Identifying Suitable Indicators to Assess Chiang Mai as a Sustainable City Using Delphi Method

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Abstract

Chiang Mai is facing enormous challenges, such as climate change, economic and social problems which make the government, the private, and public sectors to tackle the problems and develop the city towards sustainability. This research aims to identify suitable indicators to assess the potential of Chiang Mai as sustainable city. Chiang Mai City Development Plan, Chiang Mai Smart City Strategy Plan 2019, the Master Plan for Development of Chiang Mai Transportation System, Bio-Circular-Green Economic Model (BCG), Transit-oriented development (TOD) and Sustainable Development Goals (SDGs) are considered and used to formulate related indicators that will be assessed for suitability by at least 20 experts using Delphi method. The level of importance is assessed using a five-point Likert-type scale. Average value and standard deviation calculations are conducted to confirm the significance of the indicators chosen. In this work, the focus is on the 1st round of Delphi method questionnaire to identify appropriate indicators to assess the sustainability of Chiang Mai city. From the first Delphi method, 29 out of initial 64 indicators were selected by the experts. 25 additional indicators were also proposed by the experts. A total of 54 indicators were to be used in subsequent 2nd and 3rd rounds of questionnaire by the Delphi method. The indicators obtained from this research may be used to assess the sustainability potential of other cities. The metrics found may be unique for Chiang Mai and differ from other cities in previous studies. They can be applied to assess the potential of Chiang Mai's sustainable urbanization, and used as a conceptual framework for planning Chiang Mai city development towards sustainability.

Keywords: 1) Sustainability 2) Sustainable city 3) Transit-oriented development 4) Urban planning

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Introduction

Nowadays, many large cities have a huge impact around the world. Globally, 67-76 percent of the global population consumes large amount of energy, and 71-76 percent of this consumption is pre-polluted by carbon dioxide (Athanassiadis, et al., 2018, pp. 112-123), (Hu, Wei and Chang, 2022 p. 1). Meanwhile, the global population is projected to reach 6.5 billion by 2050 (Hanberry, 2022, p. 1), (Chan and Lee, 2019, p. 2). This put stress on limited resources, while the societies and the economy are also affected in terms of reduced gross domestic product (GDP), human living conditions, habitat, etc. Therefore, creating a clear plan for urban development is essential to achieve sustainability (Feleki, Vlachokostas and Moussiopoulos, 2018, pp. 563-577). In terms of economy, environment, and social activities to drive the city growth efficiently, new development guidelines and strategic planning are emerged, affecting all aspects of urban relations. Especially, the proper and consistent use of technology will provide a driving force for quality, and responding to the growth and development of the city as well (Excellence Center in Infrastructure Technology and Transportation Engineering, 2017, pp. 31-661).

Current urban development is a concern for many researchers because developing countries are experiencing rapid urbanization processes. This is mainly due to the fact that migration of the population from rural areas to urban areas is increasing. Difficulties in rapid immigration are also a daunting problem in developing countries, resulting in an inadequate infrastructure and facilities to keep pace with rapid urbanization (Athanassiadis, et al., 2018, pp. 112-123). City Sustainability Index and the metric system have been used as a tool for characterizing the sustainability of cities. They have been studied in previous research. The indicators from these previous studies has been adopted and used to assess the potential of Chiang Mai city according to the framework studied (Pongruengkiat, et al., 2022, pp. 2-8).

Chiang Mai, according to the Department of Public Works and Town & Country Planning (Strategy and Information for The Chiang Mai Provincial Development Unit, 2019, pp. 1-56), is a city that have potential in many dimensions including economic, social well-being, and green environment. For example, in terms of economic, Chiang Mai has tendency of increased economic by the result of income from tourism especially from hotels and restaurants, education, and health services. The city has beautiful landscapes, unique culture and tradition of Lanna (northern Thai heritage). Additionally, this city has diverse forms of tourism, many restaurants, boutique hotels and famous resorts and homestays. Therefore, it is the main attraction for both domestic and foreign tourists that making Chiang Mai a major tourist destination of the world.

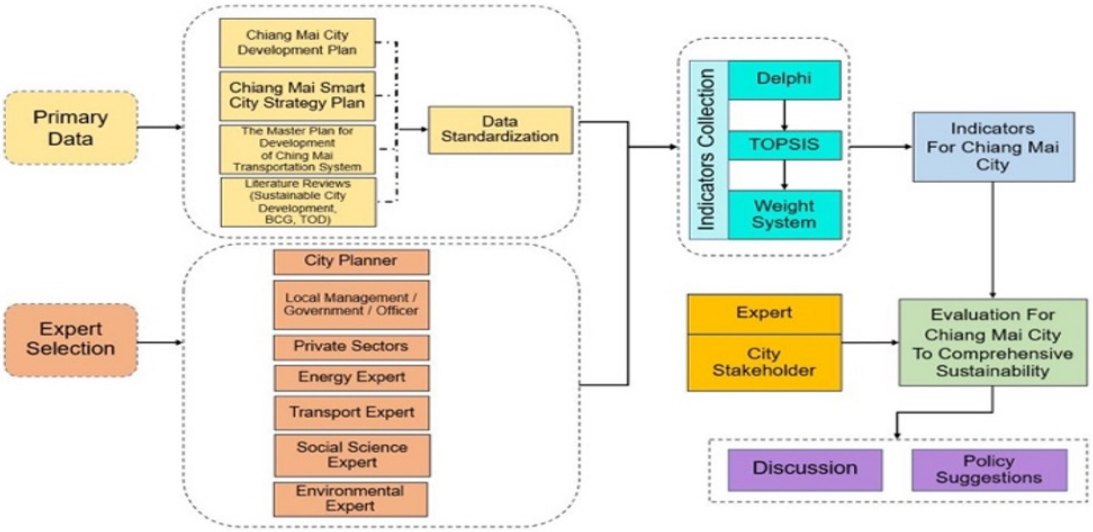

Figure 1 Framework research (Modified from Chan and Lee, p. 22)

Chiang Mai is a city with great potential covering all aspects of economy, society and environment. However, if Chiang Mai city lacks good urban planning, it may lead to in city development that deems unsustainable. Therefore, this research focuses on finding indicators to assess the potential of a sustainable city for Chiang Mai. The indicators selected for this research were from Chiang Mai City Development Plan, Chiang Mai Smart City Strategy Plan 2019, The Master Plan for Development of Chiang Mai Transportation System, BCG, TOD and SDG concepts. These selected indicators are prioritized by experts in their respective fields and analyzed by the Delphi method. In this study, Delphi Round 1 was utilized to identify indicators suitable for the Chiang Mai context, with the input of experts from various fields. Delphi Rounds 2 and 3 will be carried out in subsequent studies.

Literature Review

The pursuit of sustainability in urban environments has become a paramount concern as cities face unprecedented challenges related to population growth, resource depletion, climate change, and social inequalities. To effectively assess and enhance urban sustainability, researchers and policymakers have increasingly turned to indicators and expert consensus methods like the Delphi method. In 2019, Chan and Lee employed the Delphi method to evaluate Cambodia's progress in sustainable development. Their research revealed that Cambodia demonstrates a clear commitment to sustainable and green development through its national strategies, the establishment of key councils, and the initiation of urban development programs. Nevertheless, there is a pressing need to address the gaps in sustainable city indicators and assess their alignment with the UN SDG 11 framework. Additional research is necessary to determine the suitability and effectiveness of these indicators in promoting sustainable development at both the local and national levels in Cambodia (Chan and Lee, 2019, p. 20). In 2022, Li, Taeihagh and Tan stated that

the emergence of smart city initiatives has become a pivotal strategy for addressing the complex challenges faced by modern urban environments. These initiatives represent a convergence of technology, human capital, and governance practices aimed at creating sustainable, efficient, and livable urban spaces. The concept of a smart city encompasses not only technological innovation and deployment but also the cultivation of smart people and the implementation of effective policies. While smart city solutions often involve the integration of cutting-edge technologies, it is equally essential for cities to draw on knowledge and governance lessons from other jurisdictions to tailor initiatives to their unique local contexts. This literature review examines the factors that facilitate policy transfer among smart cities, drawing insights from expert opinions and surveys conducted on an e-Delphi platform. In an era where urbanization and technological advancements are reshaping the landscape of cities, the effective transfer of policies and knowledge is crucial for the success of smart city initiatives. This literature review highlights six key factors that facilitate policy transfer and offers three policy recommendations to accelerate the adoption of smart city solutions. By embracing policy entrepreneurship, financial instruments, policy learning, capacity building, explicit regulatory mechanisms, and policy adaptation, cities can navigate the uncertainties and challenges of smart city development and work collaboratively to build more sustainable and livable urban environments (Li, Taeihagh and Tan, 2022, p. 7).

Methods

Method and Framework

Multi-criteria decision analysis (MCDA) is part of operation research that assesses multiple conflicting criteria in decision making. The MCDA is a method that help decision-making with a multi-part assessment aims to find a clear method of answering questions (Chan and Lee, 2019, p. 12). Nowadays, there are many methods to solving decision-making problems, and each method has different accuracy. To find and select the methods of analysis that depending on situation and criteria of the problem. According to previously studies, it was found that MCDA techniques are popularly used for qualitative assessment. Generally, MCDA techniques commonly used with other method such as Delphi method (Chen and Zhang, 2021, pp. 18-19). It was found that Delphi techniques plays a role in prioritizing. It has unique characteristics. Firstly, its developed issues do not need improvement, such as the criteria and indicators (Meesil, 2016, pp. 1256-1267; Musa, et al., 2015, pp. 244-249). Figure 2 shows the research sequence. Starting from collecting preliminary data from Chiang Mai City Development Plan, Chiang Mai Smart City Strategy Plan 2019, The Master Plan for Development of Chiang Mai Transportation System, BCG, TOD and SDGs, experts in various fields were then invited to complete the Delphi survey and prioritize the indicators that affect sustainable urbanization.

Selection of Indicator, Data Collection, and Classification

According to previous studies, all indicators from major sources as following: Chiang

Mai City Development Plan, Chiang Mai Smart City Strategy Plan 2019, The Master Plan for Development of Chiang Mai Transportation System, Bio-Circular-Green Economic Model (BCG) (Otwong, Jongmeewasin and Phenrat, 2021, p. 5), Transits city, Transit-oriented development (TOD) (Sung and Oh, 2011, pp. 70-82) and Sustainable Development Goals (SDGs) (Bogers, et al., 2022, p. 3) are reviewed, classified, and selected. They can be grouped into 18 groups and have a total of 64 indicators, as shown in Table 1. These groups of indicators are based on the three pillars of sustainable development.

Table 1 Indicators reviewed, classified and selected

Category	Indicator
Energy	I1 Consumption of electricity per capita
	I2 Consumption of fuel per capita
	I3 The use of renewable energy in Chiang Mai area
	I4 Projects and research on promoting the use of renewable energy
	I5 Energy conservation work
Environment quality	I6 Air quality
	I7 Emissions in transportation
	I8 Water
	I9 Waste
Land use	I10 Population density
	I11 Integrated town plan
	I12 Expansion pattern of city
Transport-ation	I13 Type of transport (public, individual)
	I14 Number of personal vehicles
	I15 Number of public vehicles
	I16 Vehicle usage rate
Health and wellbeing	I17 Number of beds in the hospital
	I18 Number of hospitals and rehab centers through the Ministry of Health
	I19 Number of doctors
	I20 The potential of the hospital
	I21 Sickness rate
	I22 Duration and ease of access to the public health system

Category	Indicator
Health and wellbeing	I23 Population health
	I24 Number of exercise locations and health promotion places
	I25 Average age of the population
Population	I26 Population
	I27 Birth rate
Labor	I28 Unemployment and Employment Rate
	I29 Average income per capita
	I30 level of knowledge and expertise of workers
Housing	I31 Number of residences
	I32 The cost of buying or renting
	I33 Distance/duration to travel for activities
Education	I34 Number of universities, schools, colleges
	I35 Graduation rate from bachelor's degree
	I36 Number of students
	I37 Literacy rate
	I38 The rate of employment in different areas / different areas After graduating at all levels and institutions
Violence	I39 Number of crimes
	I40 Number of police
	I41 Number of Police Stations
	I42 The amount of crime-risk areas (dark areas)
Culture	I43 Number of ethnicities living in Chiang Mai
	I44 Number of festival management
	I45 Number of recreational activities
	I46 Number of traditions
	I47 Income from cultural activities
Convenience	I48 Number of department and convenience stores
	I49 Number of markets
	I50 Number of entertainment businesses
	I51 Number of restaurants
GPP	I52 Total product value in Chiang Mai

Category	Indicator
Creativity	I53 Number of creative courses
	I54 Number of Creative Events and Exhibitions
	I55 Income from Creative events and exhibitions
Innovation	I56 Amount of innovation research
	I57 Income from research and innovation
	I58 Innovation success rate
Trade	I59 Amount of Trade, Amount of Trade Value
	I60 Income for each sector
Tourism	I61 Number of tourists
	I62Tourist spending rate
	I63 Currency exchange rate
Service	I64 Number of service businesses

Questionnaire Development

Delphi's poll process is conducted in three rounds (Chan and Lee, 2019, pp. 4-17). This questionnaire was not done only once and developed at different times, shown in Figure 3. The details are as follows:

Round 1: a validated questionnaire was used and the indicators of sustainable urbanization were selected based on the previously mentioned data. Because sustainable city indicators are complex and numerous, therefore, the researcher has developed a questionnaire divided into 18 categories, with a means for the participants to add information that they consider important to simplify and make it easier to complete the questionnaire of the participants this time.

Round 2: In the second round, the indicators from the first questionnaire will be used to determine the level of importance of these indicators by using the five-point Likert method.

Round 3: A questionnaire in Round 2 will be used to confirm the importance of the indicator. The mean values are to be added to the questionnaire.

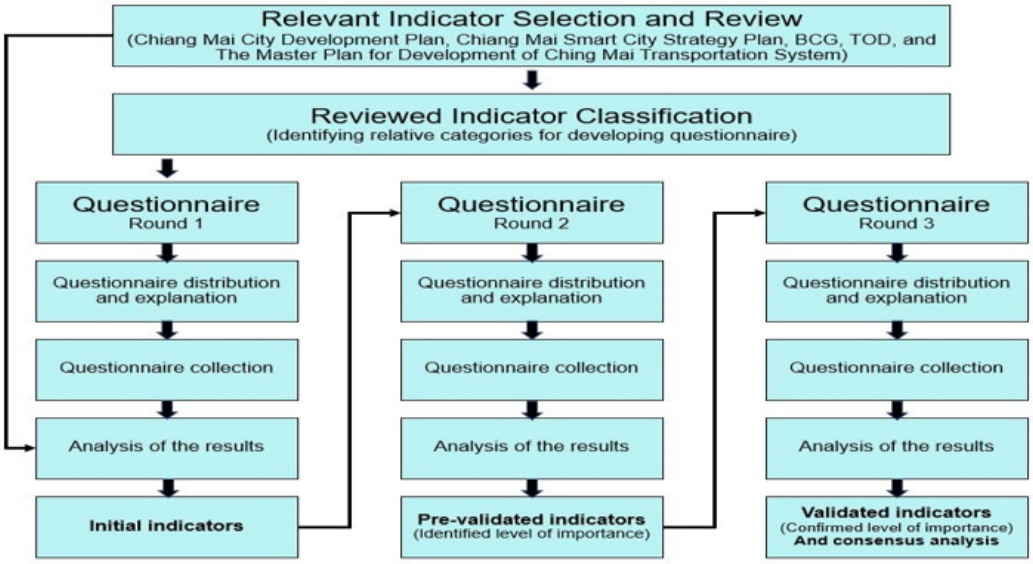

Figure 2 Research flow.

Panelist Selection, Invitation, Participation

Based on previous literature studies, the majority of studies involved 8-16 participants. Therefore, over 20 participants with expertise in various fields related to urban development, transport and logistics, energy technology, economic development and social wellbeing were selected for this study. Each of the selected branches are all related to the sustainability of the city, consisting of city planners, local managers/governmental officers, private sectors, energy experts, transport experts, social science experts and environmental experts by inviting 2-5 experts in each field.

Panel Survey Processes

Before completing the questionnaire, the participants were briefed on the objectives of this research. including the Delphi method of polling, where the lecture focuses on filling out additional questionnaires for the spaces. Participants were asked to identify at least five indicators related to Chiang Mai sustainability, and there were plenty of space for participants to add groups of indicators they saw as relevant and important to being a sustainable city. This method must meet the guidelines of (Chan and Lee, 2019, p. 8), (Sourani and Sohail, 2015, pp. 54-76). In the future research, more work is planned for the next round of questionnaires. In the second round, the questionnaire will be improved from the indicators acquired from the previously round. Then, the significance level of the indicator will be added by a five-point Likert-type scale. The details are as follows: 5. means most important, 4 means very important, 3 means important, 2 means less important and 1 means not important. In the third round, the questionnaire will be improved from the second round of questionnaires. In these circumstances, the mean values will be added to verify the priority level of the indicators that are identified.

Analysing Consensus and Investigation

Ultimately, the final decision will be made in Round 3 to confirm the level of impor-

tance of the indicators. Therefore, in this study, consensus analysis was taken from Round 3 of a similar study (Chan and Lee, 2019, p. 9). The results of identifying the level of importance of indicators considered consensus were that more than 83% of the responses voted on the pointers that were classified as the most important, very important and important. Sourani and M. Sohail (Sourani and Sohail, 2015, pp. 54-76) suggested the percentage of responds of the questionnaire agreed on the criterion rankings. On the 5-point Likert category, consensus may be determined based on 75% or more of the respondents agreeing on a given rank equal to or above 3.00. Consequently, this research determined the consensus based on the importance of a voted indicator equal to or higher than 3.00 and the percentage of panelists who agreed on an indicator with the rating of 3 to 5. Over 75% of the accredited indicators that achieved this consensus will be selected as the Sustainability City Indicator for Chiang Mai.

The consensus sustainable city indicator is also from audits and agreements, which is appropriate for the urban context of Chiang Mai for sustainable urban development.

Results

From the result of the first round of questionnaire using the Delphi method, one additional group of indicators was recommended by the experts. It was about Facility indicator. There were also 25 more indicators from the opinions of the experts to assess Chiang Mai's potential as a sustainable city, additional to the initial 64 indicators. It can be said that from the Delphi Round 1, a total of 19 groups and 89 indicators were obtained.

Based on the results of the first round Delphi, the indicators from Table 1 that the experts gave more than 75% of importance were I1, I3, I6, I8, I9, I10, I11, I13, I15, I16, I17, I19, I22, I26, I28, I29, I31, I34, I39, I44, I46, I48, I49, I51, I52, I54, I56, I59 and I61. It means that from the indicators in Table 1, a total of 29 out of 64 indicators were selected by the experts to be used in Rounds 2 and 3 of Delphi method. The indicators that gained less than 75% of the experts' attention will be excluded from the list of indicators used in the subsequent rounds. In addition, the first Delphi study revealed that the experts were also interested in introducing additional indicators that may affect Chiang Mai as a sustainable city. A total of 25 additional indicators was introduced. They are shown in Table 2.

Table 2 Additional indicators recommended by the experts

Category	Indicator
Energy	Proportion of using renewable energy in the organization
Land use	Ratio of green area to total area
	Road area per total area
Transportation	Number of stops and distribution of public transport
	Average travel per capita in different modes is connected to different fuel consumption.
Health and wellbeing	Ratio of the elderly to the population
	Death rate
Population	Latent population
Housing	Residential building type
Education	Proportion of the under-educated population to the educated population
Violence	Area per number of CCTV cameras
Culture	Database-number of local experts/craftsmen/artists
	The number of museums that provide knowledge of the local culture
	Statistics on the number of tourists who come during the festival
Creativity	Number of local creative businesses
Innovation	Number of agencies that support innovation research
	Number of Startup
Tourism	Number of accommodation
	Statistics of foreign tourists and Thai people
	Objectives of foreign tourism
	Number of days of provincial tourism for foreign and Thai tourists
	Number of tourist attractions by type
Service	Service business type
	Service business income per total provincial income
Facility	Utilities consumption rate

Based on the results obtained from the Delphi Round 1 and additional indicators in Table 2, it can be seen that there are 54 indicators to be used for Rounds 2 and 3. They were derived from original indicators with more than 75% of importance (29 indicators) and additional indicators introduced by the experts (25 indicators). The indicators identified in this study will serve as the initial set of indicators in the second and third rounds of the Delphi method in future research. This will aid in the quest to discover and employ suitable indicators for assessing Chiang Mai's potential for sustainability.

The benefits derived from this research include the establishment of a systematic approach for evaluating Delphi method indicators when applied to urban development, as well as the creation of a valuable reference source. This is especially significant because, in the past, city assessments in various regions lacked a systematic foundation for their indicators. Furthermore, the methodology employed in this research can be extended to develop indicators tailored to other urban contexts. Additionally, this research engaged experts who provided their insights and suggested indicators suitable for Chiang Mai as a sustainable city. Notably, the experts actively contributed by proposing additional indicators beyond the initial 25, indicating their high level of involvement and commitment to this research. This underscores the experts' recognition of the research's societal relevance and potential benefits for the broader community.

Conclusion and Discussion

In this work, the indicators that may affect the sustainability of Chiang Mai were studied. Data was gathered from various sources as a basic information to create a query according to the Delphi method. They consisted of data from Chiang Mai City Development Plan, Chiang Mai Smart City Strategy Plan 2019, The Master Plan for Development of Chiang Mai Transportation System, BCG, Transits city, TOD and SDGs. After the completion of the Delphi method round 1, it was revealed that the experts endorsed 29 appropriate indicators to assess the potential of Chiang Mai as a sustainable city with 25 additional indicators. A new group of indicators was facility. Moreover, the number of indicators that were highly valued by 75% of experts were 29 of initial 64 indicators. The indicators obtained from this study will be further given weighting in rounds 2 and 3 of the Delphi method in the forthcoming studies.

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