The following scenarios should be understood as examples and their weights can be adapted if necessary:

- The scenario "Walkability index weighted" serves as a reference for comparing the "Conflicts", "Infrastructure" and "Comfort" scenarios. The weights of the indicators are the same as described in chapter 5.7. For this scenario, every category has a weight factor of 33.3 %. (Cat. A = 33.3 %, Cat. B = 33.3 %, Cat. C = 33.3 %).
- In the scenario "Conflicts" category A (conflicts and impairment potential) has the strongest weight (62.5 %), mainly focusing on traffic safety, followed by category C (Pedestrian comfort) (25.0 %) and lastly by category B (Space and infrastructural conditions) (12.5 %).
- The focus of scenario "Infrastructure" is on the quality of the pedestrian built environment. Therefore, category B has the strongest weight (62.5 %), followed by category C (25.0 %) and lastly by category A (12.5 %).
- Scenario "Comfort" prioritises category C (62.5 %), which is focusing on the enjoyment of walking. Category A has a weight of 25.0 % and category B has a weight of 12.5 %.

Table 6.3-1: Sensitivity analysis for different category weight scenarios. Source: Author's own

Route	**Traditional market**			**Condominium**			**Shophouse**			**Separate house**			**Historic centre**		
Category*	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Weighted categories [%]	41.2	61.1	71.4	77.0	65.9	62.8	38.9	68.6	79.6	72.3	53.6	51.5	89.6	84.8	78.0
Overall score [%] Scenario "Walkability index weighted"	57.9			68.5			62.4			59.1			84.1		
Overall score [%] Scenario "Conflicts"	51.2			72.0			52.8			64.8			86.1		
Overall score [%] Scenario "Infrastructure"	66.5			66.5			67.6			55.4			83.7		
Overall score [%] Scenario "Comfort"	68.1			66.7			68.1			57.0			81.7		
*Category A: Conflicts and impairment potential; B: Space and infrastructural conditions; C: Pedestrian comfort															

Comparing the results between the scenarios, it can be seen that the differences between the reference scenario "Walkability index weighted " and the other scenarios are not exceeding 10 %. The route in the historic centre has the smallest discrepancy between the scenarios. The three indicators that are having the highest weight factor (5.0) are encroachment (category A), sidewalk conditions (category B) and tree canopy/shadow coverage (category C). Therefore, every category contains one indicator of very strong importance. As a result, since these three indicators have a similar value in route 5, the weight factors have a limited influence on the overall scenario scores. Looking at the results of the scenarios route 1 "Traditional market" and route 3 "Shophouse" have the highest discrepancy. The scenario "Conflicts", describes heavy sidewalk encroachment, that is negatively influencing the overall walkability score. Whereas scenario "Infrastructure" and "Comfort" describing the urban structure and the built environment are positively affecting the walkability scores. The sensitivity analysis is showing, that the traditional Vietnamese urban structure (shophouse neighbourhood), is more influenced by the indicator weights, than the newly built car-oriented neighbourhoods. The observed differences between the scenarios are in the expected range (≥ - 10 % – ≤ 10 %).

6.4 Limitations [AS & QT]

During the research, the authors encountered a wide range of limitations that are described in the following subchapters.

6.4.1 Survey design

Due to the restrictions imposed by the local government, a Pen-and-Paper Interview (PAPI) on-site was not possible. Vietnam closed the borders for international travellers, and the authors were forced to use the Computer-Assisted Web Interviewing (CAWI) method for gathering data. This method managed to reach mostly younger people, having a higher average income due to the higher education level of the target group. Elderly individuals, people with a lower education degree, as well as a lower income were mostly indirectly excluded from the survey. The reason is, that most of them do not have access to a computer or phone that is equipped with an internet connection and so they were harder to reach.

6.4.2 Limitation of the WETUAV formulas

The WETUAV is based on several indicators that use a set of predefined formulas in Excel to evaluate the walkability of a route. One of the criteria used to calculate the walkability is the ward or district population density. Some ward population densities that the authors had access to date from the year 1999. Some of these locations which were wasteland twenty years ago benefited from newly developed infrastructure as well as building projects, that have changed the urban structure of the ward. Therefore, the population densities used in the WETUAV are not reflecting the current demographic situation.

6.4.3 Spatial limitation of the WETUAV

The WETUAV was specifically designed for a Vietnamese urban environment. In this study, the main focus was Ho Chi Minh City. The authors assume that the perception of the walking experience would not greatly differ in comparison to other cities of Vietnam. For other cities, the district and street name database included in the tool needs to be adapted or removed and replaced by manual typing of the location of the trip segments.

6.4.4 WETUAV application

Information for evaluating the walkability can be collected through 3 different methods. The first method, the on-site data collection method, is a method that is time-consuming and requires walking the same route segment several times before collecting all the criteria for the WETUAV. If the process of evaluation was already started, and the user concluded, that the segment length is inappropriate, the evaluation process needs to be repeated. The second method, the on-site video footage method, has the same downside as the first, being time-consuming. The last method of collecting data is through online street imagery platforms. The limitation of this method is that the images provided by these platforms are not available on all the streets and information about the time of the day, as well as the date is not available.

The user that is assessing the walkability in a neighbourhood must first complete a training course in which the indicators are described in depth. The definitions of the indicators need to be understood because the input data is dependent on the subjectivity of the user. For example, the input criteria that collects qualitative data such as shadow coverage, type of shadow, Level of Service and encroachment type, can be perceived differently by users.

6.4.5 Others

The extreme events that can occur in HCMC, for example, flooding during a tropical storm, are not assessed by the WETUAV. This type of event requires further research and needs to be analysed and included in the tool, because of the different seasons that Vietnam has. Additionally, the tool is currently developed in English which will possibly limit the scope of future users.

The WETUAV does not include the assessment of the accessibility for individuals with disabilities concerning landscape surfaces, obstacles, and modes of transportation. Although Vietnam has acceded to the United Nations Convention on persons with disabilities, including the design and construction of public transport works in urban areas, in practice, a large part of the city's infrastructure still does not support the needs of the disabled (Truong et al., 2017). As a result, assessing the accessibility for people with disabilities made little sense for the current situation.

7 Conclusion [QT]

7.1 Plausibility of the results of the WETUAV

The walkability evaluation tool developed in this thesis allows an accurate evaluation of the walkability in urban neighbourhoods in the context of Ho Chi Minh City. The results successfully reflect the overall walkability of a neighbourhood using an elaborated indicator list based on literature research and a survey with inhabitants. Even though most of the input options are subdivided into predefined drop-down lists, the assessed input data of the WETUAV can potentially differ depending on the subjectivity of the user. Therefore, for users of WETUAV, a training course is mandatory to limit misinterpretations. The influence of subjectivity on the overall WETUAV walkability score needs to be analysed in further research.

7.2 Potential for future development

Other Asian countries benefiting from similar dense urban typologies as Vietnam can use the WETUAV to calculate the walkability of existing neighbourhoods to develop pedestrian enhancement measures based on the findings of the walkability assessment. To increase the modal share of pedestrians, walkability maps on the scale of the city or neighbourhood can be created based on the WETUAV segment results and serve as a planning tool for creating sustainable neighbourhoods. Furthermore, updating the map on regular intervals can indicate the walkability trend of cities and serve as a promotion tool highlighting the benefits of walking to the public. Since the local traffic and climate conditions can significantly differ from one city to another, further tests need to be done to compare the suitability of the weight factors and indicators chosen for Vietnam. Other indicator weighting configurations could be tested based on expert interviews. Indicators found to be unsuitable should be adapted, removed, or replaced. The user-friendliness of the WETUAV has the potential to be improved. One option would be to shorten the list of input criteria to optimise the data assessment process, while preventing the degradation of data quality. The on-site video footage collection method has proven to be more time-consuming compared to its online counterpart. However, the data quality seemed to have improved providing more accurate information about the current walking conditions. Conducting a new online survey having a bigger and more diverse target group that includes elderly and vulnerable social groups evenly distributed across the city could lead to a more detailed comparison of motorisation rates, walkability perceptions and mobility behaviours between districts or wards. Updating the population densities from wards and districts can help to limit the bias created by outdated data. A large-scale testing of the tool implying several users to rate the user-friendliness of the WETUAV should be done to verify the subjectivity of the user. As described in this thesis, the activities change throughout the day, potentially influencing the outcome of the WETUAV. Therefore, a study should be conducted assessing the walkability during morning, noon, and evening for weekdays as well as weekends, to further analyse the differences of the WETUAV results.

8 Summary [AS & QT]

8.1 Starting point

Ho Chi Minh City, Vietnam's economic capital, is notoriously congested. Motorcycles are the most popular mode of transportation, accounting for 86.3 % of all trips and 98.6 % of household ownership. Nevertheless, motorcycles also cause pollution, resulting in chronic health issues, yet they are the most energy-efficient private motorised mode available. The safety of pedestrians is constantly threatened by parked vehicles encroaching the sidewalks and driving motorcycles that are trying to bypass traffic jams on the sidewalk. As a result, most individuals are discouraged from walking, despite the fact that there appears to be a potential for walking trips based on distances.

8.2 Survey

To identify the most significant factors that discourage people from walking, an online survey was conducted with the goal of gathering some key information regarding local travel behaviour and perceptions of the environment. The questionnaire consisted mainly of multiple-choice questions based on the Likert Scale and was designed to be completed within 10 minutes. The first section handled demographic information such as gender, age, residence address (district and ward), education level, vehicle ownership, and driving licenses. The second section focused on trips frequency to predefined destinations, which included work/education facilities, shops of essential goods, shops of non-essential goods, recreational facilities, entertainment, and restaurants, as well as what is preventing people from walking. The final section dealt with the pedestrian experience, beginning with the convenience of the transportation means, followed by thoughts on street activities, and finally with ideas to improve the pedestrian experience.

8.3 Development of walkability indicators for WETUAV

During the literature review, it was decided to create a list of factors regarding the pedestrian-friendly street design. The factors in the list include a wide range of issues relating to pedestrian perception, comfort, and well-being, with each component describing a different aspect of each. This list was included in the survey to evaluate their relevance. Furthermore, an analysis of the perception of walkability factors between genders concluded that despite a significant mean difference, a strong correlation of the order of the walkability factors relevance was observed. The outcome of the literature review and survey, resulted in the creation of a total of 12 indicators, which were divided into three categories. The first category describes the dynamic processes of physical encounters that are detrimental to pedestrians' well-being. The built environment for pedestrians is included in the second category, and the indications that have a favourable impact on walkability and lead to increased pedestrian comfort and convenience are found in the third category. Different indicator weights were created to evaluate the indicators' significance for walking-friendly areas. The weighting of the indicators increases the importance of indicators that have a large impact on the walkability score.

8.4 Evaluation process

The aim was to test the Walkability Evaluation Tool for Urban Areas Vietnam in different neighbourhoods of HCMC. The chosen indicator weights were also evaluated against the raw findings. The WETUAV and, in addition, the method of Walk Score® were used to evaluate 5 different walking routes. The purpose was to measure the walkability in distinctive urban environments based on the indicators. The first test route, in district 10, simulated a grocery shopping walk between a residential complex and a traditional Vietnamese market. Shophouses with alleyways were surrounded by two important arterial roadways. The second test route is in Bình Thạnh district. The route started at a bus station on Nguyễn Hữu Cảnh street, then went through a new neighbourhood with high-rise condominiums until reaching Vinhomes Central Park. The third route is in district 5. The major difference between this route and route 2 is the type of neighbourhood. The fourth route is in district 2, a neighbourhood characterised by separate houses with a low population density. This route evaluates the walkability between a separate house and a grocery shop. The last test route is in district 1. This route starts on a pedestrianised book street in Ho Chi Minh City. Following the book street, the route passes next to the Notre-Dame cathedral into Đồng Khởi street, which is a famous shopping street and ends in front of the city hall. The majority of the routes were assessed through Google Street View and only route 4 was assessed through video footage.

8.5 Results

The outcome of the WETUAV with another method, that is used to obtain the walkability of a street. The results showed that the WETUAV method, in comparison to Walk Score®, has on average a 30 percentage points lower score, indicating less favourable conditions for pedestrians. Routes 2 and 5 showed slightly lower differences in the results. These two roads are designed for cars and feature broader sidewalks that are regularly patrolled to prevent encroachment, hence reducing street activity. Compared to Walk Score®, the WETUAV, having a customised indicator list for Vietnam, has shown to be more accurate in assessing walking conditions and succeeded in recognising punctual shortcomings of a walking route.

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13 Appendix

13.1 Survey

Questionnaire: Walking habits in HCMC - Khảo sát: Thói quen đi bộ ở Thành phố Hồ Chí Minh

Our names are Trần Quốc Quang and Solomon Andrei, and we are currently studying for a master's degree in Transport Studies at the University of Natural Resources and Life Sciences in Vienna, Austria. This survey collects mobility data for a master thesis. The collected data will only serve the purpose of the thesis and will be kept anonymous and confidential. Thank you for taking the time to fill out this questionnaire. It will take around 5 minutes to fill out this questionnaire. Your support is decisive for the success of the study. If you have any questions regarding the questionnaire, please contact us via quang.tran@students.boku.ac.at or andrei.solomon@students.boku.ac.at. For further information about the Institute for Transport Studies, you can visit the following homepage: https://boku.ac.at/en/rali/verkehr

Chúng tôi là Trần Quốc Quang và Solomon Andrei, hiện đang theo học chương trình Thạc sĩ ngành Vận tải, trường Đại học Tài nguyên Thiên nhiên và Khoa học Sự sống Vienna, Áo. Khảo sát này được thực hiện để thu thập dữ liệu về thói quen di chuyển cho luận văn Thạc sĩ của chúng tôi. Dữ liệu thu thập chỉ được sử dụng cho mục đích nghiên cứu và sẽ được giữ bảo mật và ẩn danh. Chân thành cảm ơn anh/chị đã dành thời gian hoàn thành khảo sát này. Khảo sát này sẽ mất khoảng 5 phút để hoàn thành. Sự hỗ trợ của anh/chị có đóng góp rất lớn đến sự thành công của nghiên cứu này.Trong trường hợp có thắc mắc liên quan đến bảng khảo sát này, xin vui lòng liên hệ qua email quang.tran@students.boku.ac.at hoặc andrei.solomon@students.boku.ac.at. Thông tin chi tiết về Khoa Vận tải có thể được tìm thấy tại trang web: https://boku.ac.at/en/rali/verkehr

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*Required

Section 1 of 3: Demographic data

1. Gender / Giới tính *

Mark only one oval.

- ◯ Female/Nữ
- ◯ Male/Nam

2. Age / Độ tuổi *

Mark only one oval.

- ⬭ < 16
- ⬭ *16 - 21*
- ⬭ *22 - 35*
- ⬭ *36 - 45*
- ⬭ *46 - 55*
- ⬭ *56 - 65*
- ⬭ *66 - 75*
- ⬭ *> 75*

3. Are you living in HCMC? / Anh/chị có đang sống tại thành phố HCM không? *

Mark only one oval.

- ⬭ Yes / Có
- ⬭ No / Không

4. Current Residence (District & Ward) / Nơi cư trú hiện nay (Tên quận & phường) *

____

____

____

5. Highest education level / Trình độ học vấn *

Mark only one oval per row.

- ⬭ *No school / Không đi học*
- ⬭ *Primary school degree / Tiểu học*
- ⬭ *Secondary school degree / Trung học cơ sở*

- *High school degree / Trung học phổ thông*
- *University degree / Đại học*
- *Post graduate degree / Sau đại học*

6. Number of operational vehicles owned by your household / Số lượng phương tiện đang được sử dụng thuộc sở hữu của gia đình anh/chị *

Mark only one oval per row.

	0	1	2	3	4	5	>5
Car(s) / Ô tô							
Motorbike(s) / Xe máy							
Bicycle(s) / Xe đạp							
Electrical bicycle(s) / Xe đạp điện							

7. Your driving licenses / Loại bằng lái anh/chị đang có

Tick all that apply.

Holder of a car driving license / Đã có bằng lái xe ô tô	
Holder of a motorbike driving license / Đã có bằng lái xe gắn máy	
Holder of a truck driving license / Đã có bằng lái xe tải	
Not holding any driving license / Không có bằng lái	

Section 2 of 3: Walking habits / Thói quen đi bộ

8. How often do you visit the following destinations? Anh/chị có thường xuyên đến những địa điểm này không? *

Mark only one oval per row.

	Nearly daily / Hầu như hàng ngày	2-3 times a week / 2-3 lần mỗi tuần	2-3 times a month / 2-3 lần mỗi tháng	<1 time/month / Ít hơn 1 lần/tháng	Nearly never / Hầu như không
Workplace/Education facilities (Nơi làm việc/học tập)	◯	◯	◯	◯	◯
Shops of essential goods (grocery, pharmacy,…) / Các cửa hàng nhu yếu phẩm (tạp hóa, nhà thuốc...)	◯	◯	◯	◯	◯
Shops of non-essential goods (clothing store, electronic store,…) / Các cửa hàng bán sản phẩm không thiết yếu (cửa hàng quần áo, cửa hàng điện tử)	◯	◯	◯	◯	◯
Recreational facilities (park, sport facilities,…) / Địa điểm vui chơi (công viên, trung tâm thể thao…)	◯	◯	◯	◯	◯
Entertainment (karaoke, cultural events) / Địa điểm	◯	◯	◯	◯	◯

giải trí (karaoke, sự kiện văn hóa...)					
Restaurants (street food, coffee shop ...) / Quán ăn (quán ăn lề đường, quán cà phê...	⬭	⬭	⬭	⬭	⬭

9. How frequently do you walk to the following destinations? Anh/chị có thường xuyên đi bộ đến các điểm đến sau đây không? *

Mark only one oval per row.

	Nearly daily / Hầu như hàng ngày	2-3 times a week / 2-3 lần mỗi tuần	2-3 times a month / 2-3 lần mỗi tháng	<1 time/month / Ít hơn 1 lần/tháng	Nearly never / Hầu như không
Workplace/Education facilities (Nơi làm việc/học tập)	⬭	⬭	⬭	⬭	⬭
Shops of essential goods (grocery, pharmacy,...) / Các cửa hàng nhu yếu phẩm (tạp hóa, nhà thuốc...)	⬭	⬭	⬭	⬭	⬭
Shops of non-essential goods (clothing store, electronic store,...) / Các cửa hàng bán sản phẩm không thiết yếu (cửa hàng quần áo, cửa hàng điện tử)	⬭	⬭	⬭	⬭	⬭
Recreational facilities (park, sport facilities,...) / Địa điểm vui chơi (công	⬭	⬭	⬭	⬭	⬭

viên, trung tâm thể thao…)					
Entertainment (karaoke, cultural events) / Địa điểm giải trí (karaoke, sự kiện văn hóa…)	⬭	⬭	⬭	⬭	⬭
Restaurants (street food, coffee shop …) / Quán ăn (quán ăn lề đường, quán cà phê…	⬭	⬭	⬭	⬭	⬭

10. What prevents you from walking? Điều gì cản trở làm anh/chị không muốn đi bộ? *

Mark only one oval per row.

	(-2) Not at all / Không có gì cản trở	(-1)	(0)	(+1)	(+2) Very much / Cản trở rất nhiều
Traffic safety / an toàn giao thông	⬭	⬭	⬭	⬭	⬭
Air pollution & exhaust gases from traffic / ô nhiễm không khí & khí thải từ phương tiện giao thông	⬭	⬭	⬭	⬭	⬭
Traffic noise / tiếng ồn do phương tiện giao thông	⬭	⬭	⬭	⬭	⬭
Rain / mưa	⬭	⬭	⬭	⬭	⬭
Insufficient shade / Thiếu bóng mát	⬭	⬭	⬭	⬭	⬭
I don’t like to walk / Không muốn đi bộ	⬭	⬭	⬭	⬭	⬭
Lack of walking amenities (public sitting, public toilet) / Thiếu các tiện	⬭	⬭	⬭	⬭	⬭

nghi cho việc đi bộ (ghế ngồi, nhà vệ sinh công cộng)					
High crime rate / Tỉ lệ tội phạm cao					
Lack of public transport / Thiếu phương tiện giao thông công cộng					
Low route attractiveness (no greenery, no shops, indirect route) / Tuyến đường thiếu sự thu hút (thiếu cây xanh, hàng quán, phải đi vòng)					
Interrupted sidewalk or sidewalk in bad condition / Vỉa hè bị xuống cấp hoặc bị cản trở					
High temperature / Nhiệt độ cao					
Long walking trips / Quãng đường đi bộ xa					

Section 3 of 3: Transport mode perception & experience / Cảm nhận về các phương tiện giao thông và trải nghiệm việc đi bộ

11. How convenient do you perceive the following transport modes? Anh/chị nhận thấy mức độ tiện lợi của các phương tiện dưới đây như thế nào? *

Mark only one oval per row.

	(-2) very inconvenient / rất bất tiện	(-1)	(0)	(+1)	(+2) very convenient / rất tiện lợi
Walking / Đi bộ	◯	◯	◯	◯	◯
Cycling / Đạp xe	◯	◯	◯	◯	◯
Bus / Xe buýt	◯	◯	◯	◯	◯
Motorcycle / Xe gắn máy	◯	◯	◯	◯	◯
Car / Ô tô	◯	◯	◯	◯	◯

12. Which of the following examples contributes to a greater pedestrian experience? / Ví dụ nào sau đây góp phần mang lại trải nghiệm tốt hơn cho người đi bộ? *

Mark only one oval per row.

	(-2) I strongly disagree / hoàn toàn không đồng ý	(-1)	(0)	(+1)	(+2) I strongly agree / hoàn toàn đồng ý
Street food vendors / Quán ăn đường phố	◯	◯	◯	◯	◯

Street merchandise vendor / Người bán hàng rong	◯	◯	◯	◯	◯
Street services (hairdresser, shoeshiner,...) / Các dịch vụ đường phố (làm tóc, đánh giày,...)	◯	◯	◯	◯	◯
Street events (night markets, mid-autumn festival,...) / Các sự kiện đường phố (chợ đêm, lễ hội trung thu,..)	◯	◯	◯	◯	◯

13. What do you think would contribute to a greater pedestrian experience? Anh/chị nghĩ điều gì sẽ góp phần mang lại trải nghiệm tốt hơn cho người đi bộ? *

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14. From your home, where do you often go by walk? Please indicate the destination / purpose and the frequency per week. (For example: Visit a neighbour, 3 times / week) // Anh/chị thường đi bộ từ nhà mình đến những nơi nào? Vui lòng cho biết điểm đến hoặc mục đích và tần suất mỗi tuần. (ví dụ: Đi thăm hàng xóm, 3 lần / tuần)

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15. From your workplace/school, where do you often go by walk? Please indicate the destination/ purpose and the frequency per week. (Example: Going to a street food vendor, 5 times/week) // Anh/chị thường đi bộ từ nơi làm việc/học tập đến những nơi nào? Vui lòng cho biết điểm đến hoặc mục đích và tần suất mỗi tuần. (ví dụ: Đến quán ăn vỉa hè, 5 lần / tuần)

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Thank you for your participation!

Chân thành cảm ơn sự tham gia của anh/chị!

13.2 Statistics of the survey

Table 13.2-1: SPSS group statistics of different mean driving license holders by gender. Source: Author’s own

	Gender	n	Mean	Std.Deviation	Std. Error Mean
Car driving license	Female	253	0.13	0.34	0.02
	Male	151	0.30	0.46	0.04
Motorcycle driving license	Female	253	0.83	0.38	0.02
	Male	151	0.89	0.32	0.03
Truck driving license	Female	253	0.00	0.00	0.00
	Male	151	0.01	0.11	0.01
Not holding any license	Female	253	0.14	0.35	0.02
	Male	151	0.09	0.29	0.02

Table 13.2-2: SPSS t-test for different mean driving license holders by gender, significant results represented in bold. Source: Author’s own

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Car driving license	-3.933	248.297	**0.000**	0.030	0.052
Motorcycle driving license	-1.744	359.781	0.082	0.361	0.125
Truck driving license	-1.419	150.000	0.158	0.029	0.081
Not holding any license	1.534	360.788	0.126	0.029	0.043

Table 13.2-3: SPSS t-test for different mean walkability perceptions, significant results represented in bold. Source: Author’s own

		Traffic safety	Traffic air pollution	Traffic noise	Rain	Insufficient shade	I don’t like to walk	Lack of walking amenities	High crime rate	Lack of public transport	Low route attractiveness	Interrupted sidewalk	High temperature	Long walking trips
Traffic safety	t	-	-6.37	-1.96	-6.89	-12.60	5.80	-3.43	-1.57	-1.93	-7.66	-10.59	-17.02	-11.57
	Sig. (2-tailed)	-	**0.000**	**0.051**	**0.000**	**0.000**	**0.000**	**0.001**	0.117	0.054	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	-	-0.44	-0.13	-0.43	-0.75	0.38	-0.22	-0.10	-0.13	-0.49	-0.66	-1.00	-0.78
Traffic air pollution	t	6.13	-	4.55	0.17	-5.22	12.51	3.31	5.32	4.87	-0.80	-3.55	-9.54	-5.01
	Sig. (2-tailed)	**0.000**	-	**0.000**	0.866	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	0.423	**0.000**	**0.000**	**0.000**
	Mean Difference	0.44	-	0.31	0.01	-0.31	0.82	0.22	0.34	0.31	-0.05	-0.22	-0.56	-0.34
Traffic noise	t	1.80	-4.48	-	-4.80	-10.42	7.78	-1.44	0.47	0.08	-5.64	-8.51	-14.81	-9.63
	Sig. (2-tailed)	0.073	**0.000**	-	**0.000**	**0.000**	**0.000**	0.151	0.642	0.939	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	0.13	-0.31	-	-0.30	-0.62	0.51	-0.09	0.03	0.00	-0.36	-0.53	-0.87	-0.65
Rain	t	5.99	-0.10	4.40	-	-5.39	12.36	3.15	5.16	4.71	-0.96	-3.71	-9.71	-5.16

	Sig. (2-tailed)	**0.000**	0.920	**0.000**	-	**0.000**	**0.000**	**0.002**	**0.000**	**0.000**	0.339	**0.000**	**0.000**	**0.000**
	Mean Difference	0.43	-0.01	0.30	-	-0.32	0.81	0.21	0.33	0.30	-0.06	-0.23	-0.57	-0.35
Insufficient shade	t	10.45	4.56	9.14	5.14	-	17.25	8.05	10.18	9.66	4.03	1.40	-4.27	-0.39
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	-	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.161	**0.000**	0.698
	Mean Difference	0.75	0.31	0.62	0.32	-	1.13	0.53	0.65	0.62	0.26	0.09	-0.25	-0.03
I don't like to walk	t	-5.32	-11.91	-7.59	-12.99	-18.97	-	-9.25	-7.52	-7.80	-13.59	-16.67	-23.48	-17.24
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	-	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	-0.38	-0.82	-0.51	-0.81	-1.13	-	-0.60	-0.48	-0.51	-0.87	-1.04	-1.38	-1.16
Lack of walking amenities	t	3.11	-3.10	1.36	-3.30	-8.84	9.22	-	1.94	1.53	-4.17	-7.01	-13.21	-8.23
	Sig. (2-tailed)	**0.002**	**0.002**	0.176	**0.001**	**0.000**	**0.000**	-	0.053	0.127	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	0.22	-0.21	0.09	-0.21	-0.53	0.60	-	0.12	0.10	-0.27	-0.44	-0.78	-0.55
High crime rate	t	1.38	-4.91	-0.48	-5.28	-10.92	7.33	-1.90	-	-0.38	-6.10	-8.99	-15.32	-10.08
	Sig. (2-tailed)	0.168	**0.000**	0.634	**0.000**	**0.000**	**0.000**	0.059	-	0.702	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	0.10	-0.34	-0.03	-0.33	-0.65	0.48	-0.12	-	-0.02	-0.39	-0.56	-0.90	-0.68
Lack of public transport	t	1.73	-4.55	-0.11	-4.88	-10.50	7.71	-1.52	0.39	-	-5.72	-8.59	-14.90	-9.71
	Sig. (2-tailed)	0.085	**0.000**	0.912	**0.000**	**0.000**	**0.000**	0.130	0.699	-	**0.000**	**0.000**	**0.000**	**0.000**
	Mean Difference	0.12	-0.31	-0.01	-0.30	-0.63	0.50	-0.10	0.02	-	-0.37	-0.54	-0.88	-0.65
Low route attractiveness	t	6.84	0.79	5.31	0.99	-4.36	13.30	4.09	6.13	5.66	-	-2.73	-8.67	-4.24
	Sig. (2-tailed)	**0.000**	0.428	**0.000**	0.321	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	-	**0.007**	**0.000**	**0.000**
	Mean Difference	0.49	0.05	0.36	0.06	-0.26	0.87	0.27	0.39	0.37	-	-0.17	-0.51	-0.28
Interrupted sidewalk	t	9.23	3.28	7.84	3.73	-1.49	15.91	6.71	8.80	8.30	2.66	-	-5.77	-1.70
	Sig. (2-tailed)	**0.000**	**0.001**	**0.000**	**0.000**	0.136	**0.000**	**0.000**	**0.000**	**0.000**	**0.008**	-	**0.000**	0.090
	Mean Difference	0.66	0.23	0.53	0.23	-0.09	1.04	0.44	0.56	0.54	0.17	-	-0.34	-0.11
High temperature	t	13.96	8.23	12.86	9.17	4.19	21.08	11.90	14.11	13.54	7.95	5.42	-	3.36
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	-	**0.001**
	Mean Difference	1.00	0.56	0.87	0.57	0.25	1.38	0.78	0.90	0.88	0.51	0.34	-	0.23
Long walking trips	t	10.82	4.94	9.53	5.56	0.41	17.64	8.45	10.58	10.06	4.44	1.82	-3.83	-
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	0.679	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.069	**0.000**	-
	Mean Difference	0.77	0.34	0.64	0.35	0.02	1.16	0.55	0.68	0.65	0.28	0.11	-0.23	-

Table 13.2-4: SPSS group statistics of different mean walkability perceptions by gender. Source: Author's own

	Gender	n	Mean	Std.Deviation	Std. Error Mean
Traffic safety	Female	253	2.98	1.37	0.09
	Male	151	3.38	1.52	0.12
Traffic air pollution	Female	253	2.54	1.28	0.08
	Male	151	2.95	1.50	0.12
Traffic noise	Female	253	2.89	1.29	0.08
	Male	151	3.17	1.45	0.12
Rain	Female	253	2.55	1.20	0.08
	Male	151	2.96	1.31	0.11
Insufficient shade	Female	253	2.25	1.12	0.07
	Male	151	2.60	1.30	0.11
I don't like to walk	Female	253	3.39	1.32	0.08
	Male	151	3.72	1.28	0.10
Lack of walking amenities	Female	253	2.83	1.32	0.08
	Male	151	3.03	1.30	0.11
High crime rate	Female	253	2.86	1.26	0.08
	Male	151	3.32	1.28	0.10
Lack of public transport	Female	253	2.92	1.27	0.08
	Male	151	3.15	1.35	0.11
Low route attractiveness	Female	253	2.49	1.23	0.08
	Male	151	2.89	1.35	0.11
Interrupted sidewalk	Female	253	2.30	1.13	0.07
	Male	151	2.75	1.41	0.11
High temperature	Female	253	1.96	1.05	0.07
	Male	151	2.42	1.33	0.11
Long walking trips	Female	253	2.13	1.25	0.08
	Male	151	2.73	1.42	0.12

Table 13.2-5: SPSS Spearman correlations of different mean walkability perceptions by gender. Source: Author's own

Spearman correlations			
		Female	Male
Female	Correlation Coefficient	1.000	.973**
	Sig. (2-tailed)	.	0.000
	n	13	13
Male	Correlation Coefficient	.973**	1.000
	Sig. (2-tailed)	0.000	.
	n	13	13
** Correlation is significant at the 0.01 level (2-tailed).			

Table 13.2-6: SPSS two-tailed independent sample t-test of different mean walkability perceptions by gender, significant results represented in bold. Source: Author's own

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Traffic safety	-2.637	290.970	**0.009**	-0.397	0.151
Traffic air pollution	-2.773	277.471	**0.006**	-0.406	0.146
Traffic noise	-1.950	288.520	0.052	-0.279	0.143
Rain	-3.186	294.036	**0.002**	-0.415	0.130
Insufficient shade	-2.736	279.894	**0.007**	-0.347	0.127
I don't like to walk	-2.456	323.651	**0.015**	-0.328	0.134
Lack of walking amenities	-1.510	317.774	0.132	-0.203	0.134
High crime rate	-3.517	310.130	**0.001**	-0.460	0.131
Lack of public transport	-1.657	300.066	0.098	-0.225	0.136
Low route attractiveness	-3.040	293.142	**0.003**	-0.408	0.134
Interrupted sidewalk	-3.408	264.425	**0.001**	-0.459	0.135
High temperature	-3.636	261.359	**0.000**	-0.461	0.127
Long walking trips	-4.271	284.337	**0.000**	-0.598	0.140

Table 13.2-7: SPSS group statistics of different mean Transport mode convenience. Source: Author's own

	n	Mean	Std.Deviation	Std. Error Mean
Walking convenience	404	2.66	1.21	0.060
Bicycle convenience	404	2.97	1.06	0.053
Bus convenience	404	2.82	1.14	0.057
Motorcycle convenience	404	4.29	0.93	0.046
Car convenience	404	3.29	1.06	0.053

Table 13.2-8: SPSS t-test of different mean Transport mode convenience, significant results represented in bold. Source: Author's own

		Walking convenience	Bicycle convenience	Bus convenience	Motorcycle convenience	Car convenience
Walking	t	-	5.958	2.905	35.46	11.976
	df	-	403	403	403	403
	Sig. (2-tailed)	-	**0.000**	**0.004**	**0.000**	**0.000**
	Mean Difference	-	0.313	0.164	1.635	0.632
Bicycle	t	-5.141	-	-2.578	28.735	6.102
	df	403	-	403	403	403
	Sig. (2-tailed)	**0.000**	-	**0.010**	**0.000**	**0.000**
	Mean Difference	-0.309	-	-0.146	2.325	0.322
Bus	t	-2.646	2.91	-	31.989	8.944
	df	403	403	-	403	403
	Sig. (2-tailed)	**0.008**	**0.004**	-	**0.000**	**0.000**

	Mean Difference	-0.159	0.153	-	1.475	0.472
Motorcycle	t	-27.096	-25.091	-25.923	-	-18.907
	df	403	403	403	-	403
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	-	**0.000**
	Mean Difference	-1.629	-1.317	-1.466	-	-0.998
Car	t	-10.464	-6.043	-8.237	21.793	-
	df	403	403	403	403	-
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	-
	Mean Difference	-0.629	-0.317	-0.466	1.005	-

Table 13.2-9: SPSS group statistics of different mean influence of street activities towards the pedestrian experience. Source: Author’s own

	n	Mean	Std.Deviation	Std. Error Mean
Street food vendors	404	3.28	1.17	0.058
Street merchandise vendors	404	2.87	1.19	0.059
Street services	404	2.71	1.12	0.056
Street events	404	3.56	1.17	0.058

Table 13.2-10: SPSS t-test of different mean influence of street activities towards the pedestrian experience, significant results represented in bold. Source: Author’s own

		Street food vendors	Street merchandise vendors	Street services	Street events
Street food vendors	t	-	-6.900	-10.286	4.852
	df	-	403	403	403
	Sig. (2-tailed)	-	**0.000**	**0.000**	**0.000**
	Mean Difference	-	-0.409	-0.575	0.282
Street merchandise vendors	t	7.133	-	-2.946	11.910
	df	403	-	403	403
	Sig. (2-tailed)	**0.000**	-	**0.003**	**0.000**
	Mean Difference	0.415	-	-0.165	0.692
Street services	t	9.885	2.723	-	14.664
	df	403	403	-	403
	Sig. (2-tailed)	**0.000**	**0.007**	-	**0.000**
	Mean Difference	0.575	0.161	-	0.852
Street events	t	-4.736	-11.626	-15.299	-
	df	403	403	403	-
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	-
	Mean Difference	-0.275	-0.689	-0.855	-

Table 13.2-11: SPSS group statistics of different mean influence of street activities towards the pedestrian experience by gender. Source: Author's own

	Gender	n	Mean	Std.Deviation	Std. Error Mean
Street food vendors	Female	253	3.30	1.17	0.07
	Male	151	3.26	1.17	0.10
Street merchandise vendors	Female	253	2.86	1.18	0.07
	Male	151	2.89	1.21	0.10
Street services	Female	253	2.73	1.09	0.07
	Male	151	2.66	1.17	0.10
Street events	Female	253	3.63	1.15	0.07
	Male	151	3.45	1.19	0.10

Table 13.2-12: SPSS t-test of different mean influence of street activities towards the pedestrian experience by gender, significant results represented in bold. Source: Author's own

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Street food vendors	0.350	315.897	0.726	0.042	0.120
Street merchandise vendors	-0.295	310.746	0.768	-0.036	0.123
Street services	0.587	298.726	0.558	0.069	0.118
Street events	1.475	308.316	0.141	0.178	0.121

13.3 Walkability Evaluation Tool for Urban Areas in Vietnam

Table 13.3-1: WETUAV spreadsheet overview. Source: Author's own

Date of survey	2021-07-04
Start time [hh:mm]	9:30
End time [hh:mm]	9:41
Duration [min]	11
Weather conditions	Cloudy
Temperature [°C]	28
Season	Rainy season

Mandatory input*	
Optional input*	
Row indicator	
Automatic generate	

* Depending on number of route segments

		Street segment 1	Street segment 2	Street segment 3	Street segment 4	Street segment 5	Street segment 6	Street segment 7	Street segment 8
	District	Select district...	Select district...	Select district...	Select district...	Select district...	Select district...	Select district...	Select district...
	Ward	Select ward...	Select ward...	Select ward...	Select ward...	Select ward...	Select ward...	Select ward...	Select ward...
	Street	Select street...	Select street...	Select street...	Select street...	Select street...	Select street...	Select street...	Select street...
	Alleyway number (optional)	Enter alleyway number...							
	House number (optional)	Enter house number...							
	District Resi. density (inh./km²)								
Route segment ID number by type of street		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Street characteristics & sidewalk condition	Segment length	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street typology	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street width or number of lanes	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Does the street have a sidewalk?	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Sidewalk/Alleyway/Walking street condition	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Sidewalk width	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Sidewalk/Alleyway/Walking street cleanliness	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Sidewalk/alleyway encroachment type affecting my walking trajectory encountered in this route segment	Parked vehicles	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Driving motorbikes on sidewalk	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Business spillovers	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street vendors	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Advertising signs	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Trees/plants	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Bus stations/ metro entrances	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Utility poles	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Type of urban neighbourhood		Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Street activity index	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**	**Trading activities**
	Street food vendors	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street market	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street merchandise vendors	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street services	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Business spillover	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Restaurant/Coffee/teashop spillover	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Social activities	**Social activities**	**Social activities**	**Social activities**	**Social activities**	**Social activities**	**Social activities**	**Social activities**	**Social activities**
	Street events	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Children playing in the public space	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	People playing cards or board games	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	People eating out or having drinks together	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	People relaxing outside	None	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Public transport	Is there a bus station in a 400m vicinity?	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Number of stations	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Tree canopy/shadow index	Type of shadow	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Shadow coverage	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Visual aesthetics	Domestic plants/flowers in public space	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Visually active frontage	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Physically permeable frontage	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Street lighting	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Landmarks (churches/pagodas/squares/rivers)	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Walking amenities	Public sitting	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Public garbage bin	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Public toilet	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
	Rain shelter	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...
Traffic congestion of motorised vehicles		Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...	Please Select...

Table 13.3-2: WETUAV result table overview. Source: Author's own

Indicators	**Street segment 1**	**Street segment 2**	**Street segment 3**	**Street segment 4**	**Street segment 5**	**Street segment 6**	**Street segment 7**	**Street segment 8**	**Average total**
Category A: Conflicts between pedestrian and other street users									
Encroachment index									
Pedestrian traffic safety index									
Traffic air/noise pollution index									
Category B: Physical walking space and infrastructure									
Sidewalk/Street ratio index									
Sidewalk condition index									
Local centrality and social equity index									
Category C: Pedestrian comfort and convenience									
Tree canopy/shadow index									
Street activity index									
Social security index									
Availability of public transport index									
Visual aesthetics index									
Walking amenities index									
Walkability index raw									
Walkability index weighted									
*Number of valid indicators	0	0	0	0	0	0	0	0	

13.4 Segment figures, WETUAV and Walk Score® results of route 2 to 5

13.4.1 Route 2

Figure 13.4-1: Route 2 segment 1, Nguyễn Hữu Cảnh, ward 22, Bình Thạnh district. Source: Image data ©2019 Google Street View

Figure 13.4-2: Route 2 segment 3, Nguyễn Hữu Cảnh 208, ward 22, Bình Thạnh district. Source: Image data ©2019 Google Street View

Figure 13.4-3: Route 2 segment 4, Trần Trọng Kim, ward 22, Bình Thạnh district. Source: Image data ©2019 Google Street View

Table 13.4-1: Walkability index and indicator scores of WETUAV for route 2. Source: Author's own

Route 2	**Segment 1**	**Segment 2**	**Segment 3**	**Segment 4**	**Segment 5**	**Segment 6**	**Segment 7**	**Segment 8**	**Average**
Category A: Conflicts between pedestrian and other street users									**76%**
Encroachment density index	1.50	N/A	5.00	5.00					**3.83**
Pedestrian traffic safety index	3.00	0.00	4.70	4.70					**3.10**
Traffic air/noise pollution index	3.20	4.50	5.00	5.00					**4.43**
Category B: Physical walking space and infrastructure									**52%**
Sidewalk/street ratio index	0.50	0.00	2.50	2.50					**1.38**
Sidewalk conditions index	2.40	0.00	5.00	5.00					**3.10**
Local centrality index	4.00	3.00	3.00	3.00					**3.25**
Category C: Pedestrian comfort and convenience									**52%**
Tree canopy/shadow index	3.00	3.00	5.00	5.00					**4.00**
Street activity index	5.00	0.00	0.00	3.13					**2.03**
Social security index	1.60	0.60	2.60	2.83					**1.91**
Availability of public transport index	5.00	4.00	3.00	0.00					**3.00**
Visual aesthetics index	1.00	1.60	4.05	3.40					**2.51**
Walking amenities index	1.63	0.00	3.50	2.88					**2.00**
Walkability index raw	**55%**	**33%**	**67%**	**65%**					**55%**
Walkability index weighted	**54%**	**28%**	**80%**	**84%**					**62%**
*Number of valid indicators	12	11	12	12	0	0	0	0	

Table 13.4-2: Walk Score® results for route 2. Source: Author's own based on Walk Score®

Route 2	**Segment 1**	**Segment 2**	**Segment 3**	**Segment 4**	**Segment 5**	**Segment 6**	**Segment 7**	**Segment 8**	**Average Walk Score®**
Walk Score®	**88%**	**93%**	**93%**	**66%**					**85%**
Number and street	176 Đường Nguyễn Hữu Cảnh	208 Đường Nguyễn Hữu Cảnh	208 Đường Nguyễn Hữu Cảnh	Trần Trọng Kim					
Ward	Ward 22	Ward 22	Ward 22	Ward 22					
District	Bình Thạnh	Bình Thạnh	Bình Thạnh	Bình Thạnh					

13.4.2 Route 3

Figure 13.4-4: Route 3 segment 2, Nguyễn Trãi, ward 3, District 5. Source: Author's own

Figure 13.4-5: Route 3 segment 3, Trần Bình Trọng, ward 3, District 5. Source: Author's own

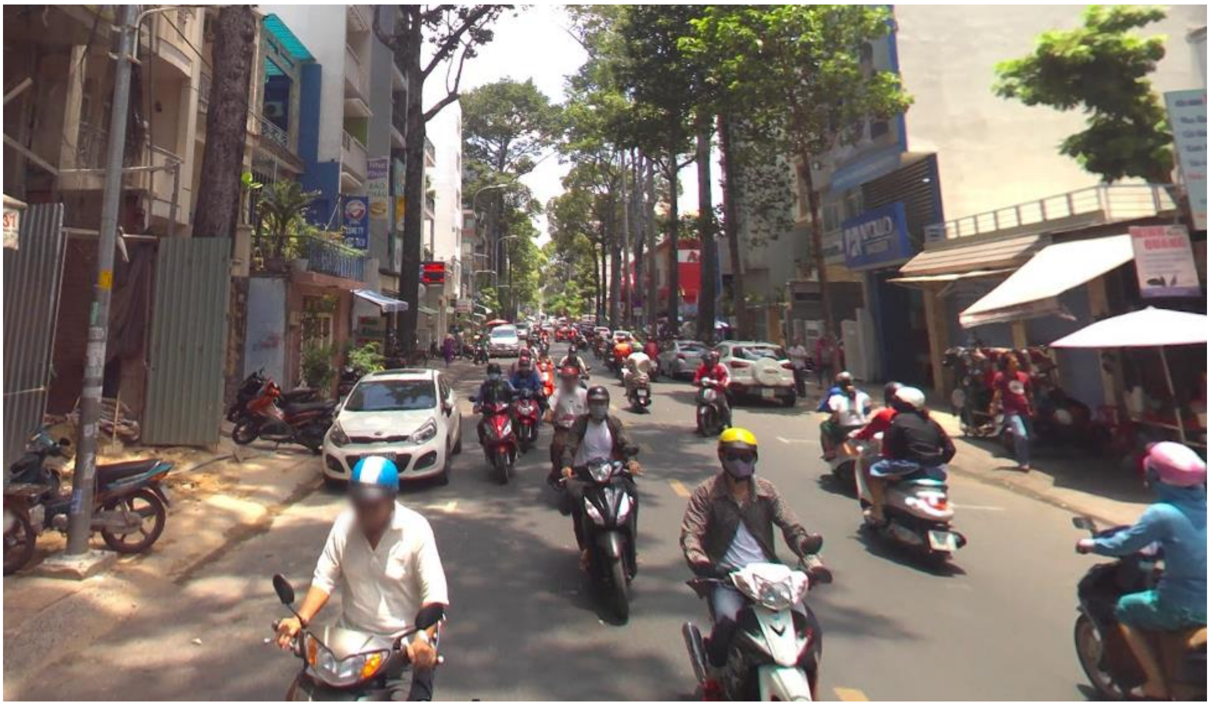

Figure 13.4-6: Route 3 segment 4, Trần Bình Trọng, ward 4, District 5. Source: Image data ©2019 Google Street View

Figure 13.4-7: Route 3 segment 5, Trần Phú, ward 4, District 5. Source: Author's own

Table 13.4-3: Walkability index and indicator scores of WETUAV for route 3. Source: Author's own

Route 3	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average
Category A: Conflicts between pedestrian and other street users									**47%**
Encroachment density index	N/A	0.00	0.00	0.00	0.00				**0.00**
Pedestrian traffic safety index	5.00	3.40	3.20	2.20	3.20				**3.40**
Traffic air/noise pollution index	5.00	3.50	3.20	3.20	3.35				**3.65**
Category B: Physical walking space and infrastructure									**75%**
Sidewalk/street ratio index	4.75	3.00	2.75	2.75	1.75				**3.00**
Sidewalk conditions index	5.00	3.60	3.20	2.60	1.60				**3.20**
Local centrality index	5.00	5.00	5.00	5.00	5.00				**5.00**
Category C: Pedestrian comfort and convenience									**71%**
Tree canopy/shadow index	4.00	4.00	4.00	4.00	5.00				**4.20**
Street activity index	5.00	5.00	5.00	5.00	4.38				**4.88**
Social security index	2.80	4.00	4.00	3.60	3.48				**3.58**
Availability of public transport index	5.00	5.00	5.00	4.00	5.00				**4.80**
Visual aesthetics index	3.40	3.60	3.60	2.60	3.20				**3.28**
Walking amenities index	0.00	0.00	0.00	0.00	2.38				**0.48**
Walkability index raw	**82%**	**67%**	**65%**	**58%**	**64%**				**67%**
Walkability index weighted	**87%**	**62%**	**60%**	**55%**	**57%**				**64%**
*Number of valid indicators	11	12	12	12	12	0	0	0	

Table 13.4-4: Walk Score® results for route 3. Source: Author's own based on Walk Score®

Route 3	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average Walk Score®
Walk Score®	**96%**	**96%**	**97%**	**97%**	**96%**				**96%**
Number and street	Hẻm 80 Nguyễn Trãi	60 Nguyễn Trãi	Trần Bình Trọng	Trần Bình Trọng	Trần Phú				
Ward	Ward 3	Ward 3	Ward 3	Ward 4	Ward 4				
District	District 5	District 5	District 5	District 5	District 5				

13.4.3 Route 4

Figure 13.4-8: Route 4 segment 1, hẻm 24 Trần Ngọc Điện, ward Thảo Điền, District 2. Source: Author's own

Figure 13.4-9: Route 4 segment 2, Trần Ngọc Điện, ward Thảo Điền, District 2. Source: Author's own

Figure 13.4-10: Route 4 segment 3, Thảo Điền, ward Thảo Điền, District 2. Source: Author's own

Table 13.4-5: Walkability index and indicator scores of WETUAV for route 4. Source: Author's own

Route 4	**Segment 1**	**Segment 2**	**Segment 3**	**Segment 4**	**Segment 5**	**Segment 6**	**Segment 7**	**Segment 8**	**Average**
Category A: Conflicts between pedestrian and other street users									**67%**
Encroachment density index	N/A	1.75	1.75	N/A					**1.75**
Pedestrian traffic safety index	5.00	4.35	4.15	0.00					**3.38**
Traffic air/noise pollution index	5.00	5.00	4.60	5.00					**4.90**
Category B: Physical walking space and infrastructure									**32%**
Sidewalk/street ratio index	4.75	1.75	2.50	0.00					**2.25**
Sidewalk conditions index	5.00	2.20	3.20	0.00					**2.60**
Local centrality index	0.00	0.00	0.00	0.00					**0.00**
Category C: Pedestrian comfort and convenience									**31%**
Tree canopy/shadow index	4.00	3.00	4.00	0.00					**2.75**
Street activity index	4.17	0.00	3.75	0.00					**1.98**
Social security index	0.83	0.00	1.55	0.00					**0.60**
Availability of public transport index	0.00	3.00	3.00	0.00					**1.50**
Visual aesthetics index	1.00	2.00	2.80	1.00					**1.70**
Walking amenities index	1.13	0.50	1.00	0.00					**0.66**
Walkability index raw	**52%**	**35%**	**53%**	**12%**					**38%**
Walkability index weighted	**73%**	**42%**	**59%**	**8%**					**45%**
*Number of valid indicators	11	12	12	11	0	0	0	0	

Table 13.4-6: Walk Score® results for route 4. Source: Author's own based on Walk Score®

Route 4	**Segment 1**	**Segment 2**	**Segment 3**	**Segment 4**	**Segment 5**	**Segment 6**	**Segment 7**	**Segment 8**	**Average Walk Score®**
Walk Score®	**76%**	**90%**	**92%**	**91%**					**87%**
Number and street	24 Đường Trần Ngọc Diện	15 Đường Trần Ngọc Diện	16 Đường Thảo Điền	55 Ngô Quang Huy					
Ward	Ward Thảo Điền	Ward Thảo Điền	Ward Thảo Điền	Ward Thảo Điền					
District	District 2	District 2	District 2	District 2					

13.4.4 Route 5

Figure 13.4-11: Route 5 segment 2, Công xã Paris, ward Bến Nghé, District 1. Source: Author's own

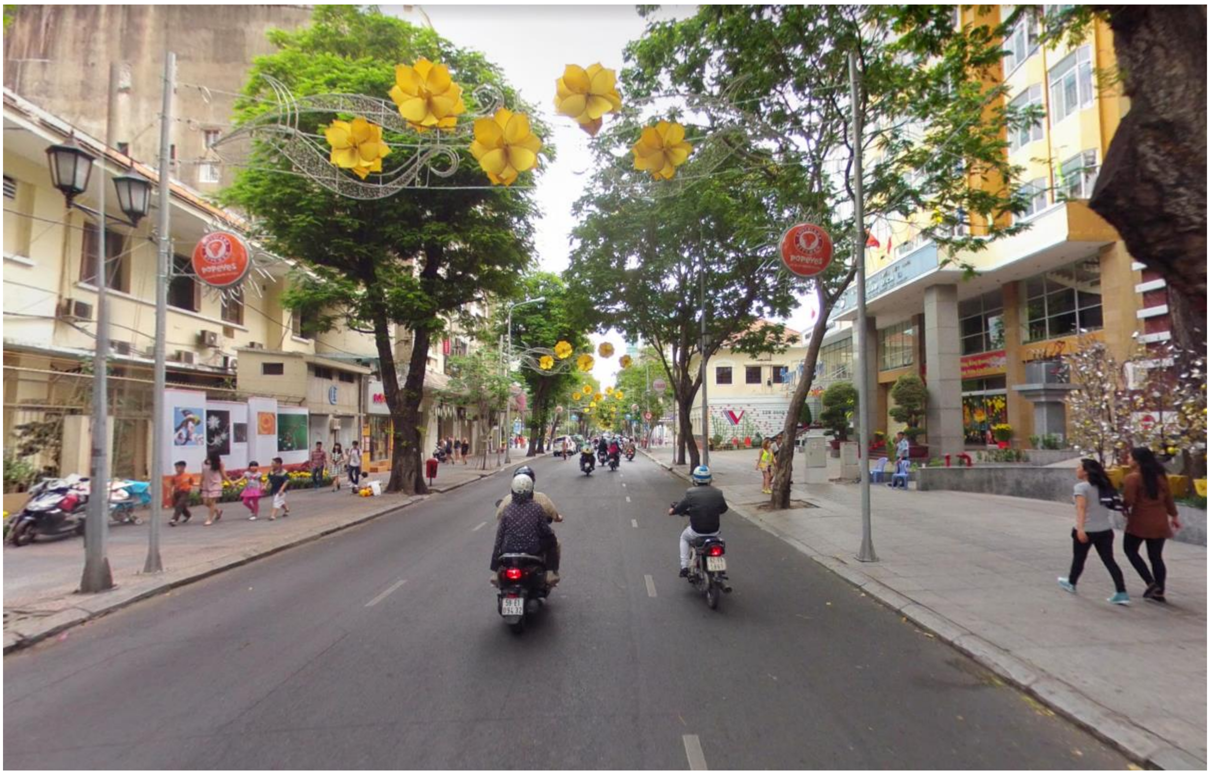

Figure 13.4-12: Route 5 segment 3, Đồng Khởi, ward Bến Nghé, District 1. Source: Image data ©2019 Google Street View

Figure 13.4-13: Route 5 segment 4, Lê Thánh Tôn, ward Bến Nghé, District 1. Source: Image data ©2019 Google Street View

Table 13.4-7: Walkability index and indicator scores of WETUAV for route 5. Source: Author's own

Route 5	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average
Category A: Conflicts between pedestrian and other street users									**85%**
Encroachment density index	5.00	5.00	4.00	5.00					**4.75**
Pedestrian traffic safety index	5.00	4.20	3.20	4.20					**4.15**
Traffic air/noise pollution index	5.00	4.45	2.80	3.35					**3.90**
Category B: Physical walking space and infrastructure									**71%**
Sidewalk/street ratio index	5.00	2.25	2.50	3.00					**3.19**
Sidewalk conditions index	5.00	4.60	4.40	5.00					**4.75**
Local centrality index	2.75	2.75	2.75	2.75					**2.75**
Category C: Pedestrian comfort and convenience									**72%**
Tree canopy/shadow index	5.00	5.00	5.00	4.00					**4.75**
Street activity index	5.00	5.00	2.50	0.00					**3.13**
Social security index	3.20	3.00	1.10	1.00					**2.08**
Availability of public transport index	5.00	5.00	5.00	5.00					**5.00**
Visual aesthetics index	5.00	3.80	3.40	3.60					**3.95**
Walking amenities index	4.81	2.31	2.25	1.25					**2.66**
Walkability index raw	**92%**	**76%**	**63%**	**58%**					**72%**
Walkability index weighted	**97%**	**89%**	**74%**	**73%**					**83%**
*Number of valid indicators	12	12	12	12	0	0	0	0	

Table 13.4-8: Walk Score® results for route 5. Source: Author's own based on Walk Score®

Route 5	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6	Segment 7	Segment 8	Average Walk Score®
Walk Score®	**100%**	**100%**	**100%**	**100%**					**100%**
Number and street	7 Đường Nguyễn Văn Bình	Công xã Paris	229 Đồng Khởi	Lê Thánh Tôn					
Ward	Ward Ben Nghe	Ward Ben Nghe	Ward Ben Nghe	Ward Ben Nghe					
District	District 1	District 1	District 1	District 1					