Built Heritage

PROJECT ANALYSIS ARTICLES

Open Access

The Thai GoodWalk Index and the Thai Walkability Index: their application to urban regeneration exemplified by a historic riverside neighbourhood in Bangkok, Thailand

Niramon Serisakul[1,2*], Adisak Guntamueanglee[2*], Thanaporn Ovatvoravarunyou[2], Munchuchada Dechakaneewong[2] and Preechaya Navaraj[1]

Abstract

The urban heritage regeneration strategy through walkability is widely accepted. However, in the context of a developing country, the tools to measure walkability, which are crucial for urban planning and development, still need to be improved. This article investigates ways to revitalise a run-down historic riverside area in Bangkok. It develops two indices, the Thai GoodWalk Index (TGWI) and the Thai Walkability Index (TWI). A hybrid of both indices is based on geospatial techniques and technology to optimise problem analysis processes, create problem-solving options, enhance spatial site selection decision capabilities, and assist urban planners in carrying out spatial scenario planning processes. It demonstrates how the GoodWalk Index has been employed to plan and prioritise urban development projects. This is exemplified by the Master Plan for the Regeneration of Kadeejeen-Klongsan, a historic riverside neighbourhood in Bangkok with limitations in density, functional mix of spaces, and access networks, especially in riverfront areas. The TGWI and TWI can be applied to the regeneration of other historic districts throughout Thailand.

Keywords Thai GoodWalk Index, Thai Walkability Index, Measuring walkability, Spatial scenario planning processes, Historic riverside neighbourhood, Bangkok

1 Introduction

Walkability has been defined as the extent to which the urban environment is pedestrian-friendly. This is based on pedestrians' accessibility to varied destinations within an appropriate time and effort, with good-quality walking conditions, including comfort, safety, and convenience (Southworth 2005; Leslie et al. 2007). Improving walkability is a key strategy in the regeneration of historic districts.

A walkable city provides a variety of benefits to the health of the city dwellers (Frank, Andresen and Schmid 2004; Geller 2009; Tani et al. 2021; Lawlor and Just Economics 2014). It also helps strengthen the local economy, especially for small businesses (New York City Department of Transportation 2008; Tolley 2011; Litman 2011), benefits the environment (Kenworthy and Laube 2001; Thomson and Newman 2018; European Commission 2004; Neves and Brand 2019), and fosters a safe and warm community as a result of increased urban interactions (Leslie et al. 2005; Appleyard 1981; Koszowski et al. 2019).

*Correspondence:
Niramon Serisakul
niramon.s@uddc.net
Adisak Guntamueanglee
adisak.g@uddc.net
[1] Department of Urban and Regional Planning, Faculty of Architecture, Chulalongkorn University, 254 Phaya Thai Rd, Wang Mai, Pathum Wan, Bangkok 10330, Thailand
[2] Urban Design and Development Center, Center of Excellence in Urban Strategies (CE.US.), Chulalongkorn University, 388 Amigo Tower, 9th Floor, Si Praya Rd., Maha Phruttharam, Bang Rak, Bangkok 10500, Thailand

In the context of historic districts, enhancement of walkability is a principle for the regeneration of heritage neighbourhoods (UNESCO 2016; Sutikno and Kurniawan 2013; Masoumzadeh and Pendar 2019) as people are likely to appreciate the value and magnitude of the cultural heritages better by walking, admiring, and interacting with their surroundings (Gehl 2011). In historic districts, cultural heritages are usually situated amid networks of narrow pedestrian streets. Upgrading such networks can improve the interconnectedness of cultures representing different ages and eras, creating an opportunity for learning experiences for both dwellers and visitors (Masoumzadeh and Pendar 2019; Shafray and Kim 2017; Gargiulo and Sgambatia 2022). Pedestrian networks that connect cultural sites, households, and public facilities can further help redistribute mass tourism that usually concentrates on individual historical sights. More importantly, increased walkability creates an opportunity to stimulate the economy and re-function historic buildings. Using renovation or maintenance, historic buildings can be revitalised to serve modern-day economic activities better (UNESCO 2016).

The literature review points to direct associations between physical environment and walkability (Jacobs 1961; Gehl 2011). Key factors affecting walkability include density, mix, and access, known as Urban DMA (Dovey and Pafka 2020). Walkability depends on functionally mixed neighbourhood spaces used for multiple purposes, including work, education, shopping, recreation, public transportation, and public services. If these destinations are connected within walkable distances, people will be encouraged to walk within them (Saelens, Sallis and Frank 2003; Frank, Engelke and Schmid 2003).

Thai GoodWalk Index (TGWI) and Thai Walkability Index (TWI) are urban spatial data analytic tools based on the Geographic Information System (GIS) to optimise problem analysis processes, create problem-solving options, and make more precise decisions, including spatial site selection. These tools aim to assist urban planners in carrying out spatial scenario planning processes. We use the TGWI and the TWI to measure the levels of walkability in Bangkok and other cities in Thailand.

The article will demonstrate how the TGWI and the TWI have been employed to plan and prioritise urban development projects. By using the Master Plan for the Regeneration of Kadeejeen-Klongsan, a historic riverside neighbourhood of Bangkok, as a case study, the article describes a layout design that promotes walking in the neighbourhood and surrounding areas in a way that contributes to supporting the local economy through shopping and distributing income to shops along the way, as well as being an accessible travel option for all. Equalising access to essential services will help people become more resistant and resilient to health crises and stress. It will encourage an active lifestyle and support the sustainability of the city's economy.

2 Research methods

Much research has developed indicators and indices for assessing walkability in various formats worldwide. These can be categorised into two main groups. The first emphasises a quantitative approach, focusing on studying the potential of urban structures and morphometrics. This approach utilises fundamental urban component data, such as road networks, pedestrian pathways, significant location positions, land use characteristics, and buildings. Indices in this category include Space Syntax (Hillier 1996), Walk Score (Walk Score 2011), Urban Network Analysis, UNA (Sevtsuk and Mekonnen 2012), Public Transport Accessibility Level: PTAL (Transport for London 2015), UrbanDMA (Dovey and Pafka 2020), etc.

The second group, focusing on a qualitative approach, studies pedestrian areas' quality and specific characteristics. This approach relies on data on the unique features of road and pedestrian areas directly linked to urban community design. It addresses aspects including safety, convenience, attractiveness, and liveliness. Indices in this category include the Global Walkability Index: GWI (Krambeck 2006) Pedestrian Environmental Quality Index: PEQI (San Francisco (Calif). Department of Public Health 2009) Quality of Pedestrian Level of Service: Q-PLOS (Talavera-Garcia and Soria-Lara 2015) The Walking Suitability Index of the territory: T-WSI (D'Alessandro, Valeri and Appolloni 2020).

The 'GoodWalk Thailand' project creates a hybrid of both approaches. This project was initiated to develop a tool to assess walkable levels by reviewing previous studies and formulating the measurement for the Thai city context. It was created by the Urban Design and Development Centre–the Centre for Excellence in Urban Strategies, Faculty of Architecture, Chulalongkorn University (UDDC-CEUS), in collaboration with the Thai Health Promotion Foundation (ThaiHealth). It differs from earlier studies by including indices for different aspects of 'walkability' in Bangkok and Thailand. The underlying concepts of these indices have been applied in the development of the TGWI and the TWI, with adjustments made to the classification of amenities and walking distance based on Bangkokian and Thai behaviours in the components and indicators to align with the context of Bangkok and Thailand.

The study is divided into two levels. First is a city-level study that introduces the TGWI, which investigates the potential of urban structures and morphometrics to

promote walking on a city-wide scale, highlighting limitations imposed by the city's structure and foundations. The second level involves a street-level study, called the TWI, which examines the characteristics of road and pedestrian landscape components for street-level design (Serisakul and Guntamueanglee 2023).

3 City-level study: the TGWI

From the discussion above regarding the diversity of 'walkability' indices, it is evident that there are different emphases when considering the indices that focus on studying the potential of urban structures and morphometrics. For instance, Space Syntax emphasises accessibility and connectivity, UNA relies on accessibility and density principles, while Walk Score and PTAL incorporate all three components of accessibility, density, and diversity. These principles align with the UrbanDMA concept. The underlying concepts of these indices have been applied in the development of the TGWI, with adjustments made to the classification of amenities and walking distance based on Bangkokian and Thai behaviours in the components and indicators to align with the context of Bangkok and Thailand.

The TGWI[1] was developed by the UddC-CEUS, Chulalongkorn University. This index applies the fundamental concept of urban structures and morphometrics to describe the interplay of factors that promote an urban environment supportive of pedestrian mobility in three dimensions: density, land use integration, and accessibility capabilities. It utilises network analysis techniques to create pedestrian-friendly service spaces by employing the city's pedestrian path network.

This analysis takes into account two factors: distance and public transport efficiency. 'Distance' refers to the acceptable walking distance, the distance people are willing to walk to access urban public transportation by foot. The maximum acceptable walking distance people in Bangkok are comfortable walking is 800 m (Urban Design and Development Centre 2015).

Public facilities/amenities that serve as the walking destination endpoints are determined through surveys of people's daily urban travel needs in Bangkok. These are derived from the basic objectives of urban travel, which encompass six categories of 36 types. These categories include

- W: places of work (three types): company (w_1), industrial estate (w_2), and office building (w_3).
- E: educational institutions (four types): daycare (E_1), primary-secondary school (E_2), university (E_3), and non-formal learning centre (E_4).
- C: commercial and recreational establishments (nine types): market (C_1), home accessories (C_2), other stores (C_3), restaurant (C_4), supermarket (C_5), convenience store (C_6), fast food restaurant (C_7), coffee shop (C_8), and restaurant chain outlet (C_9).
- R: recreational areas (eight types): bookstore (R_1), cinema (R_2), entertainment venues (R_3), sports club (R_4), parks (R_5), garden (R_6), ancient sites/museums (R_7), and other places (R_8).
- S: public service and transaction facilities (nine types): government office (S_1), bank/ATM (S_2), office of public utilities (S_3), post office (S_4), Places of religious worship (S_5), cooperatives (S_6), police station (S_7), hospital/clinic (S_8), and pharmacy (S_9).
- T: public transportation hubs (3 types): rail station (T_1), river station (T_2), and bus stop (T_3).

The significance of these public facilities is established based on the frequency of daily access and the order of priority within each facility type.

3.1 Calculation procedures for the TGWI

The relationships between the variables used to analyse the potential of the urban environment to promote walking can be represented in a straightforward equation format, as shown in Eqs. 1 to 7:

$$TGWI = \sum_{d=1}^{D} \lfloor W + E + C + R + S + T \rfloor \quad (1)$$

...in which...

$$W = \sum_{d=1}^{D} \lfloor \beta_{w1-w3} w_{1-3} \rfloor, \quad (2)$$

$$E = \sum_{d=1}^{D} \lfloor \beta_{e1-e4} e_{1-4} \rfloor. \quad (3)$$

$$C = \sum_{d=1}^{D} \lfloor \beta_{c1-c9} c_{1-9} \rfloor, \quad (4)$$

$$R = \sum_{d=1}^{D} \lfloor \beta_{r1-r8} r_{1-8} \rfloor. \quad (5)$$

$$S = \sum_{d=1}^{D} \lfloor \beta_{s1-s9} s_{1-9} \rfloor, \quad (6)$$

$$T = \sum_{d=1}^{D} \lfloor \beta_{t1-t3} t_{1-3} \rfloor. \quad (7)$$

Where:

[1] The Good Walk Index was developed from the project called 'Good Walk Thailand', implemented by UddC, Chulalongkorn University, with support from the Thai Health Promotion Foundation (ThaiHealth).

W = Score value for workplace destinations
E = Score value for educational institutions
C = Score value for commercial and recreational establishments
R = Score value for recreational areas
S = Score value for public service facilities/amenities
T = Score value for public transportation hubs
β_{xi} = The coefficient of the specific sub-category of public facility
d = Distance from the public facility location
D = Maximum walking distance, which is set at *800* m

The TGWI, which reflects functional walking, identifies GoodWalk (GW) scores ranging from 0 to 100 points, divided into five levels of the physical environment as follows:

Level 1: Scores from 66 to 100
No vehicle traffic/Highest potential for promoting walking
Level 2: Scores from 49 to 65
Little vehicle traffic/High potential for promoting walking
Level 3: Scores from 33 to 48
Some vehicle traffic/Moderate potential for promoting walking
Level 4: Scores from 16 to 32
Moderate vehicle traffic/Low potential for promoting walking
Level 5: Scores from 0 to 15
Very heavy vehicle traffic/Very low potential for promoting walking

Areas at Level 3 to Level 1 or with a GW score of 33–100 are considered as areas with an environment that promotes walking, often referred to as *'walkable urban areas'* (Table 1).

3.2 Application of the TGWI for the regeneration of a historic district in Bangkok

The local government body, the Bangkok Metropolitan Authority (BMA), shares the same challenges related to urban regeneration as other cities in Thailand: the need for more total authority in decision-making. A large number of land plots in the city are managed and owned by nationally owned agencies and institutions, over which it cannot exercise control. Furthermore, the BMA has to deal with budget limitations when implementing urban regeneration projects, especially high-value mega projects.

Due to the abovementioned conditions, the BMA needs a mechanism to drive its strategy. This tool, known as 'urban acupuncture', assists in implementing small-scale, low-budget projects that can create positive changes and impact. These projects are suitable for the regeneration of the inner city and may be more suitable and better serve the community's needs than larger projects (de Solà-Morales, Frampton and H. Ibelings 2008). Urban acupuncture is generally used to enhance urban fabric, for example, by improving walking and cycling paths or increasing small green public spaces to increase accessibility and create an inviting atmosphere in a specific urban area. It is instrumental to the design of urban regeneration and planning and assists the BMA in efficiently selecting priority urban areas to be developed.

Improving walkability and urban regeneration is a novel agenda in Thailand's urban development policy. Understanding and tools for policy planning are relatively limited. The TGWI has been introduced to serve two objectives. First, to help planners measure the level of walkability. The assessment results can be utilised in drafting urban policies on a wide range of topics such as the promotion of public health, invigorating the local economy, planning urban public facilities, development

Table 1 The definition of GW levels

Colour code	Level	Score	Definition
	Level 1	66–100	No vehicle traffic/ Highest potential for promoting walking
	Level 2	49–65	High potential for promoting walking
	Level 3	33–48	Some vehicle traffic/ Moderate potential for promoting walking
	Level 4	16–32	Moderate vehicle traffic/ Low potential for promoting walking
	Level 5	0–15	Very heavy vehicle traffic/ Very low potential for promoting walking

Source: Urban Design and Development Centre 2015

of station surrounding areas, management of learning cities, and management of street vendors (Serisakul and Guntamueanglee 2022a, b). Second, it can be exploited as a decision-support tool while planning and prioritising urban regeneration projects.

3.3 The formulation of the Master Plan for the Regeneration of Kadeejeen-Klongsan, Bangkok

The Master Plan for the Regeneration of Kadeejeen-Khlongsan is a prototype of the Master Plan for the Regeneration of Bangkok's Inner City under Bangkok 250 Project Phases 1 and 2.

Kadeejeen-Khlongsan is a historic neighbourhood on the bank of the Chao Phraya River. The settlement began in the Thonburi Period in 1767 when the King of Thailand established a new capital on the western bank of the Chao Phraya River. The former palace was situated at the heart of the old town, which expanded as residences for high-ranking officials and commoners were built. The settlement was a ribbon development next to the canal and riverside towns. Places of worship for Buddhists, Christians, and Muslims were established for the townspeople who relocated from Ayutthaya. Thonburi remained the capital for 15 years until the Chakri dynasty established a new capital on the eastern bank in 1782, which commenced the Rattanakosin Period.

The Kadeejeen-Khlongsan neighbourhood is considered one of Bangkok's cultural heritage sites and is known as 'the Bangkok-Thonburi Historic Neighbourhood'. It includes Phra Nakhon District, Pomprap Sattru Phai District, Samphan Thawong District (Rattanakosin area on the eastern bank) and a part of Thonburi and Khlongsan Districts (Thonburi area on the western bank). As a centre of urban art and culture, 1,533 cultural sites from different eras are dispersed densely within an area of approximately 12 km^2.

The neighbourhood possesses high potential for cross-river connectivity and should be redeveloped as an urban cultural learning centre. According to the GW scores, the Rattanakosin area scores as high as 70 out of 100 (Fig. 1). This results from the access networks that facilitate efficient pedestrian flows, smaller building block system, as well as its cultural heritage sites and public facilities such as the commercial district and traditional community. Another important contributing factor is the presence of formal and non-formal educational service areas such as museums, public parks, and libraries for tourists and learners, which are concentrated within walkable distances (Fig. 2).

However, the situation is quite different for Kadeejeen-Khlongsan on the western bank, which scores only 49 on the GW score (Fig. 3). The district's physical

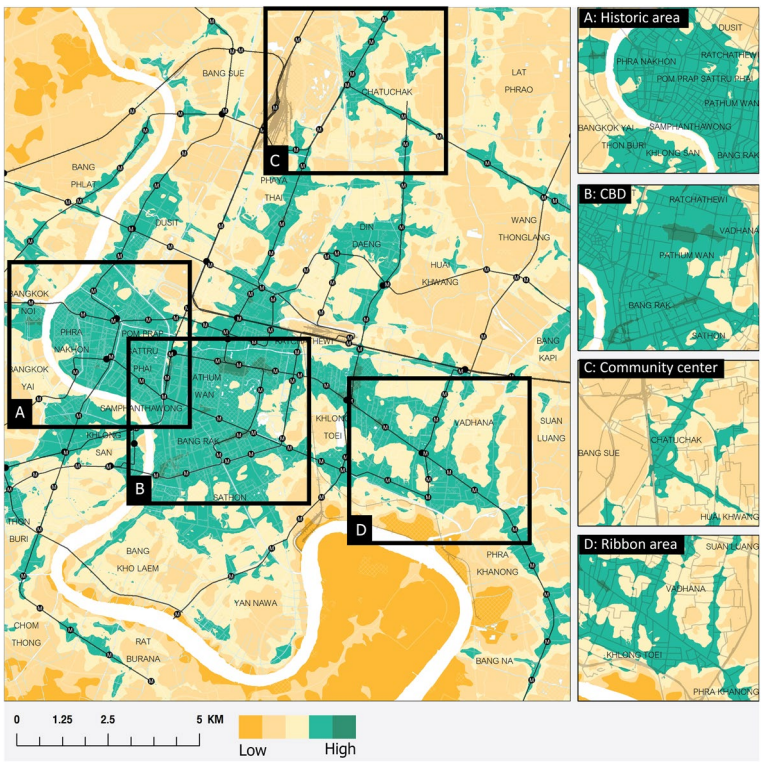

Fig. 1 Mapping Bangkok with the GW scores in inner-city areas and four walkability zones (Source: the authors)

Fig. 2 Map of Bangkok-Thonburi historic district in 1932 (Source: Chulasai, Povathong, and Tachakitkachorn 2006)

environments involve deep dead-end alleys and low accessibility spaces such as the riverfront. Despite its exceptional historical assets, dating back to the Ayutthaya period, and its multicultural heritage of Buddhism, Christianity, and Islamic religion reflected through 121 sites, poor accessibility and connectivity of pedestrian networks, especially among main destinations such as religious sites, schools, and the riverfront, is a major constraint to walkability. Certain spots are considered inconvenient and unsafe for pedestrians. However, the visitor rate remains low despite the neighbourhood's potential to become an urban cultural learning centre. Consequently, the chance for the community to benefit from promoting cultural tourism is limited.

Using the urban DMA concept to analyse Kadeejeen-Khlongsan, its density differs dramatically from Rattanakosin. There is a high-density level only at the heart of the neighbourhood, Tha Din Deang Road and Pier Station, a site for old warehouses and business activities. The scale of the functional mix is relatively low compared to the Phra Nakhon area, as a mixed-used environment is found in areas dispersed along the main streets.

The map on potential analysis of Kadeejeen-Khlongsan, according to the Urban DMA concept, reveals a low level of access networks and interconnectivity in areas along the Chao Phraya River, caused by a lack of connectivity with the roads parallel to the river. Access networks are a major weak spot for the neighbourhood. A large-scale shift in the urban structure occurred as the transport pattern converted 'from river to roads'. This has a drastic influence on spatial arrangements within the neighbourhood. Historically, the front of local houses faced the river. With the increase in road traffic and the decline in river traffic, modern houses face the street, not the river.

The riverfront and canal front quarters, which used to be prime locations for religious sites, houses of the

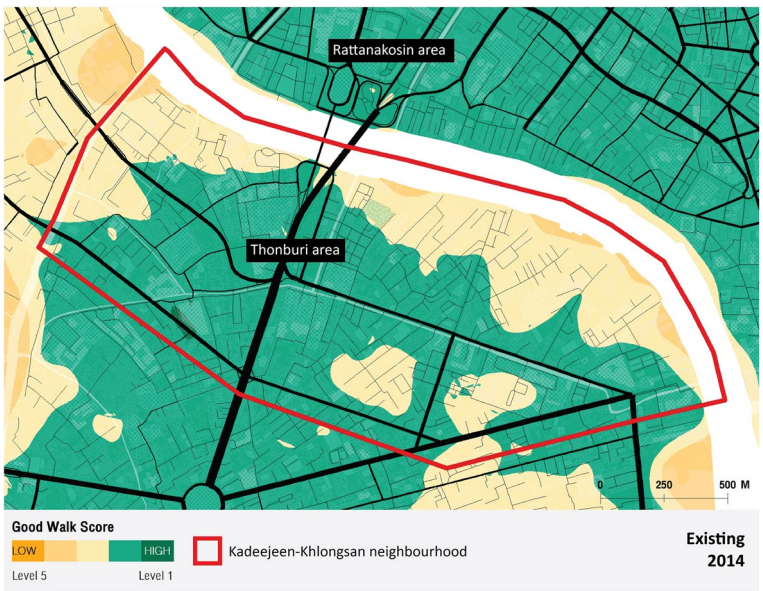

Fig. 3 Map of the GW scores in Kadeejeen-Khlongsan neighbourhood in 2014 (Source: the authors)

nobility, and markets, are now idle and relatively inaccessible. These formerly eventful urban spaces finally deteriorated and have become a development challenge (Supsook 2003).

4 Street-level study: the TWI

Consultations between the local dwellers and employees in the neighbourhood, the BMA, the public and private sectors, and the civil society reveal great prospects for urban regeneration, in line with the megatrends including the urban rail mass transit project, integration of cultural tourism that emphasises mutual learning and learning from real-life experience, promotion of self-guided walking tours, as well as new opportunities arising from the digital platforms and social media for small local businesses. These beneficial factors have been summed up as a vision for the Kadeejeen-Khlongsan neighbourhood to be a multicultural riverfront neighbourhood that embraces cultural tourism and improves the locals' quality of life.

4.1 Calculation procedures for the TWI

The TWI was developed by UDDC-CEUS for the Good-Walk Thailand project. The three core components of the W include as described below.

- Safety (three factors): safety in traffic interfaces (F1), illumination (F2), and eyes on the street (F3).
- Convenience (three factors): configuration (F4), shading (F5), and sidewalk amenities (F6).
- Livability (two factors): greenery (F7) and activities (F8).

The relationships between the factors used to analyse the walkability levels can be represented in a straightforward equation format, as shown in Eq. 8:

$$TWI = F1 + F2 + F3 + F4 + F5 + F6 + F7 + F8 \quad (8)$$

Where:

F1 = safety in traffic interfaces
F1 = illumination
F3 = eyes on the street
F4 = configuration
F5 = shading
F6 = sidewalk amenities
F7 = greenery
F8 = activities

The TWI, calculated from the quality of each factor in five rating scales, has scores ranging from 0 to 40 points, divided into five levels as follows:

Level 1: Scores from 33 to 40–Very high walkability
Level 2: Scores from 25 to 32–High walkability
Level 3: Scores from 17 to 24–Moderate walkability
Level 4: Scores from 9 to 16–Low walkability
Level 5: Scores from 0 to 8–Very low walkability

4.2 Urban acupuncture to improve walkability

Walkability has been regarded as one of the key regeneration strategies. Urban spaces involving cultural heritages and cultural landmarks will need to be transformed to improve walkability. Target areas include both historic and cultural buildings situated close to the riverfront and canals (Fig. 4).

Promoting walkability through improved access networks of waterfront spaces comprises two main strategies. The first strategy is improving access by establishing linkages at two levels: (1) City level by restoring spaces along the Chao Phraya River and integrating them into the Rattanakosin cultural tourism scheme; (2) District level by improving the pedestrian access networks between the historic sites and the markets, taking into consideration the former urban structure and the old town pedestrian networks. The second strategy is promoting density and functional mix through conserving and re-functioning historical buildings, such as utilising religious buildings as learning and recreation spaces or remodelling old residences as shops or cafés to attract visitors.

For the first strategy, we employed the urban acupuncture method, which seems to be the least intrusive measure to improve walkability but with great promise. The proposed projects consist of two types of pedestrian networks:

Type 1 is to improve the pedestrian access networks at the city level to link visitors and economic potential from the eastern side to the western side.

Type 2 is to Improve the pedestrian access networks at a district level of Kadeejeen-Khlongsan on the western side (Fig. 5)

Elaborating on the implementation of Type 1 projects, the Chao Phraya Sky Park Project (Fig. 6) links Kadeejeen-Khlongsan to Rattanakosin, the heart of cultural tourism in Bangkok. The project connects the old pier in Kadeejeen-Khlongsan with the flower market and Ong Ang Canal of the Rattanakosin.

The Chao Phraya Sky Park Project creates an 8 × 280 m. walkway and bicycle track by renovating the electric

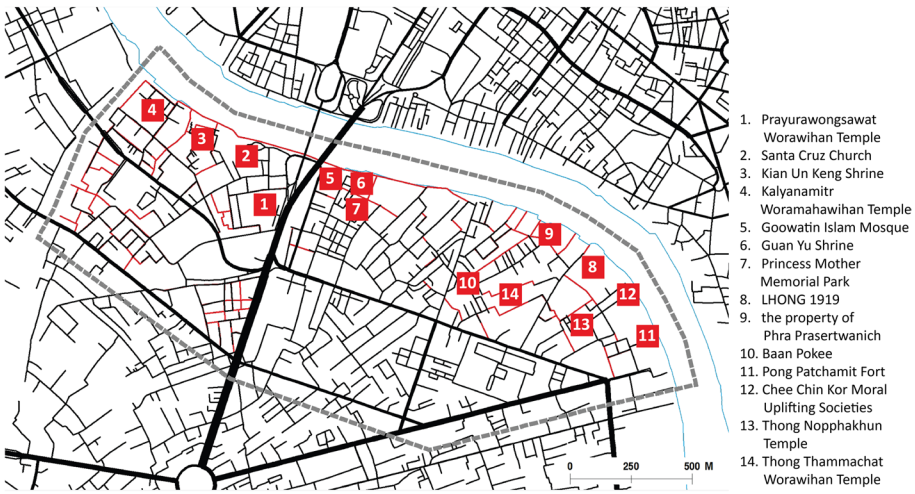

Fig. 4 Cultural landmarks in the Kadeejeen-Khlongsan neighbourhood (Source: the authors)

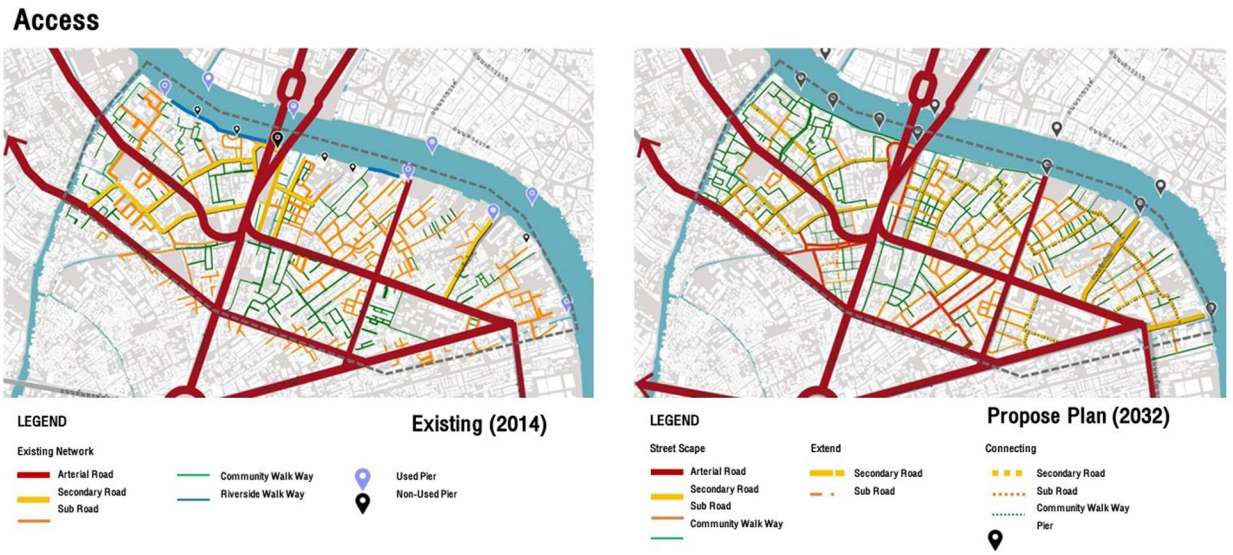

Fig. 5 Proposed plan for improvement of the pedestrian access networks under the Master Plan for the Regeneration of Kadeejeen-Khlongsan (Source: Bangkok Metropolitan Administration, Chula Unisearch, and Urban Design and Development Centre 2015)

train's original structure, which was abandoned for over 30 years. It was known locally as the 'amputated bridge'. The project proposal was to refurbish the old concrete structure as a multi-purpose walkway and bicycle track for various public activities such as exercise, relaxation, and mini concerts. Greenery was added to the structure and redesigned to reduce traffic dust, fumes, and noise. The Sky Park provides a good spot for the public to enjoy from sunrise to sunset. The project was completed in 2020, opened to the public, and became one of the most popular destinations for visitors (Fig. 7).

Elaborating on the implementation of Type 2 projects, two strategic projects were planned to improve the pedestrian access networks at the district level of Kadeenjeen-Khlongsan, involving two types of networks to integrate the neighbourhood's original waterway networks.

First is the access network of the riverfront, involving a connection between the Chao Phraya Sky Park and the historic riverfront areas. The new network radically improves pedestrian flows to the previously inaccessible spots. Small alleys have been overhauled to improve

Fig. 6 Picture of Chao Phraya Sky Park (Source: Bangkok Metropolitan Administration, Chula Unisearch, and Urban Design and Development Centre 2015)

Fig. 7 Picture of Chao Phraya Sky Park (Source: the authors)

walk-friendliness and safety. The proposal included redecorating small public green spaces for leisure and community activities. They are designed to connect these green spaces to religious sites and waterfront cultural heritage sites. The project was completed in 2023 (Figs. 8 and 9).

Second is the access networks in inner streets, which involve revitalising a quiet and private narrow pedestrian network for local dwellers. The improvement will be conducted with care through consultations with the locals, aiming to connect the community with the heritage sites and improve convenience and safety (fire safety, for example). The project is in the pipeline to be implemented in the near future.

The Second strategy is promoting density and functional mix through the conservation and functioning of historical buildings. This strategy includes improvement of density and functional mix includes three area types:

(1) Cultural heritage sites will be enhanced as destinations for cultural tourism that offer visitors learning experiences and leisure. This should be combined with conservation tourism that includes religious sites, squares, and monuments in the vicinity;
(2) Suansantarana Park can be increased by reconditioning abandoned spaces or ineffective utilisation of the public environment. The primary function is to serve as a recreational space that can also be used for recreational area, local market promotion and community gathering place (Fig. 10);
(3) Shophouses and local residences along the streets should be renovated or repurposed for innovative activities to boost the local economy, considering the creative economy concept and local cultural heritages (Fig. 11).

Fig. 8 Illustration of Kadeejeen River Walk (Source: Bangkok Metropolitan Administration, Chula Unisearch and Urban Design and Development Centre 2015)

Fig. 9 Picture of Kadeejeen River Walk (Source: the authors)

Fig. 10 Suansantarana, Khlongsan district, Bangkok (Source: the authors)

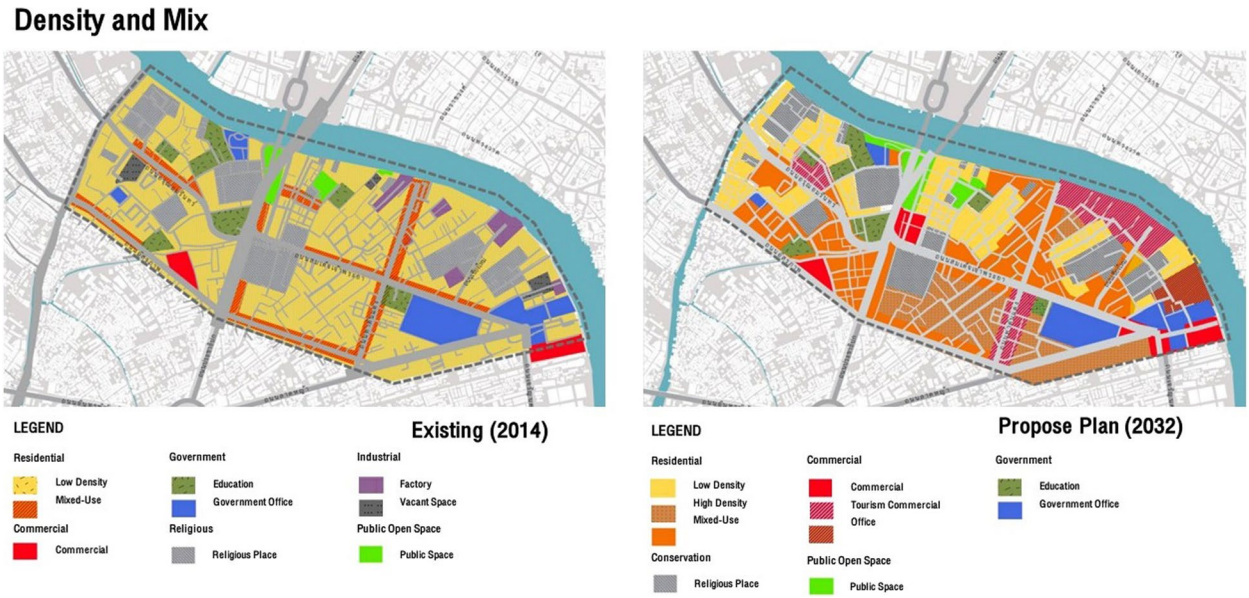

Fig. 11 Proposed plan for improvement of density and functional mix under the Master Plan for the Regeneration of Kadeejeen-Khlongsan (Source: Bangkok Metropolitan Administration, Chula Unisearch, and Urban Design and Development Centre 2015)

Kadeejeen-Khlongsan is projected to score higher on the TGWI (Fig. 12), improving from 49 to 76 after the completion of the regeneration projects, which will generate greater pedestrian flows along the riverfront quarters, improve community walkways, and increase access networks of the main and inner streets.

The Chao Phraya Sky Park Project, Ong Ang Canal Walking Street, Kadeejeen Riverfront Promenade, and Suansantanara Park (Phase 1) have been completed. The next phase will be the Khlongsan Riverfront Promenade from Chao Phraya Sky Park towards Taksin Bridge, which will be planned and implemented according to the master plan with the cooperation of the BMA and other development partners.

From the foregoing, the Master Plan for the Regeneration of Kadeejeen-Khlongsan (Fig. 13) is a plan designed to promote pedestrian activity in the neighbourhoods by connecting the city on both sides of the river and taking advantage of the waterfront area in the revitalisation of the historic districts. These neighbourhoods are surrounded by cultural heritage sites that are difficult to reach. Moreover, they have become an important destination to reconnect aspects of Bangkok's heritage.

The revitalisation of Kadeejeen-Khlongsan also helps to support the local economy by highlighting shopping options and distributing income to shops in the neighbourhood along the alleyways, which house the smallest economic units. These connected neighbourhoods are now accessible to everyone, with equal access to basic services to help people endure and cope with future health crises and everyday stress. The regeneration of Kadeejeen-Khlongsan promotes an active lifestyle while helping to distribute income to the local economy, with spillover effects into the larger urban economy to help sustain the momentum of commerce.

5 Discussion and conclusion

The regeneration of historic districts and the improvement of walkability are key priorities for cities worldwide. In the context of Bangkok, the issues of 'regeneration' and 'walkability' require in-depth studies. Knowledge of geospatial techniques and technology to optimise problem analysis processes, create problem-solving options, and enhance spatial site selection decision capabilities, which are instrumental to urban regeneration and planning design, also needs to be built on.

At the macro level, the creation and use of the TGWI as a supporting tool for urban spatial data analytics and urban planning processes can be employed to plan and prioritise urban development projects. The method is applicable to the regeneration of other historic districts throughout Thailand.

At the micro level, using the TWI in the regenerative planning of Bangkok's historic districts, such as Kadeejeen-Khlongsan, enables the neighbourhood to be easily traversed on foot, as this project creates a travel option accessible to everyone. There is equal access to basic services that will help buffer future health crises and stress.

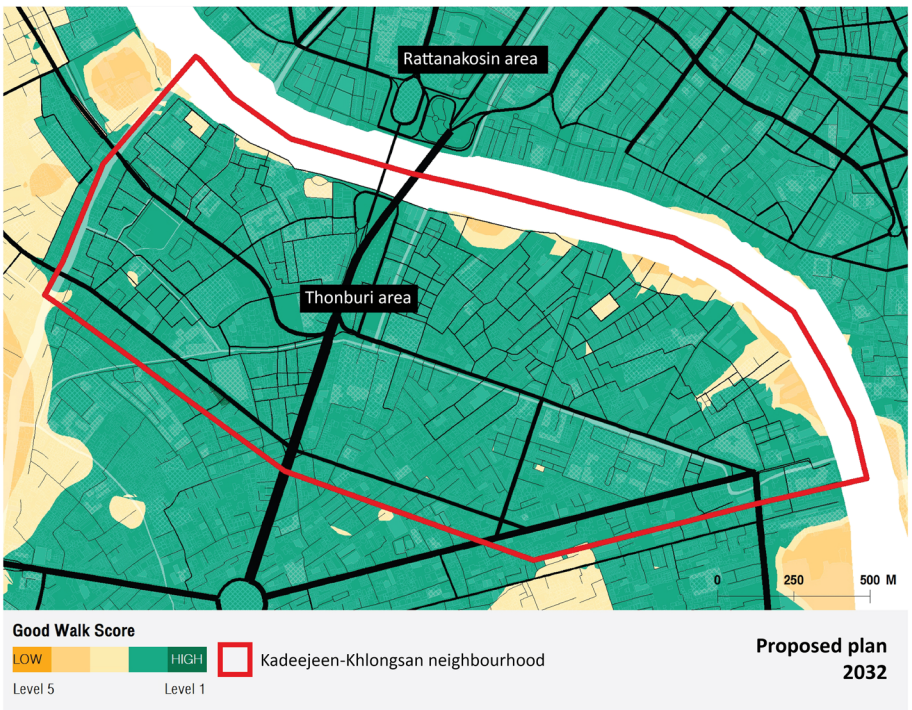

Fig. 12 A Projection of the GW scores in the Kadeejeen-Khlongsan neighbourhood in 2032 (Source: the authors)

Fig. 13 Master Plan for the Regeneration of Kadeejeen-Khlongsan (Source: Bangkok Metropolitan Administration, Chula Unisearch and Urban Design and Development Centre 2015)

The abundance of outdoor, fresh-air activities reduces the risk of transmission of infectious diseases, and an active lifestyle boosts social, mental, and physical health while helping to distribute income to the local and urban economies.

The project implementation encountered delays, resulting in the completion of projects later than planned. This was largely due to political instability and budget limitations, causing discontinuity and delays in operations. However, through an intensive consultation process, the understanding and commitment of key stakeholders were achieved. These stakeholders, including permanent civil servants in the BMA, the residents and the private sector, helped push the project forward and cooperated continuously. This ongoing cooperation will be crucial in the progress of the project until it is completed.

Abbreviations

BMA	Bangkok Metropolitan Administration
CBD	Central Business District
GW	GoodWalk
TGWI	Thai GoodWalk Index
TWI	Thai Walkability Index

Acknowledgements
The team would like to express its gratitude to the executives and officials at the Bangkok Metropolitan Administration, especially the Department of City Planning for the budgetary support and active participation in the project.
The team would like to express its appreciation for the Thai Health Promotion Foundation for the budgetary support in the creation of the GoodWalk Index.
A special thank goes to all the participants to the consultations – the local dwellers and employees in the Kadeejeen-Klongsan neighborhood, the public and private sectors, the civil society, and the general public.
We would like to thank the working team and consultants from Forx Design Studio Company Limited, Shma Soen Company Limited, N7A Company Limited, Land Process Company Limited, Civil and Structural Engineers Company Limited, and Urban Design and Development Center, Center of Excellence in Urban Strategies, Chulalongkorn University.

Authors' contributions
Niramon Serisakul contributes on the topic of urban acupuncture, analysis of the Master Plan for the Regeneration of Kadeejeen-Klongsan, and application of the GoodWalk Index for regeneration of a historic district in Bangkok. Adisak Guntamueanglee contributes on the design and use of the GoodWalk Index for regeneration of a historic district in Bangkok, and provides the spatial data. Thanaporn Ovatvoravarunyou contributes on details of the Kadeejeen-Klongsan neighborhood and the changing trends. Munchuchada Dechakaneewong contributes on details of the Kadeejeen-Klongsan neighborhood and the changing trends. Preechaya Navaraj contributes on the analysis of the Master Plan for the Regeneration of Kadeejeen-Klongsan. All authors have read and approved of the final manuscript.

Funding
Some content of the article is taken from the Bangkok 250 Project of Chula Unisearch, Chulalongkorn University, conducted by Urban Design and Development Center, Center of Excellence in Urban Strategies, Chulalongkorn University, funded by the Bangkok Metropolitan Administration. And some content of the article derives from the GoodWalk Project, funded by Thai Health Promotion Foundation.

Availability of data and materials
Not Applicable.

Declarations

Competing interests
Not Applicable.

Received: 25 December 2022 Accepted: 21 March 2024
Published online: 16 May 2024

References

Appleyard, D. 1981. *Livable streets*. Berkeley: University of California Press.
ARUP. 2016. *Cities Alive: Towards a walking world*. London: ARUP.
Bangkok Metropolitan Administration, Chula Unisearch, and Urban design and development Center. 2015. *Bangkok 250 (Phase I)*. Bangkok: Bangkok Metropolitan Administration.
Chula Unisearch, and Urban Design and Development Center. 2015. *A study of walking accessibility to urban facilities and walkability index in Bangkok metropolitan region Phase I*. Bangkok: Thai Health Promotion Foundation.
Chula Unisearch and Urban design and development Center. 2019. *The Study on Walking Accessibility to Daily Facilities and Walkability Index (Phase III)*. Bangkok: Thai Health Promotion Foundation.
Chulasai, B., P. Povathong, and T. Tachakitkachorn. 2006. *Bangkok area map in 1907–1932: Compilation and systematization of database for the study of architecture and city of Bangkok*. Bangkok: Thailand Science Research and Innovation.
D'Alessandro, D., D. Valeri, and L. Appolloni. 2020. Reliability of T-WSI to evaluate neighborhoods walkability and its changes over time. *International Journal of Environmental Research and Public Health* 17 (21): 7709.
de Solà-Morales, M., K. Frampton, and H. Ibelings. 2008. *A matter of things*. Rotterdam: NAi Publishers.
Dovey, K., and E. Pafka. 2020. What is walkability? The urban DMA. *Urban Studies* 57 (1): 93–108.
European Commission. 2004. *Reclaiming city streets for people chaos or quality of life*. Retrieved from https://ec.europa.eu/environment/pubs/pdf/streets_people.pdf.
Frank, L. D., P. Engelke, and T. L. Schmid. 2003. Health and community design: The impact of the built environment on physical activity. *Journal of Epidemiology and Community Health* 59(3): 250.
Frank, L. D., M. A. Andresen, and T. L. Schmid. 2004. Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine* 27(2): 87–96.
Gargiulo, C., and S. Sgambatia. 2022. Active mobility in historical centres: Towards an accessible and competitive city. *Transportation Research Procedia* 60: 552–559.
Gehl, J. 2011. *Life between buildings: Using public space*. Washington DC: Island Press.
Geller, P. 2009. Bodyscapes, biology, and heteronormativity. *American Anthropologist* 111 (4): 504–516.
Hillier, B. 1996. *Space is the machine*. Cambridge: Cambridge University Press.
Jacobs, J. 1961. *The death and life of great American cities*. New York: Random House.
Kenworthy, J, and F. Laube. 2001. *Millennium cities database for sustainable transport*. Bruxelles: International Association of Public Transport.
Koszowski, C., R. Gerike, S. Hubrich, and T. Götschi. 2019. *Active mobility: Bringing together transport planning, urban planning, and public health: Challenges, solutions and collaborations*.
Krambeck, H. 2006. *The global walkability index*. Massachusetts: Massachusetts Institute of Technology (MIT).
Lawlor, E., Just Economics. 2014. *The pedestrian pound: The business case for better streets and places*. London: Living Streets.
Leslie, E., B. Saelens, L. Frank, N. Owen, A. Bauman, N. Coffee, and G. Hugo. 2005. *Residents' perceptions of walkability attributes in objectively different neighbourhoods: A pilot study*.
Leslie, E., N. Coffee, L. Frank, N. Owen, A. Bauman, and G. Hugo. 2007. Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes. *Health & Place* 13(1): 111–122. https://doi.org/10.1016/j.healthplace.2005.11.001.
Litman, T. A. 2011. Economic value of walkability. *World Transport Policy & Practice* 10 (1): 5–14.
Masoumzadeh, S., and H. Pendar. 2019. Walking as a medium of comprehending contextual assets of historical urban fabrics. *Urban Research & Practice* 14 (1): 50–72.
Neves, A., and C. Brand. 2019. Assessing the potential for carbon emissions savings from replacing short car trips with walking and cycling using a mixed GPS-travel diary approach. *Transportation Research Part A: Policy and Practice* 123: 130–146.
New York City Department of Transportation. 2008. *The economic benefits of sustainable streets*. New York: New York City Department of Transportation. Retrieved from https://www.nyc.gov/html/dot/downloads/pdf/dot-economic-benefits-of-sustainable-streets.pdf.
Saelens, B.E., J.F. Sallis, and L.D. Frank. 2003. Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine* 25 (2): 80–91.
San Francisco (Calif). Department of Public Health. 2009. *Pedestrian environmental quality index (PEQI): An assessment of the physical condition of streets and intersections*. San Francisco: San Francisco Department of Public Health.
Serisakul, N., and A. Guntamueanglee. 2022a. *Bangkok walkable city*. Bangkok: Li-Zenn.
Serisakul, N., and A. Guntamueanglee. 2022b. Walkability index: A study to establish indicators and assess the potential to promote pedestrian traffic in Greater Bangkok. *NAJUA Journal* 19 (2): 246–287.
Serisakul, N., and A. Guntamueanglee. 2022c. *Walkable city*. Bangkok: Li-Zenn Publishing.
Serisakul, N., and A. Guntamueanglee. 2023. *Walkable city: Muea Krung Thep Ok Doen*. Bangkok: Li-Zenn Publishing.
Sevtsuk, A., and M. Mekonnen. 2012. Urban network analysis. A new toolbox for ArcGIS. *Revue Internationale de Géomatique* 22 (2): 287–305.

Shafray, Ekaterina, and Seiyong Kim. 2017. *A study of walkable spaces with natural elements for urban regeneration: A focus on cases in Seoul, South Korea*.
Southworth, M. 2005. Designing the walkable city. *Journal of Urban Planning and Development* 131 (4): 246–257.
Supsook, S. 2003. The Transformation of Bangkok's Spatial Configuration: A Story of Watkalaya Community. In *the Proceeding of the 7th Annual Conference of Architecture*, 333-348. Bangkok: Faculty of Architecture, Chulalongkorn University.
Sutikno, F.R., and E.B. Kurniawan. 2013. Walkability and pedestrian perceptions in Malang City emerging business corridor. *Procedia Environmental Sciences* 17: 424–433.
Talavera-Garcia, R., and J.A. Soria-Lara. 2015. Q-PLOS, developing an alternative walking index. A method based on urban design quality. *Cities* 45: 7–17.
Tani, Y., M. Hanazato, T. Fujiwara, N. Suzuki, and K. Kondo. 2021. Neighborhood sidewalk environment and incidence of dementia in older Japanese adults: The Japan gerontological evaluation study cohort. *Merican Journal of Epidemiology* 190 (7): 1270–1280.
Thomson, G., and P. Newman. 2018. Urban fabrics and urban metabolism – from sustainable to regenerative cities. *Resources Conservation and Recycling* 132: 218–229.
Tolley, R. 2011. *Good for Busine$ The benefits of making streets more walkking and cycling friendly*. National Heart Foundation of Australia.
Transport for London. 2015. *Assessing transport connectivity in London*. London: Transport for London.
UNESCO. 2016. *Culture urban future global report on culture for sustainable urban development*. Paris: UNESCO.
Urban Design and Development Center. 2015. *A study of walking accessibility to urban facilities and walkability index in Bangkok metropolitan region phase I*. Bangkok: Thai Health Promotion Foundation.
Walk Score. 2011. *Walk score methodology*. Seattle: Walk Score.

Publisher's Note