Evaluating Sustainability of Urban Mobility of Suburban Area, Pathumthani Province, Thailand

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ABSTRACT

In this study, evaluating sustainable urban mobility is to understand the level of transport development of suburban areas as well as applied in network planning to promote public transport travel. This is a way to lower the utilization of personal vehicles and traffic congestion. This study adopted a collection of 10 indicators on the basis of the Sustainability of Urban Mobility Index for an enhancement of urban mobility in suburban areas. The indicators of urban transport encompass the environmental, social, and economic dimensions of the transportation system in relation to sustainability. This framework adopts a standardized data collection methodology, integrating both primary and secondary data sources. Specifically, 1,000 datasets were collected from residents of Pathum Thani as primary data, while Indicator 4 was derived from secondary surveys, incorporating data from Indicator 5, Indicator 8, Indicator 9, and Indicator 10. The analysis revealed that the key determinants influencing the development of the transportation system in the study area were Indicator 5: Traffic Fatalities, Indicator 9: Air Quality, and Indicator 4: Public Transport Reliability and Quality. With this methodological approach, it does not only facilitates in-depth discussions on urban transport challenges, but also contributes to enhancing accessibility, fostering high-quality mobility, and promoting sustainable transportation solutions within and beyond urban areas. As a robust analytical tool, it enables the assessment of existing urban mobility conditions and supports policymakers in formulating evidence-based policies for more efficient and sustainable urban transport systems.

1. INTRODUCTION

The growth of suburban areas in Pathum over the decades has resulted in both positive and negative impacts on its surrounding regions. Notably, the expansion of communities in peripheral areas has been driven by urbanization, which, in turn, has been influenced by the development of infrastructure and public services. The construction of expressways and road networks has significantly enhanced connectivity to the capital city [1]. A key factor accelerating this urban expansion is the extension of the railway from Bang Sue to Thammasat station (Dark Red Line), alongside the proliferation of large-scale housing developments, student dormitories, and condominiums [2], [3]. However, this rapid growth has often occurred without comprehensive urban planning, particularly concerning residents' quality of life and well-being. Moreover, insufficient planning for an integrated public transport network has led to inadequate connectivity between suburban areas and other parts of the city [4], [5].

Traffic congestion remains a critical challenge in the vicinities of Bangkok, as evidenced by the vehicle-to-capacity ratio (VCR) exceeding 1.00 during the morning rush hour, indicating severe roadway saturation [6], [7]. In addition to congestion, road safety concerns are paramount, with Pathum Thani Province reporting a mortality rate of 9.628 per 100,000 due to road traffic accidents, ranking highest within the metropolitan area [8].

Furthermore, air pollution poses a significant public health risk. In 2019, the average concentration of PM2.5 exceeded 160 micrograms per cubic meter, while PM10 levels surpassed 141 micrograms per cubic meter, both of which exceed thresholds known to adversely impact human health [9], [10]. Compounding these issues, the widespread burning of waste and agricultural fields, particularly in preparation for rice cultivation, has further deteriorated air quality and exacerbated health concerns among residents [11].

To address these multifaceted challenges and strategically prepare for future development, Pathum Thani

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Province must implement integrated solutions for sustainable urban mobility [12], [13]. When considering the expansion of the Dark Red Line mass transit system, significant gaps remain in local accessibility, particularly in key areas such as Rangsit Market and Rattanakosin 200 Village, where high traffic volumes coincide with the availability of mass transit services. Notably, the absence of an integrated feeder system has resulted in inadequate connectivity between mass transit stations and major urban activity centers, limiting accessibility to key destinations [14].

The current modes of transport in Pathum Thani Province pose significant challenges for first- and last-mile connectivity within the overall urban transport chain. Issues related to service quality, environmental impact, road safety, and integration with the formal mass transit system further exacerbate mobility inefficiencies [15], [16].

Recognizing the importance of sustainable urban transport, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has designed a framework of ten indicators to evaluate urban transport sustainability [16], [17]. These indicators encompass transport network and system performance, environmental sustainability, social equity, and economic viability, serving as a framework for assessing urban mobility and guiding evidence-based policymaking [18], [19].

By leveraging this analytical tool, stakeholders can foster informed discussions and advance strategies aimed at enhancing urban accessibility, promoting sustainable transport solutions, and ensuring high-quality mobility services. These efforts are particularly crucial in suburban areas such as Pathum Thani Province, where improving transport integration and multimodal connectivity remains essential for sustainable urban development.

2. URBAN MOBILITY IN PATHUMTHANI PROVINCE

Pathum Thani, north of Bangkok, Thailand's capital, is administratively divided into seven districts: Mueang Pathum Thani, Thanyaburi, Khlong Luang, Lat Lum Kaeo, Lam Luk Ka, Nong Suea, and Sam Khok. As of the latest records, the province encompasses a total area of 1,526 square kilometers (Fig. 1). According to the Local Development Plan of Pathum Thani Province (2018–2022), the current population stands at 1,146,092 inhabitants. The spatial distribution of built-up areas by the Office of Public Works and Town Planning, Pathum Thani (2020) by using heatmap (Kernel Density Estimation) functions (Fig. 2). The ratio of urbanized land to the total provincial area exceeds 42.30%, reflecting substantial urban expansion. Moreover, Pathum Thani exhibits the highest immigration rate (+2.24) within the metropolitan region surrounding Bangkok, highlighting its role as a key destination for urban migration and regional growth [20]. Pathum Thani Province is currently experiencing rapid urban expansion, transforming its role from a predominantly agricultural society into a major residential and economic hub [3], [4]. However, this urbanization has also led to significant traffic congestion, particularly during morning and evening peak hours [21]. The primary cause of this congestion is the heavy dependence on private vehicles, with car registrations increasing by approximately 2% annually [22]. Pathum Thani features a transportation hub that enhances connectivity within and beyond its economic center. Integrated with mass transit system of the Dark Red Line, it provides direct access to Bangkok while also connecting to the paratransit network serving local areas Additionally, the province benefits from bus networks operating along major corridors, providing essential connectivity to key urban nodes (Fig. 3).

However, it was found that over 70% of residents opt for private cars due to the inefficiencies of public transportation, which often requires more than three modal transfers and significantly increases overall travel time [3], [12].

To address these challenges, this study conducts a comparative analysis of mobility patterns across different districts in Pathum Thani Province, as outlined in Table 1, which presents the fundamental characteristics of each area. Furthermore, the study evaluates the sustainability of the existing transportation network to inform the development of an integrated mobility network. This approach aims to provide viable travel alternatives, minimize unnecessary modal shifts, alleviate traffic congestion, and promote public transport usage as a sustainable urban mobility solution in the province [23].

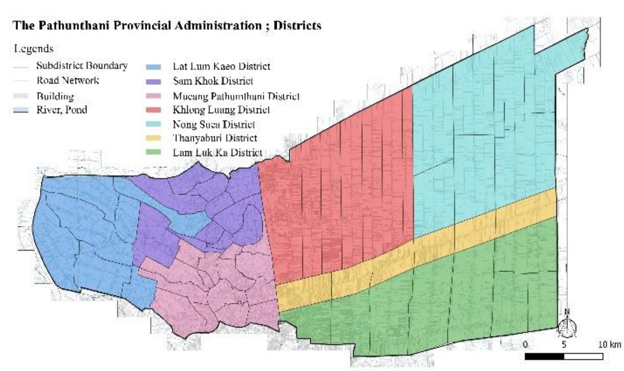

Fig. 1. The Pathumthani Provincial Administration; Districts Area and Boundary.

This study evaluates urban mobility in the suburban areas of Pathum Thani Province using the Sustainable Urban Transport Index (SUTI) framework. It integrates insights into successful urban mobility strategies in various cities, offering valuable lessons for local planning, policy discussions, and evidence-based decision-making in suburban settings.

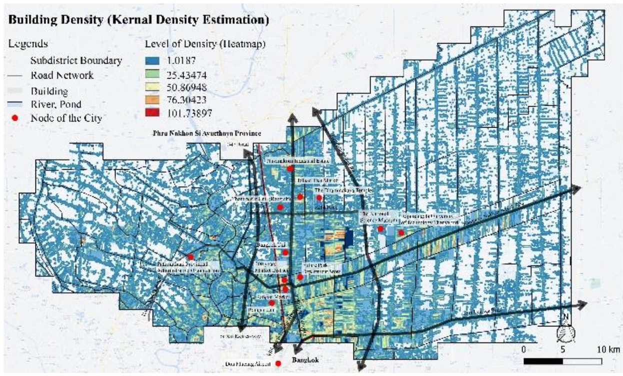

Fig. 2. Building Density by Heatmap (Kernal Density Estimation) Function.

The SUTI framework, developed by UNESCAP, serves as a standardized tool for evaluating urban transport sustainability and is designed for broader utilization across cities in Asia [17]. An extensive set of candidate indicators was initially compiled through reviews and then assessed based on two key criteria: relevance to sustainable transport and methodological reliability [24].

For the analytical process, indicators are normalized linearly on a scale of 1 to 100., as represented in Equation (1). This normalization process ensures comparability across indicators by standardizing values within a consistent range.

$$z_{i,c} = \frac{(x_{i,c})-(x_{min,i})}{(x_{max,i})-(x_{min,i})} \times 100 \quad (1)$$

where,

Z is the normalized indicator of x for issue i and city c;

X_{min} is the minimum actual value for each indicator, whereas X_{max} presents the maximum value;

SUTI is obtained through geometric aggregation as depicted in the equation (2).

$$SUTI = \sqrt[10]{i1 * i2 * i3 \ldots .* i10} \quad (2)$$

Pathum Thani Province was selected as the study area for data gathering, analysis, and the preparation of an assessment report on suburban transport. To enable comparative analysis across suburban areas, a standardized data collection approach was adopted. Data was gathered following established guidelines and recorded using an calculation sheet of excel by using SUTI tool to analyzing, monitoring, and evaluation [18], [19]. Indicator data collection and compilation adhered to these guidelines, with details outlined as follows [19].

- *Indicator 1*: coverage of transport plans, including public transit, intermodal infrastructures and active mobility facilities,
- *Indicator 2*: mode sharing of active mobility and public transport,
- *Indicator 3:* accessibility to public transport services,
- *Indicator 4*: reliability and quality of public transport,

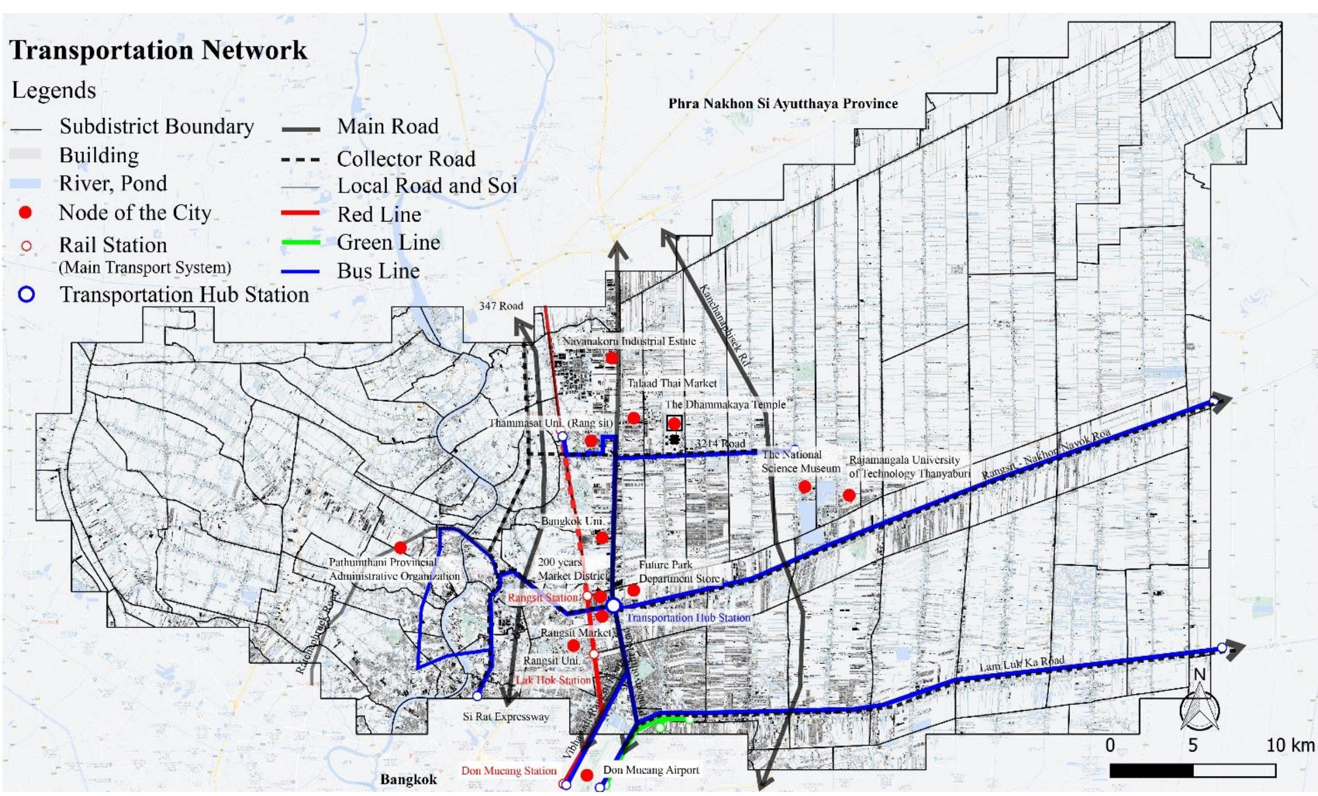

Fig. 3. Transportation Network, Pathumthani Province.

- *Indicator 5:* number of fatalities per 100,000 inhabitants in road traffic,
- *Indicator 6*: affordability – traveling costs as part of income,
- *Indicator 7*: operational costs of the public transport system,
- *Indicator 8*: investment in public transport systems,
- *Indicator 9*: air quality in city (PM 10) and
- *Indicator 10*: transport-related greenhouse gas (GHG) emissions.

The analysis details are presented in Table 2. The set of indicators are measured to offer a simplified and user-friendly framework for comparing suburban areas and measuring urban mobility sustainability. This approach enables informed decision-making, guiding efforts to improve indicators with low normalized scores. Local governments and relevant authorities can efficiently collect and compile data for the set of indicators with normalization facilitated by an Excel-based tool. Ultimately, periodic assessments allow authorities to track progress over time, evaluating the impact of policies and interventions on urban mobility sustainability in suburban contexts.

3. RESEARCH METHODOLOGY AND ANALYSIS

The data collection for this study was primarily derived from primary sources, enabling the analysis of most indicators. A total of 1,000 datasets were collected from Pathum Thani residents, focusing on behaviour and preferences related to sustainable mobility in suburban areas. The questionnaire was structured into three sections: Personal characteristics (socioeconomic factors), Travel behaviours and Preferences for sustainable mobility options in a suburban context. Responses were evaluated on the basis of a six-point Likert scale ranging from 1 (strongly disagree) to 6 (totally agree). Data for Indicator 4 was obtained from the questionnaire survey, while data for Indicators 5, 8, 9, and 10 was sourced from the Office of Transport and Traffic Policy and Planning and the Pollution Control Department, Thailand. Table 3 and Table 4 present the actual input data as well as the normalized values for different indicators across diverse areas. Table 5 displays the calculated SUTI values for each district in Pathum Thani, where a higher SUTI score indicates better overall urban mobility performance.

Table 1 Basic Characteristics of the Seven Districts

Details	Districts						
	Lat Lum Kaeo	Sam Khok	Mueang Pathumthani	Khlong Luang	Nong Suea	Thanyaburi	Lam Luk Ka
Size (km^2)	183.12	94.967	125.151	299.152	413.632	112.124	297.71
Population (Person)	69,300	55,822	211,230	288,751	54,708	212,181	284,419
Average Density (inh./km^2)	378.44	587.80	1,687.80	965.23	132.26	1,892.38	955.36

Table 2. Metrics for Sustainable Urban Transport Index

No.	Indicators	Natural Units	Weights	Normalization	
				Min.	Max.
1.	Coverage of transport plans: Inclusion of public transit, intermodal infrastructure, and active mobility facilities	0–16 scale	0.1	0	16
2.	Mode share: Proportion of active mobility and public transport	Percent of trips	0.1	10	90
3.	Accessibility: Convenient access to public transport services	Percent of the population	0.1	20	100
4.	Public transport performance: reliability and quality of services	Percent satisfied with service	0.1	20	95
5.	Road safety: Fatalities per 100,000 population in road traffic	Number of fatal accidents	0.1	35	0
6.	Affordability: Traveling costs as a proportion of household income	Percent of income	0.1	35	3.5
7.	Investment: Funding allocation for public transit development	Cost recovery ratio	0.1	22	100
8.	Investment in public transport network and systems	Percent of total investment in transport	0.1	0	50
9.	Environmental impact: Urban air quality (PM10)	μg/m3	0.1	150	10
10.	Emissions: Transport GHG emissions (CO)	Tons per capita per year	0.1	2.75	0
	Total		1.0		

Source: [17]; [16]; [24]

Table 3 Measured Input Data of 10 Indicators

No.	Indicators	Lat Lum Kaeo	Sam Khok	Mueang Pathumthani	Khlong Luang	Nong Suea	Thanya-buri	Lam Luk Ka
Actual values								
1	Coverage of transport plans: Inclusion of public transit, intermodal infrastructure, and active mobility facilities	8.00	10.00	12.00	5.27	12.21	9.04	6.31
2	Mode share: Proportion of active mobility and public transport	54.28	56.00	40.00	41.11	31.10	60.32	49.65
3	Accessibility: Convenient access to public transport services	36.08	30.00	45.00	51.94	39.92	64.35	54.32
4	Public transport performance: reliability and quality of services	38.36	30.00	30.00	50.32	40.32	50.33	49.34
5	Road safety: Fatalities per 100,000 population in road traffic	17.32	15.00	30.00	33.22	10.11	33.58	34.09
6	Affordability: Traveling costs as a proportion of household income	11.01	20.00	10.00	15.00	25.00	20.00	20.98
7	Investment: Funding allocation for public transit development	51.92	60.00	50.00	54.32	26.75	26.75	25.54
8	Investment in public transport network and systems	8.45	10.00	30.00	20.54	19.35	30.86	30.22
9	Environmental impact: Urban air quality (PM10)	118.00	61.00	61.00	128.00	68.00	145.00	143.00
10	Emissions: Transport GHG emissions (CO)	1.77	0.60	1.50	2.00	1.11	1.01	1.15

Table 4 Normalized Input Data of 10 Indicators

No.	Indicators	Lat Lum Kaeo	Sam Khok	Mueang Pathumthani	Khlong Luang	Nong Suea	Thanya-buri	Lam Luk Ka
Normalized values								
1	Coverage of transport plans: Inclusion of public transit, intermodal infrastructure, and active mobility facilities	50.00	62.50	75.00	32.94	76.31	56.50	39.44
2	Mode share: Proportion of active mobility and public transport	55.35	57.50	37.50	38.89	26.38	62.90	49.56
3	Accessibility: Convenient access to public transport services	20.09	12.50	31.25	39.93	24.90	55.44	42.90
4	Public transport performance: reliability and quality of services	24.48	13.33	13.33	40.43	27.09	40.44	39.12
5	Road safety: Fatalities per 100,000 population in road traffic	50.53	57.14	14.29	5.09	71.11	4.06	2.60
6	Affordability: Traveling costs as a proportion of household income	76.16	47.62	79.37	63.49	31.75	47.62	44.51
7	Investment: Funding allocation for public transit development	38.35	48.72	35.90	41.44	6.09	6.09	4.54
8	Investment in public transport network and systems	16.90	20.00	60.00	41.08	38.70	61.72	60.44
9	Environmental impact: Urban air quality (PM10)	22.86	63.57	63.57	15.71	58.57	3.57	5.00
10	Emissions: Transport GHG emissions (CO)	35.65	78.18	45.45	27.27	59.64	63.27	58.18

Table 5. SUTI Value for the Districts in Pathumthani

No.	Districts	SUTI
1	Lat Lum Kaeo	35.0110
2	Sam Khok	38.8797
3	Mueang Pathumthani	39.0613
4	Khlong Luang	29.4274
5	Nong Suea	34.6897
6	Thanyaburi	25.8012
7	Lam Luk Ka	22.2911

3.1 Lat Lum Kaeo District

The analysis results, shown in Fig. 4, indicate that Lat Lum Kaeo District achieved an aggregate SUTI score of 35.10. The district scored highest in Affordability in terms of traveling costs as part of income (Indicator 6) and showed moderate performance in Mode share (active mobility and public transit) (Indicator 2), Traffic fatalities (Indicator 5), and Transport plans (Indicator 1). However, Public transport reliability and quality (Indicator 4), Air quality (Indicator 9), and Access to public transport (Indicator 3) received low scores, with the lowest recorded in the Indicator 8 (Investment in public transport systems).

Most of land use in Lat Lum Kaeo is used for agriculture and industries along the collector road and relies on personal motorcycles to commute for working and living nearby.

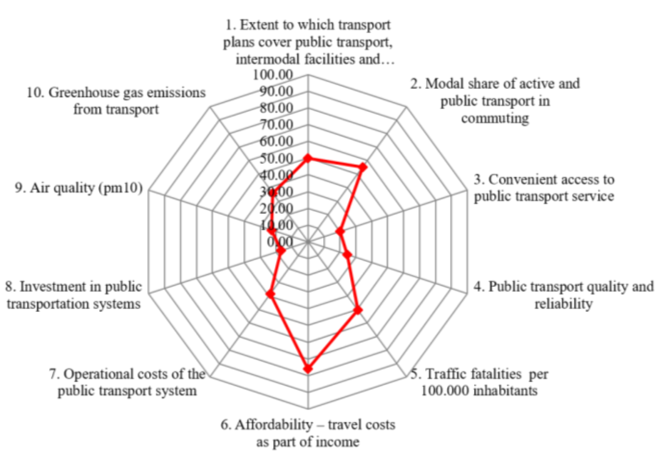

Fig. 4. SUTI for Lat Lum Kaeo District.

Access to public transport systems is only semi-public systems available such as minibuses and vans, etc. Therefore, there is a low accessibility system and low investment in public transport option.

3.2 Sam Khok District

Sam Khok District achieved an aggregate SUTI score of 38.87, as shown in Fig. 5. It shows the highest level of score in transport GHG emissions (Indicator 10) and performed well in Air quality (Indicator 9), Transport plans (Indicator 1), and Mode sharing of public transport and active mobility (Indicator 2). However, Investment in public transport of Indicator 8) and Public transport quality and reliability of Indicator 4 received low scores, with Accessibility to public transport services (Indicator 3) ranking the lowest.

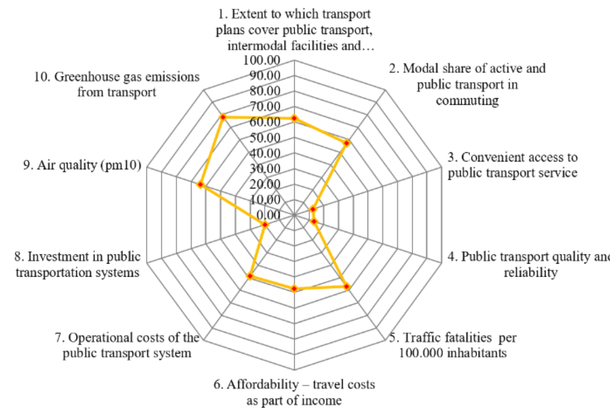

Fig. 5. SUTI for Sam Khok District.

As well as land use in the Lat Lum Kaeo area, Sam Khok district is used for agriculture and commerce along the secondary road near the provincial government center and adjacent to the waterfront area. Therefore, residents' way of life is living along the waterfront and traveling by relying on their personal cars.

3.3 Mueang Pathumthani District

Mueang Pathum Thani District achieved an aggregate SUTI score of 39.06, as illustrated in Fig. 6. It scored highest on Affordability of traveling costs as part of income (*Indicator 6*). The district also scored well in Transport plans cover public transport (*Indicator 1*), Air quality (*Indicator 9*) and Investment in public transport systems (*Indicator 8*). Access to public transport service (*Indicator 3*) and Traffic fatalities (*Indicator 5*) have low score. The lowest score is in Public transport reliability and quality' (*Indicator 4*).

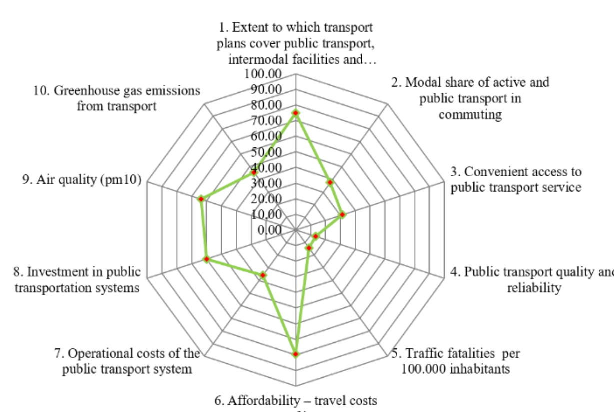

Fig. 6. SUTI for Mueang Pathumthani District.

Mueang Pathum Thani district is the government center of the area, including provincial offices, provincial administrative organizations, and related administrative organizations. It is also an area connected to Bangkok as a vicinity province, thus it has a high urban character and a transportation network covering the area. The urbanization along the highway is also due to local plans to support the expansion of the main road of urban areas and the collector road surrounded by allocation of commercial buildings that support walking and public transport for greater accessibility. On the other hand, due to the location of an industrial estate with many trucks roaming, therefore, the high rate of accidents and deaths is a major problem in the area and needs to be addressed in order to enhance the sustainability of the transportation networks and system.

3.4 Khlong Luang District

The analysis results, shown in Fig. 7, indicate that Khlong Luang District achieved an aggregate SUTI score of 29.42. The district scored highest in Affordability in terms of traveling costs as part of commuters' income (Indicator 6) and performed well in Operational costs of public transport (Indicator 7), Investment in public transport (Indicator 8), and Public transport reliability and quality (Indicator 4). However, Transportation plans (Indicator 1), Modal share of active mobility and public transport (Indicator 2), and Transport GHG emissions (Indicator 10) received low scores, with Air quality (Indicator 9) ranking the lowest.

Khlong Luang District is destination of university and a science park with many workers and students in the study area and the location of the Nava Nakorn Industrial Estate with more than 50 factories and the Thai market as a centre of fruits and vegetable distribution. Therefore, this location presents as a hub of freight transports throughout Thailand which has high traffic congestion and a high risk of accidents.

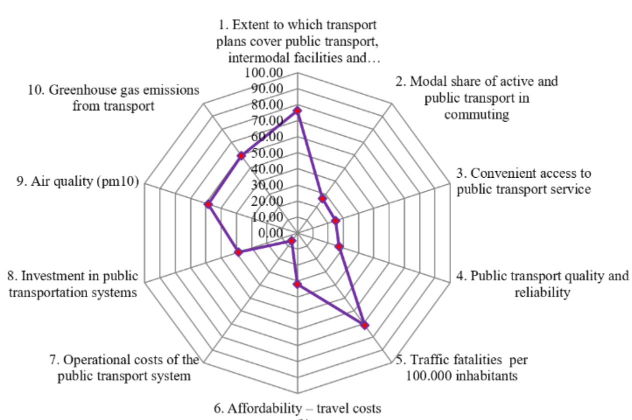

Fig. 7. SUTI for Khlong Luang District.

3.5 Nong Suea District

The analysis results, shown in Fig. 8, indicate that Nong Suea District achieved an aggregate SUTI score of 34.68. The district scored highest in Transport plans (Indicator 1) and performed well in the number of fatalities of road traffic (Indicator 5), Transport GHG emissions (Indicator 10), and Air quality (Indicator 9). However, Public transport reliability and quality (Indicator 4), Mode sharing of active and public transport (Indicator 2), and Accessibility of public transport (Indicator 3) received low scores, with the minimum score recorded in Operational costs of the public transport system (Indicator 7). Nong Suea District is primarily agricultural, with development concentrated along collector roads. Residents predominantly rely on personal motorcycles for commuting and have limited access to public transport, which consists mainly of semi-public services such as minibuses and vans. Consequently, the district exhibits low accessibility, minimal traffic fatalities, and adequate infrastructure for active mobility.

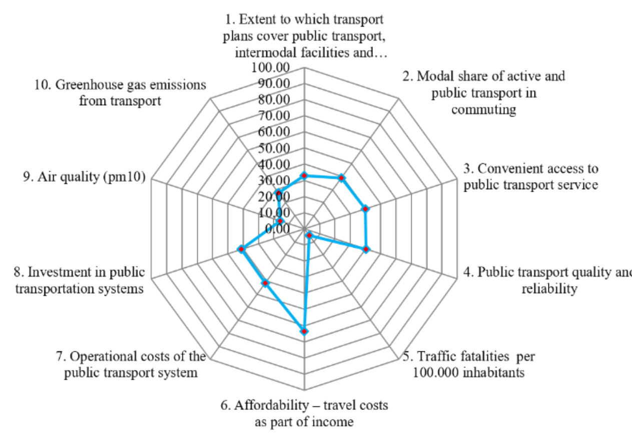

Fig. 8. SUTI for Nong Suea District.

3.6 Thanyaburi District

The analysis results as shown in Fig. 9, indicate that Thanyaburi District achieved an aggregate SUTI score of 25.80. The district scored maximum in Transport GHG emissions (Indicator 10) and performed well in Mode sharing of public transport and active mobility (Indicator 2), Investment in public transport (Indicator 8), and Transport plans (Indicator 1). However, Public transport reliability and quality (Indicator 4), Operational costs of the public transport network and system (Indicator 7), and Traffic fatalities (Indicator 5) received low scores, with Air quality (Indicator 9) ranking the lowest.

3.7 Lam Luk Ka District

The analysis results, shown in Fig. 10, indicate that Lam Luk Ka District achieved an aggregate SUTI score of 22.29. The district scored highest in Investment in public transport network and systems (Indicator 8) and performed well in Transport GHG emissions (Indicator 10), Modal share of active mobility and public transport (Indicator 2), and Affordability – travel costs as part of income (Indicator 6). However, Air quality (Indicator 9) as well as Operational costs of the public transport networks and system (Indicator 7) received low scores, with Traffic fatalities (Indicator 5) ranking the lowest.

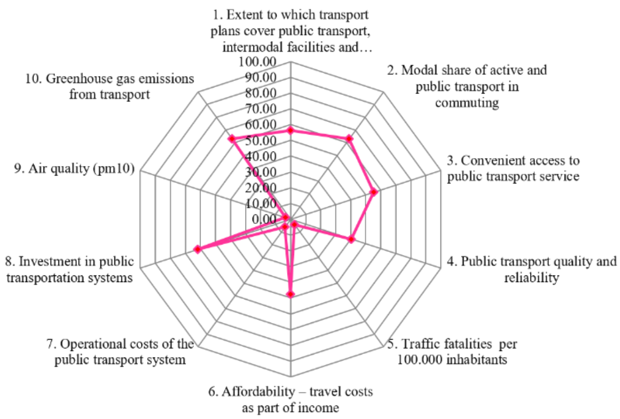

Fig. 9. SUTI for Thanyaburi District.

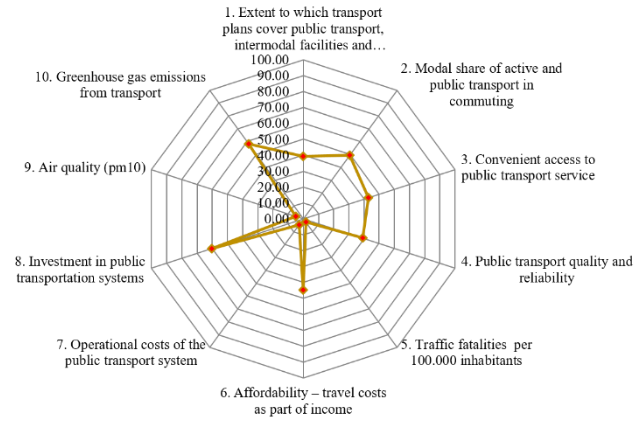

Fig.10. SUTI for Lam Luk Ka District.

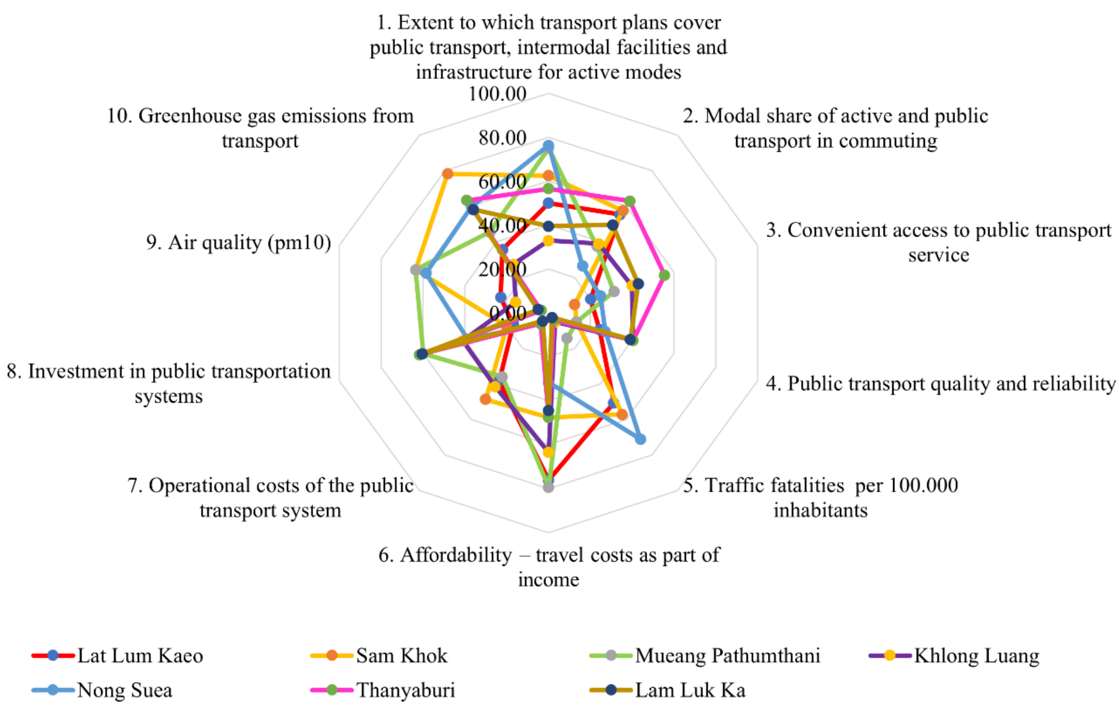

Fig. 11. Compare Overall Districts SUTI.

4. CONCLUSION

The sustainability assessment of Pathum Thani's transportation system identified key factors influencing its development: Number of fatalities in road traffic (Indicator 5), Air quality (PM10) (Indicator 9), and Public transport reliability and quality (Indicator 4), particularly in Khlong Luang and Lam Luk Ka Districts. While the overall index was low, central and riverside areas performed better due to community-oriented travel behaviors. This study recommends using the index results to formulate policy strategies that promote public transportation and traffic management systems aimed at reducing private vehicle dependency and GHG emissions (CO). The indicator set and index demonstrate a valuable tool for city-specific assessments, enabling authorities to gather data for ten urban transport indicators and conduct periodic sustainability evaluations using the Excel-based SUTI tool. The findings support evidence-based policymaking to enhance urban mobility and contribute to achieving SDG Target 11.2 on sustainable transportation (Fig. 11).

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