Engineering and Applied Science Research
https://www.tci-thaijo.org/index.php/easr/index
Published by the Faculty of Engineering, Khon Kaen University, Thailand

Application of strategic environmental assessment for mass transit system: Case study of Uttaradit Province, Thailand

Pitsanu Pannaracha* and Dondej Tungtakanpoung

Department of Civil Engineering, Faculty of Engineering, Naresuan University, Phitsanulok 65000, Thailand

Received 13 May 2024
Revised 7 June 2024
Accepted 21 June 2024

Abstract

This research aims to apply Strategic Environmental Assessment (SEA) at the strategic action. Plan and program of the mass transit system in Uttaradit province, Thailand. Some steps of SEA process were applied to such strategic action by focusing on the development and assessment of the appropriate alternatives together with the selected appropriate indicators. The alternatives for mass transit development plan were proposed as following; Alternative 1: No Development Plan (or No Action Plan), Alternative 2: Conventional Mass Transit System Development Plan (Conventional Plan), Alternative 3: Smart and Environmentally Friendly Mass Transit Development Plan (Smart plan). With the Pairwise Comparison and the Impact Matrix Analysis, the Smart Plan was assessed as the appropriate alternative when compared with the Conventional Plan and No Action Plan as for 49.36%, 32.17%, and 18.47 % respectively. The mass transit system under the Smart Plan were proposed as Road, Railway, and Road with Railway systems. On the same assessment procedure, the impact score of the Road with Railway, Railway and Road system were 36.64 %, 33.90% and 29.46% respectively. The appropriate alternative mass transit system was road and railway system. SEA was practical tool applied to the strategic level of the mass transit development.

Keywords: SEA, Mass transit system, Indicators, Alternatives, Pairwise comparison, Impact matrix analysis

1. Introduction

Thailand has a high potential on competitiveness to be the connecting network center of transportation/ logistics system, trade economy and tourism, as well as the neighbor countries group to various regions [1]. Enhancement on the potential of the border cities development is therefore important to the socio-economic and culture among neighbor countries of the Asian region [2]. Uttaradit province, Thailand, is one of the provinces housing the permanent border crossing point namely Poo Doo. It has high potential to serve as a central hub for trade, investment, and tourism. Despite Uttaradit province currently having designated strategies for development, plans for infrastructure, and logistics improvement through the main road transportation system, its transportation development remains fragmented and isolated [3]. To accomplish the government's strategic and development plans aimed at positioning Uttaradit province as a key center for production and industry in the Indochina Region, it is necessary to establish mass transit systems for goods and people, creating connections within and outside of the province, connecting Uttaradit to different regions of Thailand as well as neighboring countries. This initiative should also incorporate Transit-Oriented Development (TOD) principles [4]. Inclusive TOD is a necessary foundation for long-term sustainability, equity, shared prosperity, and civil peace in cities [5]. It is therefore necessary to develop the modal integration [6] as well as smart and environmentally friendly transportation [7].

To accomplish sustainability of the mass transit development, Strategic Environmental Assessment, SEA, was introduced to assess for the strategic action defined as policy, plan and program. Policy refers to guidance drawn up by government administrations. Plan refers to a set of coordinated and timed objectives for the implementation of a policy in a particular sector or area. Program is a set of projects in a particular sector or area.

"SEA is the systematic process supporting decision making for planning, based on the balance of economic, social, and environmental aspects" [8]. It also gives an importance on the participation of stakeholders in all relevant sectors. More importantly, SEA involves considering and evaluating developed alternatives to determine the most appropriate one for decision-making [9]. Regarding the mass transit system is considered as sectoral-based [10], SEA is implemented at a strategic action as mentioned above [11]. However, SEA applied for this study was scoped for only plan and program level, not policy level.

SEA has been increasing international recognition as a mean of ensuring environmental impacts being considered in transport policy and plan making. Reviewing that mostly SEA application to the strategic action is designated by the national law, particularly in the European countries. In the Asia region, China is the leading country on SEA application. Some SEA applications are presented as follows. Fischer [12] reported about introduction and testing of a generic SEA framework for transport planning system in the northern and western European countries. The framework was employed for evaluating the existing practice. SEA applied for the strategic action of transportation including: policies; network plans; corridor plans; and programs. The framework could be used to

*Corresponding author.
Email address: pitsanup66@nu.ac.th; pitsanu.panna@gmail.com
doi: 10.14456/easr.2024.48

identify possible core tasks of the European Union TEN-T (Trans-European Transport Network) related corridor-plan SEAs in Germany and England [12].

Application of SEA to the regional land transport strategies (RLTS), according to the New Zealand Transport Strategy and the Land Transport Management Act 2003. Analysis had been undertaken in 2004-2005., suggesting that SEA has the potential to significantly assist improving future planning. SEA tool kit equipped with a range of methods can be used to strengthen RLTS development. To facilitate the understanding and effective use of these methods, the central government could fully support by providing guidance and support for SEA application [13].

In addition, SEA application in China has been performed by the EIA Law in China for environmental impact, which is called as Plan-EIA. SEA implementation has been made to integrate environmental considerations into transport decision-making process. Following the universalization of SEA in recent years, a number of successful case studies had been provided and well-illustrated by scholars and organizations, in order to apply the relevance of the international experience to the development of transport SEA in China. [14].

In accordance with the Directive 2001/42/EC, the European Union (EU) has introduced SEA, aiming to support the implementation of actions in the long run and evaluate the impacts of policy, plans and programs. Development of scenarios analysis as a tool is performed to facilitate strategic thinking in SEA and to support an integrated planning process basing on participation of the main stakeholders. Case studies developed in different contest where scenario methods are tested within SEA process, a cognitive methodological framework is proposed to highlight the role of scenario analysis in each phase of SEA decision-making process from the definition of the main scenarios to the evaluation of the strategic action and the monitoring after the plan implementation [15].

Some research studies in Thailand employed SEA for strategic plan of Special Economic Zone at Chiang Khong, Chiang Rai, and Chiang Saen Chiang Rai. SEA process had been implemented following the SEA Guidelines developed by the Office of Natural Resource and Environmental Policy and Planning [16]. In addition, SEA had applied for various strategic level (plan and program) of the governmental agencies; for example: Industrial Development in Rayong Province watershed management (IWD B.E. 2554-2556) [17]. Watershed Management of the Mun River basins (ONWR.B.E.2562-2564) [18], noting that such SEA studies in Thailand were not the research projects, they had been employed for plan development following the SEA Guideline developed by the Office of National Economic and Social Development Council (NESDC, 2021) [19].

Interestingly, SEA study was introduced as one task of the Study on Roadmap Developing for Intelligent and Environmentally Friendly Transportation of Uttaradit Province. It is intended to demonstrate such transportation planned with appropriate alternative based on the sustainable consideration; equilibrium of economic, social and environment perspectives.

2. Materials and methods

As mentioned above, SEA study presented herein was aimed to prove that the Intelligent and Environmentally Friendly Transportation is appropriate plan for Uttaradit Province. The SEA study had employed SEA Guideline of NESDC 2021, as well as the lesson learned from IWD B.E. 2554-2556 and ONWR B.E. 2562-2565. It would present SEA as practical tool applied for the strategic action of mass transit development plan and program. It is the action research undertaken as follows.

2.1 Scope of study area

Study area covered the area of Uttaradit province, Thailand, where locates at the southmost of the northern region of Thailand, It occupies with the area of 7,854 square kilometers categorized as the twenty fifth rank of the country, consisting of 9 districts; Muang Uttaradit (Sila At Railway Station), Tha Pla, Nam Pat, Fak Tha. Ban Khok (Phu Doo International Point of Entry), Tron, Phichai, Laplae and Thong Saen Kha (Figure 1). The population of Uttaradit Province is 439,629 persons of which the density is 56.08 people/ km^2 [20]. Uttaradit Province is one of the economic corridor's province characterized by its high potential site for development. It is the border province existed with the road network connecting the Eastern Economic Corridor, Thailand, Myanmar and Laos through Luangprabang-Indochina-Mawlamyine Economic Corridor (LIMEC) and Chiang Mai-Vientiane Economic Corridor (CVEC). Phu Doo International Point of Entry plays an important role for transportation and communication, particularly logistics. Whereas the conceptual approach of SEA for mass transit system is shown in Figure 2.

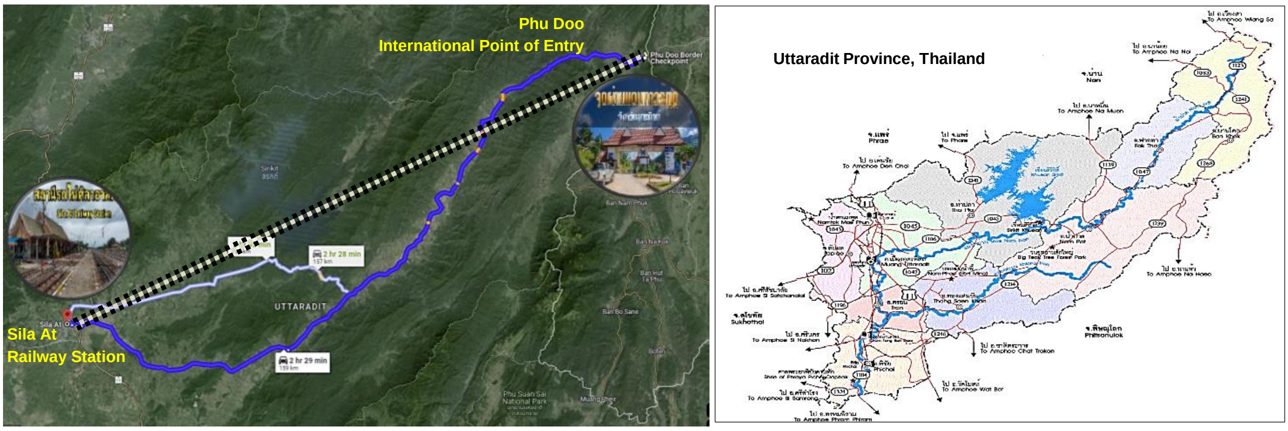

Figure 1 Scope of study area

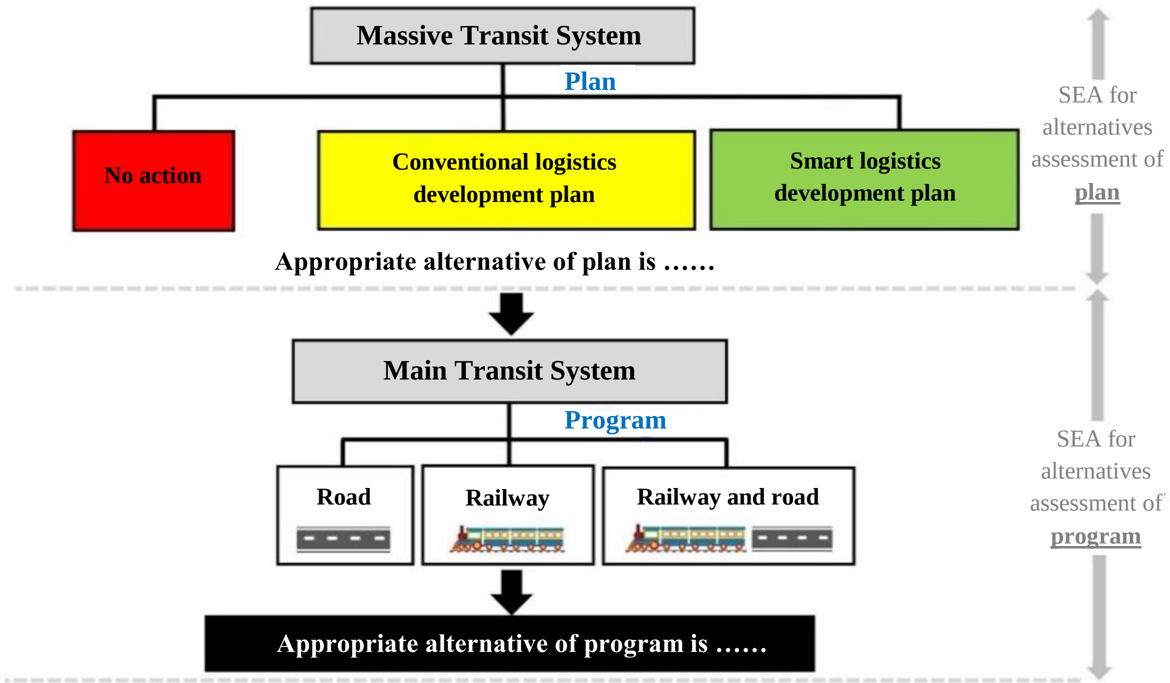

Figure 2 Conceptual approach of SEA for mass transit system

2.2 SEA for mass transit system

This study had applied SEA for strategic action of Uttaradit Provincial Development plan including mass transit system (Plan) and main mass transit system (Program), as already presented above in Figure 2. Such SEA application was primarily scoped for the development and assessment of alternatives in conjunction with the indicators designated under the sustainable development; economic, social and environmental dimensions. The study was categorically performed by the subsequent steps:

1) Designating the feasible alternatives including no development alternative (no action).
2) Designating economic, social, and environmental indicators and weighing of such indicators using pairwise comparison of Multi-Criteria Analysis (MCA) resulting in a weight score.
3) Assessing the impact of feasible alternatives on such indicators, signaling impact level.
4) Assessing the impact score of each alternative on the indicators of each dimension by multiplying the weight score by the impact level.
5) Summing up the impact scores of each dimension, resulting for the alternative with the highest overall score being as the appropriate alternative.

Subsequently, these steps are detailed below.

2.3 SEA for plan (Mass transit development plan)

This step was to assess appropriate alternative for mass transit development plan, described as follows:

1) Designating the feasible alternatives, included following alternatives [21].

- Alternative 1: No Development Plan (No Action Plan), implying that there is none of any plans to be developed for mass transits system, only budget allocated for operation and maintenance of the existing transportation system.

- Alternative 2: Conventional Mass Transit System Development Plan (Conventional Plan), implying that there is the road and mass transit system proposal basing on the project or work used to perform in the past, for example; road expansion, new road construction, etc.

- Alternative 3: Smart and Environmentally Friendly Mass Transit Development Plan: (Smart Plan) meaning that the proposed action (plan and program) employ sustainable development concept.

2) Designating economic, social, and environmental indicators relevant to their respective aspects. This step was performed by reviewing through the desktop study, information taken from the participatory meeting of the relevant agencies [22] as well as brainstorming of the SEA research team (adviser and SEA expert). These indicators were defined and presented in Table 1.

Table 1 Economic, social and environmental indicators

Economic indicators	Social indicators	Environmental indicators
1. Worthiness of investment 2. Contribution to economic growth 3. Potential for income generation	1. Adequacy and accessibility to community, tourism sites, cultural and traditional sites, and public health facilities 2. Safety during travel 3. Impact on traffic flow 4. Improvement of greenery along the road and surrounding areas along the route	1. Air pollution and climate change 2. Noise pollution and vibration 3. Ecosystem preservation (Forestry and wetland) 4. Urban landscape and scenery

3) Assessing the weight score of indicators of each dimension, employed Multi-Criteria Analysis (MCA) by pairwise comparison as explained below.

"Pairwise comparison generally means occurring in pairs or two at a time. Pairwise may also refer to: Pairwise disjoint. Pairwise independence of random variables. Pairwise comparison, the process of comparing two entities to determine which is preferred" [23].

However, this study had employed pairwise comparison to compare the weight of indicators two at a time to consider which indicator was more or less or equal weight. Pairwise comparison can be made by various methods. The one employed for this SEA study was taken from SEA study of Industrial Development in Rayong Province and Adjacent Area (IWD B.E.2554-2556) and Watershed Management of the Mun River Basin (ONWR B.E. 2562-2565) since the method is logically understandable to the stakeholders and not too difficult to apply for the SEA study of Roadmap of Intelligent and Environmentally Friendly Transportation. Therefore, the range of weight score designated for indicators in column and row were comparatively proposed. The weight scores of indicators under economic, social and environment dimensions were evaluated by the SEA research team through brainstorming of the SEA research team, opinion of stakeholders 'meeting, and conclusion by the SEA research team. Designating that the indicators were ranged as 1-5. Score of 2 was for equal weight of indicators in column and in row. The range of below 2 was for the indicator in column lower than indicator in row. The range of above 2 was for the indicator in column higher than indicator in row. If the same indicators in column and row, the score should be zero. The weight scores are defined as follows.

- Indicator in column is same as indicator in row score is 0 (no score)
- Indicator in column is lower than indicator in row score is 1.0-1.9
- Indicator in column is equal indicator in row score is 2.0
- Indicator in column is higher than indicator in row score is 2.1-3.0

4) Assessing the impact score of each alternative according to the indicators. Setting the range of impact level was proposed as for the range of impact level as follows:

- 0.10-0.20 Lowest positive impact (Highest negative impact)
- 0.21-0.40 Low positive impact (High negative impact)
- 0.41-0.60 Moderate positive impact (Moderate negative impact)
- 0.61-0.80 High positive impact (Low negative impact)
- 0.81-1.00 Highest positive impact (Lowest negative impact)

Noting that impact level can be valued as positive (+) and negative (-). However, this study gave only the positive value in order to make it simple for deliberation. Impact level of alternatives could be compared by lowest, low, moderate, high and highest as defined above.

5) Assessing the impact score of each alternative using Impact Matrix Analysis indicating the impact on indicators generated by alternatives. The impact score is multiplication of weight score and impact level.

6) Summing up the impact score of each alternative. The highest score indicates the appropriate alternative.

2.4 SEA for program (Main mass transits system)

Since the Main Mass Transits System Program was derived from the Mass Transits Development Plan. Plan and program are in the same category of strategic action, the indicators of each dimension of the Plan could be used for the Program. The program action was performed in accordance with the SEA applied for Plan, except the alternatives. The alternatives of the program were considerably proposed as follows:

- Alternative 1: Road system
- Alternative 2: Railway system
- Alternative 3: Railway and road system

3. Results and discussion

3.1 Weight scores of dimensions and indicators

Firstly, weight scores of economic, social and environmental dimensions were assessed equally as 33.33% for each dimension based on the concept of sustainable development (i.e. the balancing of economic, social and environmental aspects). Remarking that the weight score of each dimension can be assessed unequally depending the output derived from the stakeholder's consideration. This study was considered on the sustainability principle as well as the opinion taken from the meeting of stakeholders.

Secondly, weight score of each indicator was carried out following the MCA using pairwise comparison as mentioned above. The weight score of each indicator within each dimension is described in economic, social and environmental sections.

Remarking that the weight scores of dimensions, indicators, and impact levels were (1) reviewed through the desktop study, (2) discussed through the brainstorm of the SEA team including the researcher, adviser/co adviser and SEA expert, (3) proposed to the meeting of the stakeholders, finally considered by the SEA research team.

3.1.1 Economic dimension

Pairwise comparison was performed between investment worthiness with enhancement of economic growth, between investment worthiness and the potential for income generation, and between enhancement of economic growth and potential of income generation. Investment worthiness was the primary factor for plan development. Once the investment worthiness was identified it would influence the other two indicators. In these instances, these three indicators were related. The weight scores of each indicator were relatively similar; specifically, the weight score of investment worthiness, enhancement of economic growth, and potential of income generation were 2.5, 1.5, and 1.5 respectively, as presented in Table 2.

Table 2 Weight score of indicators under economic dimension of SEA applied for mass transit development plan

Indicators of economic dimension	Investment worthiness	Enhancement of economic growth	Potential of income generation
Investment worthiness	0	1.5	1.5
Enhancement of economic growth	2.5	0	2.0
Potential of income generation	2.5	2.0	0
Total weight score of each indicator	*5.0*	*3.5*	*3.5*
Ratio of each indicator weigh score to weight score of each dimension	(5.0/12) 33.3	(3.5/12) 33.3	(3.5/12) 33.3
Percentage	**13.88**	**9.71**	**9.71**

3.1.2 Social dimension

Pairwise comparison was performed as presented in Table 3 and described subsequently:

Adequacy and accessibility to various sources were compared to safety. While adequacy and access to various sources are required for people, safety is necessary for maintaining a high quality of life. The weight score of adequacy and access to various sources was marginally less than the safety score, with scores of 1.5 and 2.5 respectively.

Table 3 Weight score of indicators under social dimension of SEA applied for mass transit development plan

Indicator of social dimension	Adequacy and accessibility to various sources	Safety of transportation	Traffic volume	Enhancement on beautiful scenery along the route
Adequacy and accessibility to various sources.	0	2.5	2.0	1.0
Safety of transportation.	1.5	0	2.0	1.0
Traffic volume.	2.0	2.0	0	1.0
Enhancement of scenic beauty along the route	3.0	3.0	3.0	0
Total score	6.5	7.5	7.0	3.0
Ratio of each indicator weigh score to weight score of each dimension	(6.5/24) 33.3	(7.5/24) 33.3	(7/24) 33.3	(3/24) 33.3
Percentage	**9.02**	**10.41**	**9.71**	**4.16**

Adequacy and accessibility to various sources were compared to traffic volume. Adequacy and access to various sources were found to be relatively linked with traffic volume. Both indicators achieved similar weight scores of 2.0 each.

Adequacy and accessibility to various sources were compared to the enhancement of greenery along the road and the surrounding areas along the route. Adequacy and access to various sources were deemed more essential than the enhancement of greenery along the road and the surrounding areas along the route, with a score of 3.0 and 1.0 respectively.

With the same approach, weight score of other indicators were evaluated as follows.

Safety of transportation was compared to adequacy and access to various sources, to traffic volume, and to scenic beauty as following weight scores; 2.5: 1.5; 2.0: 2.0; 3.0:1.0 respectively.

Impact on traffic volume was compared to adequacy and accessibility to various sources, to safety of transportation, and to scenic beauty as following weight scores: 2.0:2.0., 2.0:2.0 and 3.0:1.0, respectively.

Scenic beauty was received a lower weight score than the other indicators mentioned previously. The weight score for this indicator was 1.0.

3.1.3 Environmental dimension

The weight scores of indicators are presented in Table 4 and described below.

Table 4 Weight score of indicators under environmental dimension of SEA applied for mass transit development plan

Environmental indicators	Air pollution and climate change	Noise pollution and vibration	Ecosystem (Forest and wetland)	Town scenery
Air pollution and climate change.	0	1.5	1.5	1.0
Noise pollution and vibration.	2.5	0	1.5	1.0
Ecosystem (Forest and wetland).	2.5	2.5	0	1.0
Town scenery.	3.0	3.0	3.0	0
Total weight score	8.0	7.0	6.0	3.0
Ratio of each indicator weigh score to weight score of dimensions	(8/24) 33.3	(7/24) 33.3	(6/24) 33.3	(3/24) 33.3
Percentage	**11.1**	**9.71**	**8.33**	**4.16**

Air pollution and climate change were compared to noise pollution and vibration, to ecosystem, and to town scenery. The weight scores were as follows; 2.5:1.5, 2.5:1.5 and 3.0:1.0, respectively.

Noise pollution and vibration were compared to air pollution and climate change, ecosystem, and to town scenery. The weight scores were as follows; 1.5:2.5, 2.5:1.5, 3.0:1.0, respectively.

Ecosystem was also compared to air pollution and climate change, to noise pollution and vibration, and to town scenery. The following weight scores were 1.5:2.5, 1.5:2.5 and 3.0:1.0, respectively.

Town scenery was compared to the other indicators. As mentioned above, the weight of town scenery was less than other indicators. Therefore, weight score town scenery received was 1.0.

The weight scores of indicators under each dimension were used for assessment of alternatives in the next step.

3.2 Assessment of alternative of mass transit development plan

The assessment of alternative of mass transit development plans was undertaken by calculating the impact score of each alternative. The alternatives considered were no development plan or no action (Alternative 1), conventional mass transit development plan (Alternative 2), smart mass transit development plan (Alternative 3). The assessment result is presented in Table 5.

3.2.1 Economic dimension

The impact level of each alternative on each indicator was subsequently compared, as indicated in Table 5. It is evident that Alternative 3 would induce a much higher positive impact level on the investment worthiness than Alternative 2 and Alternative 1, with scores of 0.8, 0.4, and 0.2 respectively. Similarly, the impact level of Alternative 3 compared to Alternative 2 and Alternative 1 was 0.8, 0.5, and 0.2 respectively for enhancement of economic growth, and 0.9, 0.6 and 0.2, respectively for potential for income generation.

3.2.2 Social dimension

As presented in Table 5, Alternative 3 would relatively generate a much higher positive impact level on the adequacy and accessibility to various sources than the Aalternative 2 and Alternative 1, with scores of 0.8, 0.5, and 0.2 respectively. Likewise, Alternative 3 would induce a considerably higher positive impact level than the Alternative 2 and Alternative 1 for transportation safety.

3.2.3 Environmental dimension

As illustrated in Table 5, the transit system would directly impact air pollution and climate change. Alternative 3 is projected to produce a higher positive impact than the other alternatives. The impact levels were 0.9, 0.5, and 0.3 for Alternative 3, Alternative 2, and Alternative 1 respectively. Similarly, on the subject of air pollution and climate change, the impact levels were 0.8, 0.5, 0.4 for Alternative 3, Alternative 2, and Alternative 1 respectively. Regarding the impact levels on ecosystem and town scenery, they were insignificantly different among such alternatives as none of these alternatives would significantly alter the existing status of the ecosystem and town scenery. The impact levels were 0.6, 0.5 and 0.4 for the ecosystem, and 0.6, 0.4 and 0.3 for town scenery, respectively.

The impact score presented in Table 5, indicating the total impact score (the sum of impact scores under economic, social, and environmental dimensions) were 49.36%, 32.17%, and 18.47% for Alternative 3, Alternative 2, and Alternative 1, respectively. The Smart and Environmentally Friendly mass transit development plan was the appropriate alternative.

Table 5 Assessment of alternatives of mass transit development plan

Indicators	Weight Score	Alternatives					
		No action		Conventional plan		Smart plan	
		Impact level	Impact score	Impact level	Impact score	Impact level	Impact score
Economic Dimension:							
Investment worthiness	13.88	0.2	2.78	0.4	5.55	0.8	11.10
Enhancement of economic growth	9.71	0.2	1.94	0.5	4.86	0.8	7.77
Potential of income generation	9.71	0.2	1.94	0.6	5.83	0.9	8.74
Total impact score (A)			6.66		16.23		27.61
Social Dimension:							
Adequacy and accessibility to various sources	9.02	0.2	1.80	0.5	4.51	0.8	7.22
Safety of transportation	10.41	0.4	4.16	0.6	6.25	0.9	9.37
Traffic volume	9.71	0.3	2.91	0.6	5.83	0.8	7.77
Enhancement on beautiful scenery along the route	4.16	0.4	1.66	0.5	2.08	0.6	2.50
Total weight score (B)			10.55		18.66		26.85
Environmental Dimension:							
Air pollution and climate change	11.1	0.3	3.33	0.5	5.55	0.9	9.99
Noise pollution and vibration	9.71	0.4	3.88	0.5	4.86	0.8	7.77
Ecosystem (Forest and wetland)	8.33	0.5	4.17	0.6	5.00	0.6	5.00
Town scenery	4.16	0.3	1.25	0.4	1.66	0.6	2.50
Total weight score (C)			12.63		17.07		25.25
Total (A+B+C)	161.50	29.83		51.96		79.71	
Percentage of each alternative	**100**	**18.47**		**32.17**		**49.36**	

3.3 Assessment of alternative of main transit system

As mentioned above, the main transit system was the program derived from the Smart mass transit development plan, the same indicators of each dimension were used. Thus, the indicators of economic, social, and environmental dimensions, together with their corresponding weight scores, were accordingly consistent with the assessment of alternative of mass transit development plan as already defined in Tables 1-4.

The alternatives for the main transit system considered under the appropriate alternative of the Smart mass transit development plan, previously assessed, were Road Program (Alternative 1), Railway Program (Alternative 2), and Road with Railway Program (Alternative 3). The impact level of each alternative was comparatively assessed and is presented in Table 6.

Table 6 Assessment of alternative of main transit system

Indicators	Weight Score	Alternatives					
		Road program		Railway program		Road with railway program	
		Impact level	Impact score	Impact level	Impact score	Impact level	Impact score
Economic Dimension:							
Investment worthiness	13.88	0.6	8.33	0.4	5.55	0.5	6.94
Enhancement of economic growth	9.71	0.6	5.83	0.5	4.86	0.7	6.80
Potential of income generation	9.71	0.6	5.83	0.4	3.88	0.8	7.77
Total score (A)			19.98		14.29		21.51
Social Dimension:							
Adequacy and accessibility to various sources	9.02	0.7	6.31	0.3	2.71	0.9	8.12
Safety of transportation	10.41	0.5	5.21	0.8	8.33	0.7	7.23
Traffic volume	9.71	0.4	3.88	0.8	7.77	0.7	6.79
Enhancement on beautiful scenery along the route	4.16	0.4	15.40	0.7	18.80	0.6	19.29
Total score (B)			30.81		37.60		41.43
Environmental Dimension:							
Air pollution and climate change	11.1	0.4	4.44	0.8	8.88	0.6	6.66
Noise pollution and vibration	9.71	0.5	4.86	0.8	7.77	0.6	5.83
Ecosystem (Forest and wetland)	8.33	0.6	5.00	0.7	5.83	0.65	5.41
Town scenery	4.16	0.5	2.08	0.7	2.91	0.65	2.70
Total score (C)			16.38		25.39		20.60
Total (A+B+C)	227.99	67.17		77.28		83.54	
Percentage of each alternative	**100**	**29.46**		**33.90**		**36.64**	

As shown in Table 6, the total impact score was ranked as 36.64%, 33.90%, and 29.46% for Alternative 3, Alternative 2, Alternative 1 respectively. The assessed appropriate alternative was the road with railway as the main mass transit system.

Additionally, the comment on the weight score of dimensions that should not be equal. For the study, the weigh score of each dimension was evaluated as equal based on the concept of sustainability (balancing of economic, social and environment). However; the weight score of dimensions could be designate unequally. We try to evaluate weight score under the different ratio of sustainable dimensions including 33.33, 33.33, 33.33; 40:30:30; 50:25:25; 60:20:20. Weight score of each indicator of each dimension was evaluated under such different ratio. Weight score of each indicator is considered as the constant to multiply with the impact level of each alternative to get the impact score, as presented in Table 7. It shows weight score changed under different ratio of sustainable dimensions. The overall score of each alternative was accordingly changed, but the rank of alternatives was the same of any ratio of sustainable dimensions.

Table 7 Impact scores of alternatives under different ratio of sustainable dimension

Sustainable dimension Econ : Soc : Env	Plan			Program		
	Alternatives					
	No action	Conventional plan	Smart plan	Road program	Railway program	Road and railway Program
33.33 : 33.33 : 33.33	18.47	32.17	49.38	29.46	33.90	36.64
40 : 30 : 20	17.97	32.17	49.86	27.47	30.21	42.38
50 : 25 : 25	17.21	32.17	50.62	28.19	29.07	42.74
60 : 20 : 20	16.44	32.16	51.40	28.96	27.90	43.44

4. Conclusion

The application of SEA for strategic action (plan and program) was employed for the mass transit development plan of Uttaradit province. This study focused only some steps of SEA, including development and assessment of alternatives in conjunction with the indicators of three sustainable dimensions: economic, social, and environmental indicators. The assessment of alternative consisted of several stages, including the development of alternatives, the designation of indicators under economic, social, and environmental dimensions, weighting the score of indicators, assessing the impact level of alternatives on indicators, assessing the impact sore of alternatives on indicators, and summing the impact score of all indicators of three alternatives. The alternative with the highest impact score would be considered as the appropriate alternative.

The mass transit development plan includes three feasible alternatives: No action alternative 1, Conventional plan alternative 2, and Smart plan alternative 3. Similarly, the main transit system offers three alternatives: road system, railway system, and road and railway system. Concerning the economic dimension, the indicators explored included investment worthiness, enhancement of economic growth, and potential of income generation. Social dimensions included adequacy and accessibility to various sources, safety of transportation, traffic volume, and the enhancement of beautiful scenery along the route. The environmental dimension included air pollution and climate change, noise pollution and vibration, ecosystem (forested areas and wetlands), and town scenery.

Consequently, the appropriate alternative plan was the smart and environmentally friendly mass transit development plan. The appropriate alternative program identified was the road and railway system.

However, it should be remarked that this SEA application to the Roadmap Developing for Intelligent and Environmentally Friendly Transportation of Uttaradit Province was intended to introduce SEA applied to the strategic action as Plan and Program level. It is action research employed the uncomplicated assessment procedure but filled with scientific data and knowledge as the procedure had to be involved with the participation of the stakeholders. The output of the action research was logically understanding. Application of SEA to the strategic action is possible.

5. Recommendation

This study was the introduction of SEA application to the Mass Transit System. It employed some steps of SEA, development and assessment of alternatives. The indicators, weigh scores and impact scores had employed mainly by brainstorming and consultations with researchers, advisers, and SEA experts. Nevertheless, modification of the SEA method used for any strategic actions are strongly required. As this SEA is very new to the academic perspective and knowledge of SEA approach is likely limited, strengthen of this SEA topic is strongly required. Subsequently, it is very necessary for more researches of how to academically apply to the strategic action. To obtain the full steps of SEA process, it is necessary to study the SEA Guidelines developed by the National Economic and Social Development Council, 2024.

6. References

[1] Logistics Development Strategy Division, Office of National Economic and Social Development Council. The third logistics development plan (2017-2021). Bangkok: NESDC; 2017.

[2] Department of Public Works and Town and Country Planning. Northern region plan (2017): Kampangpetch, Chiangrai, Chiangmai, Tak, Nakornsawan, Nan, Payao, Pijit, Pitsanulok, Petchboon, Prae, Mae Hongson, Lampang, Lampoon, Sukhothai, Uttaradit, Utai Thani", consultant of technology. Bangkok: DPT; 2017. (In Thai)

[3] Iamtrakul P, Raungratanaamporn I, Shinpiriya P. Framework of analysis of policy on transit oriented development around mass transit station towards sustainable town development. The Journal of Architectural/Planning Research and Studies (JARS). 2017;14(1):95-122. (In Thai)

[4] Calthorpe Associate. Transit-Oriented development design guidelines [Internet]. 1990 [cited 2024 Mar 10]. Available from: https://planning.saccounty.gov/LandUseRegulationDocuments/Documents/General-Plan/TOD-Design-Guidelines.pdf.

[5] Cervero R. Transit-oriented development's ridership bonus: a product of self-selection and public policies. Environ Plann A: Econ Space. 2007;39(9):2068-85.

[6] Bureekul T. Public participation in environmental management in Thailand. Nonthaburi: King Prajadhipok's Institute; 2000.

[7] Office of Transport and Traffic Policy and Planning, Ministry of Transportation. Thailand's transport infrastructure development strategy 2015-2022. Bangkok: OTP; 2014.

[8] Canadian International Development Agency (CIDA). Strategic environmental assessment of policy, plan, and program proposals: CIDA handbook. [Internet]. 2023 [cited 2023 Dec 10]. Available from: https://www.international.gc.ca/development-developpement/priorities-priorites/enviro/seapppp-eespppp.aspx?lang=eng.

[9] Fischer TB. Theory and practice of strategic environmental assessment: towards a more systematic approach. London: Routledge; 2007.

[10] Office of Natural Resources and Environment Policy and Planning, Ministry of Natural Resources and Environment. Strategic environmental assessment. Bangkok: Mister Copy Company; 2009. (In Thai)

[11] Office of Natural Resources and Environment Policy and Planning, Ministry of Natural Resources and Environment. Environmental quality management plan (2017-2021). Bangkok: ONEP; 2017. (In Thai)

[12] Fischer TB. Strategic environmental assessment and transport planning: towards a generic framework for evaluating practice and developing guidance. Impact Assess Proj Apprais. 2006;24(3):183-97.

[13] Ward M, Wilson J, Sadler B. Application of strategic environmental assessment to regional land transport strategies. Land Transport New Zealand Research Report 275. Wellington: Land Transport New Zealand; 2005.

[14] Zhang Z, Shi F, Li F. Integrating strategic environmental assessment into transport planning process in China. International Forum on Energy, Environment and Sustainable Development 2016 (IFEESD 2016); 2016 Apr 16-17; Shenzhen, China. Amsterdam: Atlantis Press; 2016. p. 816-9.

[15] Torrieri F. Scenario analysis and strategic environmental assessment. In: Giovanni C, editor. Strategic environmental assessment and urban planning. Cham: Springer; 2020. p. 31-45.

[16] Tengsakul D. Strategic Environment Assessment (SEA) of Special Economic Zone (ZEZ) development strategy, Chiang Saen District, Chiang Rai Province [thesis]. Bangkok. National Institute of Development Administration; 2015. (In Thai)

[17] Industrial Work Department. Strategic environmental assessment of industrial development in Muang Rayong District and adjacent area phase 1 and 2 (B.E. 2555). Bangkok: Ministry of Industry; 2012. (In Thai)

[18] Office of National Water Resources. Strategic environmental assessment of the Mun River Basin (B.E. 2564) [Internet]. 2021 [cited 2024 Jun 4]. Available form: https://drive.google.com/file/d/1gQqpN-TrkprpM07kqXiyym0y5gNyh-EH/view. (In Thai)

[19] National Economic and Social Development Council. Strategic environmental assessment guideline (revised edition). Bangkok: NESDC; 2021.

[20] Department of Provincial Administration. Register population statistic [Internet]. 2024 [cited 2024 Jun 4]. Available from: https://stat.bora.dopa.go.th/stat/statnew/statMONTH/statmonth/#/displayData. (In Thai)

[21] Therivel R, Paridario MR. The practice of strategic environmental assessment. London: Routledge; 1996.

[22] Sadler B. The status of SEA systems with application to policy and legislation. In: Sadler B, editor. Strategic environmental assessment at the policy level: recent progress, current status and future prospects. Prague: Ministry of the Environment, Czech Republic; 2005. p. 11-27.

[23] Kyne D. Pairwise comparison (definition, methods, examples, tools) [Internet]. 2024 [cited 2024 Jun 4]. Available form: https://www.opinionx.co/blog/pairwise-comparison.