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Analysis of Walkability at Thammasat University Rangsit Campus to Promote Sustainable Campus Development

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Abstract

This work studies walkability at Thammasat University, Rangsit Campus, Thailand. It learns the infrastructure, safety, accessibility, and walking areas comfort. This is to help the university meet its sustainability objectives. The approach uses multiple methods. This includes GIS mapping, environmental audits, pedestrian counts, and user perception surveys. This work assesses walkability in six campus zones. The results show differences in walkability quality. The academic area gets rather good Walk Score of 68/100. Residential and recreational areas get low Walk Scores 32-45/100. The problems are not having enough shaded paths, bad links to transit points, uneven accessibility features, and safety worries at night. This study presents a Campus Walkability Index (CWI). This includes 22 indicators from five areas. From the analysis, to improve walkability, it needs to reduce vehicle dependency, increase social interactions, and improve satisfaction. This work offers useful tips for making the campus better for walking by improving buildings and paths, changing rules, and encouraging good habits. It adds to the research on sustainable campus planning and provides ways to create university spaces that are friendly for pedestrians.

Discipline: Multidisciplinary (Urban Design, Civil Engineering & Infrastructure Management).

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1 Introduction

Founded in 1934, Thammasat University (TU) is one of the oldest universities in Thailand. Opened in 1986, the Rangsit campus (TUR) has 600 acres, located in Pathumthani province, north of Bangkok. It is a modern expansion of its main Tha-Phrachan campus. Every day, it serves 40,000 local and international students, faculty, and staff. It is originally designed based on the American suburban model that uses cars for transportation. The campus is currently confronting sustainability issues. Such issues are involved with emissions of vehicles, efficiency of land uses, and quality of the environment. TU has its sustainability goals, the "Thammasat Sustainable Campus 2030" initiative (TU, 2021), and improving pedestrian mobility becomes a key element in minimizing carbon emissions, improving health and well-being, and promoting community unity.

Having a focus on sustainability theory, TUR shows substantial walkability issues, such as broken pedestrian pathways, insufficient shade for Thailand's hot tropical climate, safety risks, and conflicts with vehicle traffic. These problems impede sustainability goals and add to transportation emissions (which are estimated to 35% of the campus's carbon footprint), and create obstacles for accessibility. The gap between sustainability claims and the actual pedestrian experience highlights a larger trend in university planning across Southeast Asia, where campus designs taken from cooler climates do not adjust well to local environmental and cultural conditions.

This study assesses walkability conditions at TUR. Also, this work built a Campus Walkability Index (CWI) for tropical university environments. This study also looks at relationships between walkability and sustainability indicators. Further, this work monitors frameworks for walkability enhancement. This work contributes to several domains. In practical terms, it offers useful suggestions for campus planning. In terms of methodology, it creates a walkability assessment tool that is sensitive to context. Theoretically, it enhances the understanding of how pedestrians behave in tropical campus settings. In terms of policy, it provides guidance for sustainable campus planning for universities in Thailand and Southeast Asia.

The research examines daytime conditions (6:00-20:00) in all publicly accessible areas of the TUR campus. It does not include the analysis of building interiors or private residential areas. Data was collected during regular academic semesters, avoiding examination periods and holidays. Also, data was collected on non-rainy days, based on available climate data (TMD 2025). The study recognizes its limitations in capturing seasonal changes and the full range of user experiences.

2 Literature Review

2.1 Theoretical Foundations of Walkability

Walkability is a complex concept of urban design, transportation planning, and environmental psychology. Lynch's (1960) study on imageability highlighted how people perceive pedestrian areas. Cerin (2006) measured perceived neighborhood walkability. However, Gehl's (1971) idea of life-between-buildings focused on social aspects. Southworth (2005) discussed designing the walkable city. Talen (2002) argued to use pedestrian access as a measure of urban quality. UNESCO (2014) suggested using education for sustainable development. Modern frameworks combine these views through the "5 C's" of walkability. These are Connectivity, Comfort, Convenience, Conviviality, and Conspicuity (Forsyth, 2015).

The ecological model of walking behavior (Sallis et al., 2006) shows various interacting levels, including intrapersonal (attitudes, abilities), interpersonal (social norms), organizational (campus policies), community (physical environment), and policy (regulations). This multi-level view guides the study's thorough assessment method.

2.2 Walkability Considerations for Campus

University campuses are special pedestrian areas with unique features. Controlled jurisdiction aspect, unlike public streets, campuses allow integrated planning across transportation, land use, and building design (Kenney et al., 2005). In terms of demographic concentration, high density of young, able-bodied pedestrians with time constraints between classes. Having multifunctional spaces, there are simultaneous accommodations of academic, residential, recreational, and commercial activities. For symbolic function, campuses are models of sustainable practice and community design (Orr, 2004).

Iamtrakul and Raungratanaamporn (2015) contended that campus master planning ought to be structured to establish a hub of urban intensification featuring a pedestrian-friendly environment. This will not only promote more compact development in neighborhood areas but will also give health, environmental, and economic advantages.

Tropical campus environments present additional considerations. These include solar orientation for shading, rain protection, heat management, and seasonal weather (Hwang et al., 2017). Southeast Asian campuses must also consider high humidity, intense rainfall, and cultural preferences.

Kongphunphin (2022) looked into how university facilities relate to the features of the area at TUR. This was done through a survey that focused on important aspects of physical facilities like convenience, service, and accessibility.

Kongphunphin et al. (2024) discussed the roles of green infrastructure (GI) at TUR. The green corridors support walking and cycling, and these corridors also improve the university's visual appeal.

2.3 Walkability Assessment Methodologies

There are many audit tools and perception surveys. Audit tools include Pedestrian Environmental Data Scan (PEDS), Systematic Pedestrian and Cycling Environment Scan (SPACES), and Irvine-Minnesota Inventory (IMI). PEDS is for microscale built environment assessment (Clifton et al., 2007). SPACES is an Australian adaptation of comprehensive auditing. IMI gives a detailed assessment of walking environments (Day et al., 2006).

Perception measures include the Neighborhood Environment Walkability Scale (NEWS) and Walking Suitability Assessment Form (WSAF). NEWS is a standardized perceptual instrument (Saelens et al., 2003). WSAF is a user-centered evaluation tool.

Emerging technologies include Geographic Information Systems (GIS), wearable sensors, and computer vision tools. GIS-based network analysis measures connectivity and accessibility. Wearable sensors are for microclimate assessment. Computer vision is for pedestrian volume and behavior tracking.

2.4 Walkability-Sustainability Tie

Many research works demonstrate the sustainability benefits of enhanced walkability. In terms of environment, it is aimed to reduce vehicle emissions, lower energy consumption for cooling (through shade trees), and decrease impervious surfaces (Frumkin et al., 2004). In terms of social, it increased social capital, improved mental health, and enhanced safety through natural surveillance (Jacobs, 1961). In terms of economics, it lowers transportation costs, increases property values, reduced infrastructure maintenance (Litman, 2017). In terms of health, it increases physical activity, reduces chronic disease risk (pm2.5), and improves cognitive function (Frank et al., 2006).

2.5 Gaps in Existing Literature

Despite many research works on walkability, there are still notable gaps. In tropical areas, many tools created for temperate climates do not effectively cater to tropical conditions. Additionally, there are a few tools designed for university environments. They have their own unique spatial and social dynamics. For cultural adaptation, there is a lack of focus on pedestrian behaviors and preferences in Southeast Asia. Moreover, most research tends to offer brief snapshots instead of monitoring frameworks. Further, assessments are often not connected to practical interventions. This study aims to fill these gaps by developing context-sensitive tools and clearly linking assessment with implementation.

3 Methodology

3.1 Research Design

A convergent parallel mixed-methods approach was used, gathering both quantitative and qualitative data at the same time, with integration during the analysis and interpretation phases. The study included five components, see Table 1.

Table 1: Components of research design

Components	Details
1. Environmental Audits	This refers to a systematic evaluation of physical infrastructure.
2. Behavioral Mapping	This refers to the observation of pedestrian movement patterns.
3. User Surveys	This refers to the assessment of perceptions and preferences.
4. GIS Analysis	This refers to the spatial modeling of connectivity and accessibility.
5. Expert Interviews	This refers to gathering insights from campus planners and administrators.

3.2 Division of Study Area

In this study, the TUR is divided into six zones. These divisions are done according to their functions and layouts, see Table 2.

Table 2: Division of the Study Area.

Zone	Covered areas
1. Central Academic Core	This covers administrative offices and classrooms.
2. Library & Learning Commons	This includes the information resource center.
3. Student Union & Commercial Zone	This comprises social and retail activities.
4. Residential Areas	This includes dorms and faculty housing.
5. Sports & Recreation Complex	This covers facilities for athletic and open spaces for recreation.
6. Peripheral Academic	This includes specialized faculties and research centers.

3.3 Data Collection Instruments

3.3.1 Campus Walkability Audit Tool (CWAT)

This research creates the Campus Walkability Audit Tool (CWAT) by evaluating 22 indicators across five areas, see Table 3.

Table 3: Campus Walkability Audit Tool (CWAT)

CWAT evaluation area	CWAT evaluation indicators
Infrastructure Quality	This includes pathway width, surface condition, and maintenance.
Safety & Security	This consists of lighting, visibility, and traffic conflict points.
Comfort & Amenities	This covers shading, seating, and drinking water.
Accessibility	This comprises ramps, tactile paving, and wayfinding.
Aesthetics & Experience	This includes green elements, architectural interest, and cleanliness.

Each indicator has scores from 0 to 4 (absent to excellent). The weighted domain scores combine to form a maximum 100-point Campus Walkability Index (CWI).

3.3.2 Pedestrian Perception Survey

This study surveys pedestrian perception during mid-September 2025, involving 200 campus users (75% students, 20% faculty/staff, and 5% visitors) using random sampling of different zones and times. Table 4 shows the survey items. In this survey, the participants were not asked for personal information.

Table 4: Pedestrian perception survey

Items of the survey
Modified Neighborhood Environment Walkability Scale (NEWS-A)
Travel behavior and mode choice questions
Satisfaction with pedestrian facilities
Safety perceptions
Open-ended suggestions for improvement

3.3.3 Behavioral Observations

Pedestrian counts were taken at 7 key locations during four different times (morning peak, midday, afternoon peak, evening) for one workweek. This survey recorded movement patterns, route selections, and how space was used using behavioral mapping.

3.3.4 GIS Network Analysis

Within the GIS system, this study creates a detailed pedestrian network dataset. Such details include pathway locations and characteristics, building entrances and destinations, topographic constraints, and land use designations.

The analysis included route connectivity (link-node ratio), accessibility to key destinations, detour index (i.e., deviation from straight-line distance), and service area analysis for 5, 10, and 15-minute walks.

3.4 Data Analysis

Quantitative data is analyzed using SPSS (v24) with descriptive statistics, correlation analysis, and regression modeling. Qualitative data underwent thematic analysis. GIS analysis conducted using ArcGIS Pro with the Network Analyst extension. Spatial statistics identified walkability hotspots and deficiencies.

4 Results

4.1 Campus Walkability Index Scores

Table 5 gives the study results of Campus Walkability Index (CWI) scores, with each score having a maximum of 100. About half of the pathways (46%) are less than 2m wide, as this is the minimum needed for two-way walking traffic with accessibility. Sidewalks with 63 spots are interrupted at road intersections. Also, this study found that 28% poor maintenance paved surfaces cause cracks, water pooling, and unevenness.

Table 5: The study results of TUR Campus Walkability Index (CWI) scores.

Evaluation item	CWI	Interpretation
Overall TUR Campus	**57.4**	**Poor-Moderate**
Zone		
1. Central Academic Core	72.2	Good
2. Library & Learning Commons	75.6	Good
3. Student Union & Commercial Zone	60.4	Moderate
4. Residential Areas	42.3	Poor
5. Sports & Recreation Complex	30.0	Very Poor
6. Peripheral Academic	40.1	Poor
CWAT evaluation		
1. Infrastructure Quality	60.1	Moderate
2. Safety & Security	45.6	Poor
3. Comfort & Amenities	42.8	Poor
4. Accessibility	56.4	Poor-Moderate
5. Aesthetics & Experience	75.4	Good

In terms of safety, 55% of the paths lack adequate lighting. There are 105 points causing conflict between pedestrians and vehicles, and these points need proper controls. Many of those surveyed (78%) said they feel unsafe walking after sunset. Further, there are only 7 emergency call stations available across TUR.

When it comes to accessibility, only half (50%) of the areas meet universal design standards (DPW, 2018). Tactile paving is missing at most spots. Also, there is not enough seating along the walking paths, with seating spaced an average of 280 meters. Wayfinding signage is also lacking, especially for visitors.

About connectivity, the distance to campus shuttle stops is 365 meters on average. The detour index is 0.71, thus the routes are 40% longer than the straight distance (Euclidean). Also, there is poor integration between building entrances and the pathway.

In studying pedestrian behavior patterns, 40% of respondents are found walking, 19% use bicycles, 24% ride motorcycles, 10% take campus shuttles, and 7% drive private vehicles.

Regarding factors of route choice, survey participants give the importance of shaded paths, shortest distance, safety from vehicles, pathway quality, and social vibrancy.

About pedestrian observation, the morning peak (7:30-8:30 local time) gave very high pedestrian volumes having direct walking. During midday (11:30-13:30), pedestrians walk leisurely by choosing longer routes via shaded paths. In the afternoon peak (15:30-17:30), pedestrians had mixed purposes, including some recreational walking. During the evening (19:00-20:00), pedestrian volumes were low because of safety concerns.

4.2 Spatial Analysis Findings

For analysis of connectivity, this study found a link-to-node ratio of 1.75, indicating moderate connectivity. Cul-de-sacs are about 10% of pathway segments. From accessibility analysis, 77% of academic buildings are accessible within a 10-minute walk from the central shuttle hub. There are 69% of residential buildings took longer than a 10-minute walk to dining facilities. The sports complex requires a 20-minute walk from the central campus. Also, peripheral faculties are isolated, requiring walks of over 25 minutes from the core.

Hotspots include the library plaza, central courtyard, and commercial zone on the main street. Moderate areas cover academic building corridors and some residential pathways. Coldspots encompass sports complex approaches, peripheral faculty access routes, and parking lot traverses.

4.3 User Perception Results

From the study results of user perception, satisfaction scores are given in Table 6. Night safety gets the lowest score, thus is needed attention.

Table 6: Satisfaction levels

Item	Satisfaction score
Overall walkability satisfaction	5.5/10
Aesthetics and greenery	7.7/10
Safety after dark	3.0/10
Rain protection	3.6/10

From the study survey, respondents suggest more shaded walkways, better lighting, continuous sidewalks, more seating, and improved wayfinding. There were several findings as follows. International respondents rated comfort lower due to poor climate adaptation. Female respondents had much lower safety perceptions. Faculty and staff valued accessibility features more than students did. Visitors faced the most challenges with wayfinding and navigation.

4.4 Correlation Analysis

The obtained data were analyzed using the statistical tool SPSS (v24) for Pearson's correlation and regression analyses. Table 7 shows the result of the correlation analysis.

Table 7: Pearson's correlation.

Relationship between Parameters	Correlation
Pathway shading ⇔ pedestrian volume	0.72
Lighting quality ⇔ evening usage	0.65
Walkability score ⇔ perceived campus satisfaction	0.67
Zone walkability ⇔ mode share for walking	0.69

For regression analysis, a linear regression model predicting walking mode share from walkability components explained 72% of the variance ($R^2 = 0.72$). Important predictors are shaded pathway proportion ($\beta = 0.44$), safety rating ($\beta = 0.32$), and directness index ($\beta = 0.26$).

5 Discussion

5.1 Key Findings

From Pearson's correlation analysis, this study found an important link between shading and how pedestrians behave (r=0.72). This indicates the important role of thermal comfort in walkability in tropical areas. According to the meteorological data, Bangkok has high solar radiation of 5.9 kWh/m^2/day, with a humidity level of 80.5% and an annual rainfall of 1,550 mm. TUR provides just 38% continuous shading of main routes. This study suggests that planning for tropical campuses should offer more shade.

For safety perception, women gave lower safety ratings. This matches global studies on women's experiences in public spaces. This problem worsens in campus settings with isolated paths and little natural surveillance at night. This hinders women's involvement on campus, especially for evening classes/events. It is also possible to do crime prevention through environmental design (Phuntarakit & Tontisirin, 2021).

The campus shows typical connectivity problems from large-scale, car-based planning. The 0.71 detour index means pedestrians walk 40% more than the direct route, leading to time delays that encourage the use of motorized transport for longer journeys. This is especially concerning during class transitions with short breaks, which account for the 24% motorcycle usage for medium distances.

5.2 Theoretical Contributions

5.2.1 Tropical Campus Walkability Framework

This research adds climate-sensitive changes to the walkability theory. The Campus Walkability Index (CWI) adds tropical factors such as solar orientation analysis, rain protection evaluation, and evaporative cooling potential. These elements are missing from tools designed for temperate climates. This work fills an important gap in the literature concerning tropical pedestrian spaces.

5.2.2 The Campus as Pedestrian Laboratory

University campuses offer unique opportunities for testing walkability interventions due to controlled management, captive populations, and educational missions. This study positions campuses as "living laboratories" for sustainable mobility innovations, with potential for rapid prototyping and longitudinal evaluation. These advantages are rarely available in municipal contexts.

5.2.3 Behavioral-Infrastructure Feedback Loops

The observed correlations suggest reinforcing feedback between infrastructure quality and pedestrian behavior: better facilities increase walking, which justifies further investment, creating virtuous cycles. Conversely, poor facilities decrease walking, reducing political support for improvements, creating vicious cycles. This dynamic systems perspective enriches traditional static walkability assessment.

5.3 Practical Implications for Campus Planning

TUR can put planning with the considerations of three phases, including immediate, mid-term, and long-term phases, as given in Table 8.

Table 8: Practical implications for TUR planning.

Phase	Practical Planning	Detail of action
Immediate Interventions (0-1 year)	Shading Retrofit	Install temporary shade structures along high-use routes
	Lighting Enhancement	Prioritize lighting in high-risk areas identified through safety audits.
	Wayfinding System	Implement consistent signage with digital integration.
	Maintenance Prioritization	Address immediate safety hazards (cracks, ponding)
Medium-Term Strategies (1-3 years)	Pedestrian Priority Zones	Designate car-free areas during peak pedestrian hours
	Continuous Pathway Network	Close critical gaps in sidewalk continuity.
	Universal Design Implementation	Achieve 80% compliance with accessibility standards.
	Microclimate Enhancement	Strategic tree planting for shade and evaporative cooling.
Long-Term Transformation (3-10 years)	Campus Mobility Master Plan	Integrate walking with cycling, shuttles, and land use
	Building-Pathway Integration	Redesign building entrances and ground-floor interfaces
	Pedestrian-Oriented Districts	Develop mixed-use hubs, reducing trip distances.
	Monitoring Framework	Establish ongoing walkability assessment and reporting.

5.4 Policy Recommendations

The results of this study give some policy recommendations (Table 9).

Table 9: Policy Recommendations for TUR

Item	Policy Recommendations
Governance Structures	- Create a Campus Walkability Task Force that includes students, faculty, and administrators - Formulate Walkability Design Guidelines for all new buildings and renovations - Require a Pedestrian Impact Assessment for capital projects
Financial Mechanisms	- Allocate a portion of parking revenue for pedestrian enhancements - Seek green campus funding for projects that improve walkability and adapt to the climate - Establish public-private partnerships (PPP) to provide amenities like seating and drinking fountains
Behavioral Strategies	- Launch "Walking Wednesdays" or similar promotional campaigns - Create walking route maps that showcase shaded and scenic paths - Include walkability education in orientation programs

5.5 Sustainability Synergies

Sustainability Synergies (SS) are to combine environmental, social, and economic strategies to get outcomes that benefit everyone. With this, the overall effect is more important than the individual contributions. SS connects people, the environment, and progress to create resilience. For example, TUR turns waste into new products or adjusts its Environmental, Social, and Governance (ESG) objectives with the UN Sustainable Development Goals.

Table 10: Sustainability Synergies for TUR.

Item	Sustainability Synergies
Climate Action Alignment	Improved walkability directly aids climate objectives (BMA, 2019): - Reducing carbon emissions by shifting from motorized transport - Mitigating urban heat islands by increasing vegetation - Managing stormwater with permeable pathway materials
Health and Well-being	- More physical activity from walking replaces time spent sitting - Mental health improvements from exposure to greenery and socializing - Lower air pollution levels due to reduced vehicle traffic
Social Sustainability	- Better accessibility encourages inclusion of people with various abilities - Enhanced safety addresses issues of gender equity - Improved public spaces strengthen community ties and campus identity

6 The Study Limitations and Research Directions

This study had some limitations. It did not account for seasonal changes. There were few evaluations of nighttime conditions apart from perception surveys. There may be sampling bias among survey participants. It cannot evaluate long-term behavior changes due to infrastructure improvements.

Future studies should carry out a long-term assessment of the effectiveness of walkability interventions. Also, a comparative analysis should be done across Southeast Asia campuses. Other research could focus on integrating real-time sensor data for monitoring microclimates and usage. Another area of research might involve an economic analysis of the returns on walkability investments (like health, productivity, and retention). Also, studies that are specific to cultural contexts regarding pedestrian preferences and behaviors should be conducted.

7 Conclusion

This TUR walkability study shows chances for sustainable changes on campus. Walkability in tropical university environments needs attention on shading, rain protection, and heat reduction. The current assessment methods and planning practices do not sufficiently cover these elements.

The Campus Walkability Index (CWI) offers a customized tool for assessing pedestrian areas in university environments, especially in tropical regions. The strong links between the index and actual walking habits confirm its usefulness for planning and prioritizing improvements. The zone-based analysis shows differences in walkability quality throughout the campus, with central areas performing reasonably well while outer zones struggle with poor connectivity, problems with amenities, and safety issues.

This study's findings show that walkability is connected to broader sustainability goals. Better pedestrian environments help reduce transportation emissions. Also, it enhances public health, promotes social equity, and boosts campus community vitality. The regression analysis, indicating that walkability accounts for 72% of the variance in walking mode share, provides strong support for investment in pedestrian infrastructure.

For TU, this research can be used as a guide to achieving its sustainable campus goals. The suggested actions are organized into immediate, medium-term, and long-term actions. The recommended governance structures, funding strategies, and monitoring systems tackle the implementation challenges that hinder sustainability efforts.

This study goes beyond TU by adding to the literature on sustainable campus planning through:

- Creating a tool for assessing tropical university settings
- Showing the links between walkability features and behavior
- Offering a framework to connect assessment with action
- Emphasizing climate adaptation as key to tropical walkability
- Viewing campuses as important places for sustainable mobility innovation

Many universities face sustainability problems. Developing pedestrian-friendly campuses is thus an effective way to reduce environmental impact and improve educational quality and health. This study warns about planning mistakes and gives an outlook on sustainable change via the essential human experience of walking.

Walkability is more than about transportation efficiency; it reflects values on accessibility, community, health, and environmental care. For TU and other schools, investing in walkability means supporting their educational goals and creating campuses that support sustainable living through the design and function.

8 Availability of Data and Materials

All information is included in this article.

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