Environmental Assessment Approach for Mass Transit System in Uttaradit Province, Thailand

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Abstract. *This research aims to apply Environmental Assessment (EA) to the mass transit system of Uttaradit Province, Thailand. EA included Strategic Environmental Assessment (SEA) for the plan and program levels and Initial Environmental Examination (IEE) for the project level. SEA was scoped for the development and assessment of the appropriate alternatives for mass transit system development plan and mass transit system program. IEE was scoped for mass transit system selection resulted by SEA study. The appropriate alternative mass transit development plan derived from the SEA study was smart plan with positive impact score as 49.36%), compared to the conventional mass transit development plan and no plan with impact scored as 32.17%, was 18.4 %, respectively. Under the smart plan, the appropriate alternative assessed for the main mass transit system program derived by SEA study was the road with railway system with impact score of 36.64% compared with was railway system and road system with impact score as 33.90% and 29.46% respectively. After SEA assessment, IEE was undertaken for the minor mass transit system at project level defined as Minor 1, Minor 2 and Minor 3. Example of Minor 1 was assessed by comparison of Alternative 1,1 and Alternative 1.2. Herein, only environmental with social dimension was carried out for assessment. The impact scores of alternatives derived by IEE study were brought to combine with engineering and economic dimension for further consideration of the appropriate alternative.*

Keywords:

Environmental Assessment, Strategic Environmental Assessment, Initial Environmental Examination, Mass Transit System, Indicators, Alternatives

1. Introduction

Under the Thirteenth National Economic and Social Development Plan (2023-2027), Thailand aims to become a key strategic gateway for trade, investment, and logistics in the region. To achieve this milestone, the country must enhance connectivity both domestically and internationally, and develop digital and logistical infrastructure to support trade and investment [1]. Accordingly, Thailand must develop its potential to become a central hub for transportation and logistics, trade, economy, and tourism, connecting with neighboring countries and various regions [2]. Especially, Thailand is enhancing its border cities to boost socio-economic and cultural ties with neighboring countries in the Asian region, including Cambodia, Laos, Myanmar, Brunei, Malaysia, Indonesia, the Philippines, Singapore, Vietnam, and Thailand [3].

Uttaradit Province, Thailand, with the permanent border crossing at Poo Doo, has high potential as a central hub for trade, investment, and tourism. Its road network connects to Myanmar, Thailand, and Laos, serving the economic corridor between Luang Prabang, Indochina, and Mao-Lamyai. Despite the strategic development plans and infrastructure improvements have been made, transportation development in Uttaradit Province remains fragmented and isolated [4]. As a result, the fragmented and isolated transportation development hinders the connection between the physical infrastructure and operational processes of the logistics system, causing delays in the flow of information, goods, finances, activities, and transactions. Uttaradit Province thus aims to set position itself as a key center for production and industry in the Indochina Region, which is in line with the government's strategic development plans. To achieve such position, it is decisive to establish the efficient mass transit systems for both cargo and people. These systems should enhance connectivity within Uttaradit, across different regions of Thailand, and with neighboring countries [5-11]. A mass transit initiative in Uttaradit Province should incorporate the Transit-Oriented Development (TOD) concept. In addition, TOD focuses on creating high-density, mixed-use communities designed around transit hubs, promoting sustainable urban growth and reducing reliance on private vehicles. This approach would involve developing residential, commercial, and recreational spaces within walking distance of public transit stations, ensuring seamless integration of transport services with urban planning. By doing so, Uttaradit Province can improve its logistical efficiency, support economic growth, and foster sustainable development in line with the regional connectivity goals. It is necessary to develop the modal integration [12] as well as smart and environmentally friendly transportation, called as the Smart development plan [13, 14], for promoting the border city development with the highest capability and efficiency towards sustainability.

To accomplish sustainable mass transit development, an Environmental Assessment (EA) is consequently considered. Theoretically, environmental assessment includes Strategic Environmental Assessment (SEA), Initial Environmental Examination (IEE), and Environmental Impact Assessment (EIA). SEA is a systematic process supporting decision-making for planning, based on the sustainable concept. SEA is applied to policies, plans, and programs. [15]. IEE serves as the initial stage in the environmental assessment process of a project. It involves a comprehensive description of the project's environmental conditions, including potential impacts on the surrounding environment. Basically, IEE is employed in feasibility studies for site and technology selection, often alongside engineering and social studies. Once a project is deemed feasible and included in the list of EIA projects, EIA is carried out. By conducting IEE, the project planners can proactively address environmental concerns and ensure sustainable development practices integrated into the project's design and implementation [16]. EIA is a comprehensive process used to evaluate the potential environmental impacts of the proposed project or development. It considers a wide range of interrelated factors, including physical resources, biological resources, human use values and quality of life values. The impact assessment of the project to environment including such physical /biological resources and human use value/ quality of life values was performed. Mitigation measures and monitoring program would be proposed for the potential impacts occurred [17].

Regarding SEA application for the strategic level in Thailand has not been made thoroughly. In vice versa, SEA has been increasing international recognition as a mean of ensuring environmental impacts being considered in transport policy and plan making. Mostly SEA application to the strategic action is designated by the national law, particularly in the European countries. Fischer (2006) 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 identify possible core tasks of the European Union TEN-T (Trans-European Transport Network) related corridor-plan SEAs in Germany and England. In the Asia region, China is the leading country on SEA application. Legally, SEA is named as Plan-EIA. In China 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 [18].

As mentioned above, SEA application on mass transit systems in Thailand is non-existent, the country mostly focusses project-level EA like IEE and EIA. This research faced challenges in applying SEA to mass transit development plans due to the need for a proactive, transparent process with extensive participation that would meaningfully contribute to achieving sustainable development [19]. Since this SEA was conducted concurrently with the engineering and town planning studies, only certain steps of SEA process were applied at the plan and program levels. Additionally, IEE was implemented at the project level to fulfill the EA study requirements. Therefore, this paper will present the SEA study for the mass transit system at the plan and program levels, followed by the IEE study at the project level. Remarking that this paper drawn from the action research, endeavoring to be practical implementation.

2. Research Methodology

2.1 Study area

Study area covered the area of Uttaradit province, located 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 provinces 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.

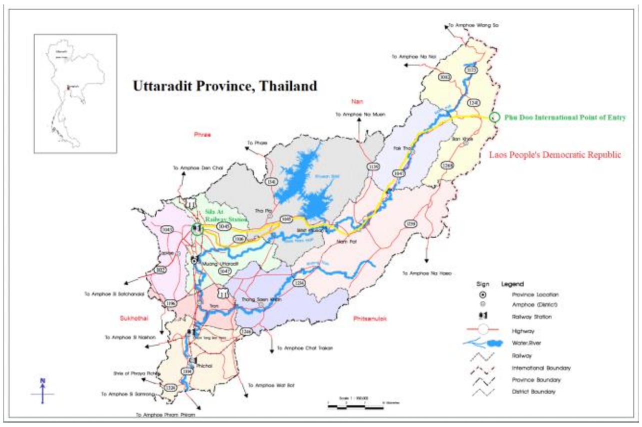

Fig. 1 Study area.

2.2 Environmental Assessment for mass transit system

EA was applied for the mass transit system at 2 levels, Plan (Development plan of mass transit system) and Program (Main mass transit system) and IEE was applied at the project level (Minor mass Transit system) , as presented in **Figure 2**.

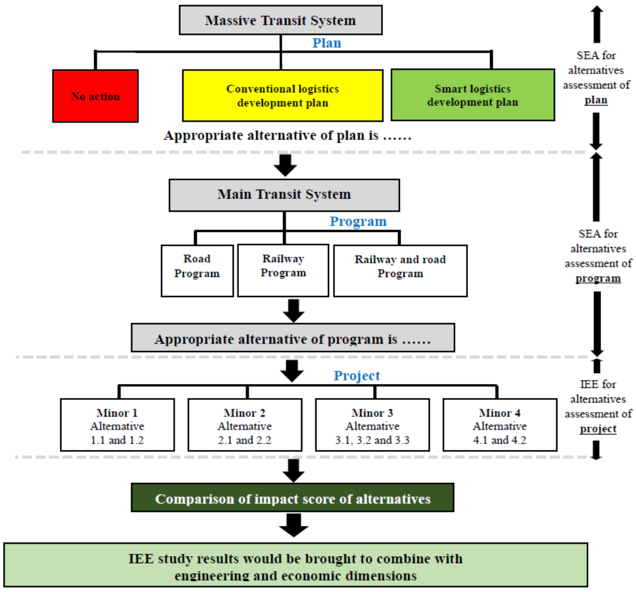

Fig. 2 Conceptual approach of EA for mass transit system

2.2.1 SEA for Strategic Levels of Mass Transit System

The application of SEA at such strategic levels (Plan and program) was functionally scoped for the development and assessment of alternatives together with the indicators defined under the sustainable development concept; economic, social, and environmental dimensions. The study had employed the following process:

1) Designating the feasible alternatives including No Development Alternative (No action).

2) Designating the weight score of economic, social and environmental dimensions basing on sustainability concept, which is the equilibrium of economic, social and environmental dimensions)

3) Designating economic, social, and environmental indicators.

4) Weighing of such indicators using pairwise comparison of the Multi-Criteria Analysis (MCA), resulting in a weight score.

5) Assessing the impact level of feasible alternatives on such indicators, rating an impact level.

6) Assessing the impact score of each alternative for the indicators of each dimension by multiplying the weight score with the impact level.

7) Summing up the impact scores of each dimension, resulting for the alternative with the highest overall score, being assessed as the appropriate alternative.

2.2.2 IEE for Project Level of Mass Transit System

IEE was applied for the minor mass transit system derived from the main mass transit system at program level, categorized as the project level. As mentioned above, IEE is used for feasibility study comprising the dimension of engineering, economic and environment amended with social aspect. IEE herein would scope for environment and social indicators. IEE process can be described as follows.

1) Designating environmental and social indicators, and calculating the weight score by pairwise comparison of Multi Criteria Analysis (MCA).

2) Assessing impact score by Matrix Impact Analysis. Impact score is the multiplication of weight score and impact level.

3) Combining the impact score of environmental with social dimensions with the score of engineering and economic dimensions. The most feasible alternative is assessed by the highest impact score.

Noting that both SEA and IEE had employed using the same procedure, but different dimensions. SEA employed economic, social and environmental dimensions. IEE employed engineering, economic and environment with social dimensions. For SEA, no action is considered as one alternative. But IEE, no action alternative is not required as the project is derived from the appropriate alternatives already assessed for plan, and program. Noting that this paper presents only the environmental with social dimension.

The results of EA applied for the Mass Transit System of Uttaradit Province; Thailand are subsequently described.

3. Results

3.1 SEA for Plan (Mass Transit System Development Plan)

3.1.1 Weight score assessment

1) Designating the feasible alternatives includes following alternatives [21, 22]

Alternative 1: No action plan or No development plan
Alternative 2: Conventional Development Plan
Alternative 3: Smart Development Plan

2) Designating the weight score as 33.3 equally for each dimension basing on sustainable development.

3) Designating economic, social, and environmental indicators relevant to their respective aspects, as considered by the researchers, adviser and SEA expert [23, 24]. These indicators are defined as presented in **Table 1**.

4) Assessing the weight score of indicators of each dimension using the MCA by pairwise comparing the weight of indicators in column and row as follows:

Indicator in column:
- Same as indicator in row score is 0
- Higher than indicator in row score is 3
- Equal indicator in row score is 2
- Lower than indicator in row score is 1

However, if the pairwise comparing the weight of indicators in column and row results are not clearly different, may be 1.5 or 2.5 may be given

Table 1 Economic, social and environmental indicators

Dimension	Indicators	Abbreviations
Economic	1. Worthiness of investment.	A
	2. Contribution to economic growth.	B
	3. Potential for income generation.	C
Social	1. Adequacy and accessibility to community, tourism sites, cultural and traditional sites, and public health facilities.	D
	2. Safety during travel.	E
	3. Impact on traffic flow.	F
	4. Improvement of greenery along the road and surrounding areas along the route.	G
Environmental	1. Air pollution and climate change.	H
	2. Noise pollution and vibration.	I
	3. Ecosystem preservation (Forestry and wetland).	J
	4. Town scenery.	K

a) Economic dimension

Pairwise comparison of indicators was performed and presented in **Table 2**. As the investment worthiness was the primary factor for plan development, it would influence the other two indicators. These three indicators were subsequently related. The weight score of the investment worthiness compared with the enhancement of economic growth was 2.5 and 1.5. Likewise, the weight score of investment worthiness compared with the potential of income generation was 2.5, 1.5.

Enhancement of economic growth compared with potential of income generation, the weight of both indicators was equal as they were inter-relatively, as of each indicator was 2.0.

Under the weight ratio of economic indicator, 33.3; the weight scores of investment worthiness, enhancement of economic growth and potential of income generation were 13.88, 9.71 and 9.71, respectively.

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

Economic indicators	A	B	C	Full score
A	0	1.5	1.5	
B	2.5	0	2.0	
C	2.5	2.0	0	
Total weight score	*5.0*	*3.5*	*3.5*	*12*
Ratio of each indicator weigh score to weight score of each dimensions	(50./12) 33.3	(3.5/12) 33.3	(3.5/12) 33.3	
Percentage of each economic indicator	**13.88**	**9.71**	**9.71**	**33.3**

b) social dimension

Pairwise comparison was performed as presented in **Table 3** and described as follows.

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

Social indicators	D	E	F	G	Full score
D	0	2.5	2.0	1.0	
E	1.5	0	2.0	1.0	
F	2.0	2.0	0	1.0	
G	3.0	3.0	3.0	0	
Total weight score	*6.5*	*7.5*	*7.0*	*3.0*	*24*
Ratio of each indicator weigh score to weight score of each dimensions	(6.5/24) 33.3	(7.5/24) 33.3	(7/24) 33.3	(3/24) 33.3	
Percentage of each social indicator	**9.02**	**10.41**	**9.71**	**4.16**	**33.3**

Adequacy and accessibility to various sources were compared to safety, traffic volume, the enhancement of greenery along the road and the surrounding areas along the route. While adequacy and access to various sources are required for people, safety is very essential for maintaining a high quality of life. The weight score of adequacy and access to various sources was considerably less than the safety score, with scores of 1.5 and 2.5 respectively. For traffic volume found access to various sources to be relatively linked with traffic volume. Both indicators attained similar weight scores as 2.0 of each. And the enhancement of greenery along the road and the surrounding areas along the route, considered more inevitability 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.

As compared above, safety of transportation scored as 2.5 and adequacy and access scored as 1.5. Safety of transportation compared to traffic volume, the weight score of each was 2.0 due to their interaction. In addition, safety of transportation was compared to the enhancement of greenery along the road and the surrounding area along the route. Evidently, safety of transportation obtained a higher weight scored of 3.0 compared to the greenery scored as 1.0.

Regarding the inter-relation of indicators of traffic volume, adequacy and accessibility to various sources, safety of transportation, the weight scores were considerably equal as of 2.0 for each pairwise comparison. However, when comparing the impact on traffic volume to the enhancement greenery along the route, impact on traffic volume scored higher weight score as 3.0 compared greenery scored as 1.0.

Greenery along the route and surrounding are along the route received a lower weight score than the other indicators mentioned previously. The overall weight score for this indicator was 1.0.

c) Environmental Dimension

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

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

Environmental indicators	H	I	J	K	Full score
H	0	1.5	1.5	1.0	
I	2.5	0	1.5	1.0	
J	2.5	2.5	0	1.0	
K	3.0	3.0	3.0	0	
Total weight score	*8.0*	*7.0*	*6.0*	*3.0*	*24*
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 of each environmental indicator	**11.1**	**9.71**	**8.33**	**4.16**	**33.3**

Air pollution and climate change were compared to noise pollution and vibration, to ecosystem, and to town scenery. Noticeably, the problems of climate change and air pollution are generated by various sources including mass transit systems. Climate change is likely adverse impacts on ecosystem. Climate change and air pollution are relatively linked of each other. Due to various sources of generation and impacts, climate change and air pollution has shown to have a higher impact than noise pollution and vibration. The weight score assigned to air pollution and climate change was higher than noise pollution and vibration, and ecosystem impacts, with scores of 2.5, 1.5 and 1.5 respectively. Air pollution and climate change compared to town scenery scored as 3.0 and 1.0 respectively.

Noise pollution and vibration were compared to the ecosystem. Mass transit systems directly generate noise and vibration but might not generate directly to ecosystem. The weight scores of noise pollution and vibration resulted as 3.0 and ecosystem resulted as 1.0.

Ecosystem was also compared to town scenery. The impact of mass transit systems on the ecosystem was rather higher than town scenery, particularly where the transit route passes through the forestry areas. As a result, the weight score for ecosystem was 3.0 and 1.0 for town scenery.

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

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

3.1.2 Assessment of impact score of alternatives

1) Setting the range of impact level as positive impact as follows.

0.100.2-0	Lowest positive impact
0.4-0.210	Low positive impact
0.6-0.410	Moderate positive impact
0.8-0.610	High positive impact
1.0-0.810	Highest positive impact

2) Assessing the impact score of each alternative using MCA, which indicates the impact on indicators generated by alternatives, like the checklist [24, 25] with two dimensions. The impact score is multiplication of weight score and impact level using **Eq.1.**

Impact score = Weight score × Impact level (**Eq. 1)**

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

The results of impact scores of each alternative under each dimension are as follows.

As mentioned earlier**,** the alternatives called as feasible 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 of such feasible alternatives of mass transit development plans was commenced by calculating the impact score of each alternative using Equation 1 (Eq.1). The assessment result is presented in **Table 5** and explained below.

Table 5 Assessment of alternatives of mass transit development plan

Indicators	**Weight Score**	**Alternatives**					
		No action plan		Conventional plan		Smart plan	
		Impact level	Impact score	Impact level	Impact score	Impact level	Impact score
Economic Dimension:							
A	13.88	0.2	2.78	0.4	5.55	0.8	11.10
B	9.71	0.2	1.94	0.5	4.86	0.8	7.77
C	9.71	0.2	1.94	0.6	5.83	0.9	8.74
Total score (a)			*6.66*		*16.23*		*27.61*
Social Dimension:							
D	9.02	0.2	1.80	0.5	4.51	0.8	7.22
E	10.41	0.4	4.16	0.6	6.25	0.9	9.37
F	9.71	0.3	2.91	0.6	5.83	0.8	7.77
G	4.16	0.4	1.66	0.5	2.08	0.6	2.50
Total score (b)			*10.55*		*18.66*		*26.85*
Environmental Dimension:							
H	11.1	0.3	3.33	0.5	5.55	0.9	9.99
I	9.71	0.4	3.88	0.5	4.86	0.8	7.77
J	8.33	0.5	4.17	0.6	5.00	0.6	5.00
K	4.16	0.3	1.25	0.4	1.66	0.6	2.50
Total score (c)			*12.63*		*17.07*		*25.25*
Total score (*a+b+c*)		29.83		51.96		79.71	
Percentage of each alternative		**18.47**		**32.17**		**49.36**	

a) Economic Dimension

The impact level of each alternative on each indicator was reasonably compared. Economically, Alternative 3 would make a much higher positive impact level on the investment worthiness than Alternative 2 and Alternative 1, with impact levels of 0.8, 0.4, and 0.2 respectively. Correspondingly, 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.

b) Social Dimension

Unambiguously, Aalternative 3 would generate significantly higher positive impact level on the adequacy and accessibility to various sources than the Aalternative 2 and Alternative 1, with impact level of 0.8, 0.5, and 0.2 respectively. Likewise, Alternative 3 would induce a considerably higher positive impact level than the Aalternative 2 and Alternative 1 for transportation safety, with impact level of 0.9, 0.6, and 0.4 respectively. Furthermore, regarding the impact level on traffic volume, Alternative 3 would present a significantly higher impact level than Aalternative 2 and Aalternative 1, with impact level of 0.8, 0.6, and 0.3 respectively. However, the impact level on the enhancement on greenery along the road and route of all three alternatives was insignificantly different, resulting in impact scores of 0.6, 0.5, and 0.4 for the Alternative 3, Aalternative 2, and Aalternative 1 respectively.

c) Environmental Dimension

Obviously, the mass transit system would directly impact air pollution and climate change. Alternative 3 is considered to induce 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, about noise pollution and vibration, 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 these alternatives might have a little to none on alteration of 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, for Alternative 3, Alternative 2, and for Alternative 1, respectively.

Impact score of each indicator under each dimension was the multiplication result of impact level and weight score. Then, the total impact score, which is the sum of impact scores under economic, social, and environmental dimensions, presented in Table 5, were 49.36%, 32.17%, and 18.47% for Alternative 3, Alternative 2, and Alternative 1, respectively. Based on this data, the Smart and Environmentally Friendly mass transit development plan assessed as the appropriate alternative. respectively (Figure 3).

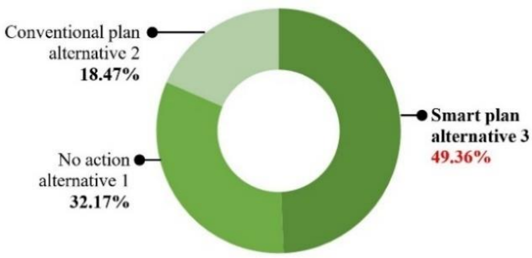

Fig. 3 Alternative assessment of mass transit development plan

3.2 SEA for program (Main mass transits system)

This task was performed in accordance with the SEA for Plan, except the alternatives were designated as follows:

Alternative 1: Road system
Alternative 2: Railway system
Alternative 3: Railway with road system

The indicators of economic, social, and environmental dimensions, together with their matching weight scores, were consistent with the assessment of alternative of mass transit development plan as defined in **Tables 1-4**.

The alternatives for the main transit system considered under the appropriate alternative of the Smart mass transit development plan, assessed previously, were Road Program (Alternative 1), Railway Program (Alternative 2), and Road and Railway Program (Alternative 3). Noting that at this program level, no action was not proposed as alternative since the program alternatives were considered for the proposed appropriate plan. The impact level of each alternative was comparatively assessed and is presented in **Table 6**, as following explanation.

a) Economic Dimension

The impact levels of the three alternatives on investment worthiness were insignificantly different since the investment of these three alternatives were not significantly diverse. However, the Alternative 1 indicated a slightly higher positive impact than Alternative 2 and Alternative 3, with impact scores of 0.6, 0.4, and 0.5 respectively. This suggests that the road system seems to be the most practical alternative for Thailand. In contrast, Alternative 3 generated a slightly higher positive impact on the enhancement of economic growth compared to Alternative 1 and Alternative 2, with scores of 0.7, 0.6, and 0.5 respectively. This is because the integration of road and railway systems would momentously enhance the accessible transit of goods and people, promoting economic growth. Similarly, Alternative 3 generated a significantly higher positive impact on potential income generation compared to Alternative 1 and Alternative 2, with scores of 0.8, 0.6, and 0.4 respectively due to the integration system of railway and road system enhancing economic growth, which in turn results in potential income generation.

b) Social Dimension

Undoubtedly, Alternative 3 would provide adequacy and accessibility to various sources rather insignificantly compared to Alternative 1, but significantly compared to Alternative 2, with impact levels of 0.9, 0.7, and 0.3 respectively. Regarding the safety of transportation, Alternative 2 would generate a positive impact level insignificantly compared to Alternative 3, but significantly compared to Alternative 1, with scores of 0.8, 0.7, and 0.5 respectively. Similarly, concerning the traffic volume, the impact level of Alternative 2 compared to Alternative 3 and Alternative 1 were 0.8, 0.7, and 0.4 respectively. This is because the impact of traffic volume directly affects the road system resulting in either high negative impact or low positive impact levels. Additionally, Alternative 2 would positively impact the enhancement of greenery along the road and the route slightly more than Alternative 3, and higher than Alternative 1, with scores of 0.7, 0.6 and 0.4 respectively. This is because the railway system would create more beautiful scenery compared to the road system, which may result in disordered scenery along the route.

Table 6 Assessment of alternative of main mass transit system

Indicators	Weight Score	Alternatives					
		Road program		Railway program		Road and railway program	
		Impact level	Impact score	Impact level	Impact score	Impact level	Impact score
Economic Dimension:							
A	13.88	0.6	8.33	0.4	5.55	0.5	6.94
B	9.71	0.6	5.83	0.5	4.86	0.7	6.80
C	9.71	0.6	5.83	0.4	3.88	0.8	7.77
Total score (d)			*19.98*		*14.29*		*21.51*
Social Dimension:							
D	9.02	0.7	6.31	0.3	2.71	0.9	8.12
E	10.41	0.5	5.21	0.8	8.33	0.7	7.23
F	9.71	0.4	3.88	0.8	7.77	0.7	6.79
G	4.16	0.4	15.40	0.7	18.80	0.6	19.29
Total score (f)			*30.81*		*37.60*		*41.43*
Environmental Dimension:							
H	11.1	0.4	4.44	0.8	8.88	0.6	6.66
I	9.71	0.5	4.86	0.8	7.77	0.6	5.83
J	8.33	0.6	5.00	0.7	5.83	0.65	5.41
K	4.16	0.5	2.08	0.7	2.91	0.65	2.70
Total score (g)			*16.38*		*25.39*		*20.60*
Total score *(d+f+g)*		67.17		77.28		83.54	
Percentage of each alternative		**29.46**		**33.90**		**36.64**	

c) Environmental Dimension

Pollution generated by the mass transit system includes air pollution and climate change, noise pollution, and vibration. The road system can be expected to produce such pollution at a higher negative impact level or lower positive impact level compared to the railway system. The impact levels were positively assessed for Alternative 2, Alternative 3, and Alternative 1 as 0.8, 0.6, and 0.4 for air pollution and climate change, and 0.8, 0.6, and 0.5 for noise pollution and vibration, respectively. Regarding the ecosystem aspect, the impact level of these three alternatives would not be significantly different, as the mass transit system would be constructed along the same route, where efforts should be made to avoid disturbing the ecosystem (Including forested areas and wetlands). The impact would be at a moderate level, with scores of 0.7, 0.65, and 0.6 for Alternative 2, Alternative 3, and Alternative 1, respectively. Similarly, the impact level of these three alternatives on town scenery would not be significantly different, with scores of 0.7, 0.65, and 0.5 for Alternative 2, Alternative 3, and Alternative 1, respectively.

The assessment of the impact score of these three alternatives on indicators under each dimension detailed in **Table 6**, indicates the total impact score is ranked as 36.64%, 33.90%, and 29.46% Alternative 3, Alternative 2, Alternative 1 respectively (**Figure 4**). The appropriate alternative identified is the road with railway as the main mass transit system.

Fig. 4 Assessment of alternative of the main mass transit system

3.3 IEE for the project level

The alternatives at project level as for the minor mass transit system were proposed as shown in **Figure 2.** Since the appropriate alternative at the program level assessed above was road with railway being developed in the future. The alternatives for the minor transit system will be studied in the later phases. At this moment, the first phase of mass transit system development would be considered only for road system under the smart development plan. This paper therefore presents only the road system as for Muang Uttaradit- Lab Lae District by proposing Alternative 1.1 and Alternative 1.2 of which description is stated in Table 7. This presentation would like to illustrate how EA employed for the Mass transit system from the plan, program to the project of the road system.

Table 7 Minor Mass Transit System

Minor	Alternative	Description	Route
1	1.1	Highway 102 towards the west and further to Highway 1041. This route occupies with likely dense community and likely heavy traffic volume	Muang Uttaradit to Lab Lae District
	1.2	New route development with shorter distance than route 1.1 having the potential development to be the main route in future	

Indictors of environment and social dimension with abbreviations are shown in **Table 8.** Indictors of environment and social dimension will be multiple with weight. The comparison of alternative impact scores shown in **Table 9**, by used data for reviewed from the map as well as the survey of area and compared of Alternatives 1.1 and 1.2 with the impact level designated as previously mentioned.

Table 8 Indicators of environmental and social dimension

Indicators	Abbreviations
1. Hydrology (Number of water resources)	L
2. Air quality, noise pollution and vibration level (Number of sensitive sources)	M
3. Erosion and sedimentation (Elevation and slope)	N
4. Terrestrial ecology (Forestry area)	O
5. Land use (Community and agriculture area)	P
6. Transportation and safety (Curve road)	Q

The impact scores were computed as the same method used for alternatives of SEA mentioned in the previous section. The comparing results of impact score of Alternatives 1.1 and 1.2 are presented in **Table 9**. Both alternatives will bring to further evaluate with other two dimensions; engineering and economic dimensions. Noting that the alternative with higher score under the environmental with social dimension might not be the decided one after combining results with other 2 dimensions. The highest score of total score of 3 dimensions (Engineering, economic and environment with social) will be the feasible project of the feasibility study. If the road type and location are in the list of EIA designated by the Office of Natural Resources and Planning, EIA will be further carried out.

Table 9 Comparison of alternatives impact scores

a) Weight score of indicators of environmental with social dimension

Indicators	L	M	N	O	P	Q	**Total score**
L	0	3.0	2.5	3.0	2.5	3.0	
M	1.0	0	1.5	2.5	2.5	2.5	
N	1.5	3.0	0	2.5	3.0	2.5	
N	1.0	1.5	1..5	0	1.5	2.5	
O	1.5	3.0	1.0	2.5	0	2.5	
P	1.0	1.5	1.5	1.5	1.0	0	
Total	*6.0*	*12.0*	*8.0*	*12.0*	*10.5*	*13.0*	*61.5*
Weight score	**2.93**	**5.85**	**3.90**	**5.85**	**5.13**	**6.34**	**30**

b) Comparison of number and character of indicator

Indicator	**Alternative 1.1** (Number)	**Alternative 1.2**	**Remark**
L	8	6	
M	6+6+1=13	5+3+3=11	
N	105-110	105-110	- Likely plain area
O	3%	3%	- Some trees along the route
P	- Community area 85 % and agriculture area 15%	- Community area 90 % and agriculture area 10%	
Q	Less	More than	

c) Comparison of alternatives impact scores of minor mass transit system: Muang - Lablae District

Indicators	**Weight score**	**Alternative 1.1** Impact level	Impact score	**Alternative 1.2** Impact level	Impact score
L	2.93	0.5	1.47	0.7	2.05
M	5.85	0.5	2.93	0.6	3.51
N	3.9	0.7	2.73	0.8	3.12
O	5.85	0.8	4.68	0.85	4.97
P	5.13	0.6	3.08	0.7	3.59
Q	6.34	0.6	3.80	0.8	5.07
Total score			**18.69**		**22.31**

Remarking that;

a) weight score of indicators of environmental with social dimension: was computed by (Total score of each indicator/ Total score) (30), where 30 is the weight score of environmental with social dimension.

b) number of environmental with social indicators considered as the receptors being impacted by road (see Table 8). Number of receptors were compared between Alternatives 1.1 and 1.2, resulting as impact level.

c) Impact score computed by impact level multiplied with weight score, being compared between alternatives. Impact scores of Alternatives 1.1 and 1.2 were 18.69 and 22.31, respectively.

4. Conclusion

Application of EA for the mass transit system of Uttaradit province Thailand was as follows; SEA employed for the strategic (plan and program) level, and IEE employed for the project level. For the plan level, SEA had been applied to the mass transit system development plan, as well as the main mass transit program under the appropriately assessed development plan. IEE study had been undertaken at the minor mass transit system as the project level derived from the appropriately assessed alternative of the program. SEA study was performed by developing the feasible alternatives; designating and weight scoring of indicators under three sustainable: economic, social, and environmental dimensions; assessing the impact level of alternatives on such indicators; assessing the impact sore of alternatives on such indicators, and summing the impact score of all indicators of the feasible alternatives. The alternative with the highest impact score would be considered as the appropriate alternative.

Regarding the economic dimension, the designated indicators included investment worthiness, enhancement of economic growth, and potential of income generation. The designated indicators under social dimension included adequacy and accessibility to various sources, safety of transportation, traffic volume, and enhancement of greenery along the route. For the environmental dimension included air pollution and climate change, noise pollution and vibration, ecosystem (forested areas and wetlands), and town scenery.

The mass transit development plan includes three feasible alternatives: No action alternative 1, Conventional plan alternative 2, and Smart plan alternative 3. Following the impact assessment process, Smart plan alternative 3 was appropriate one. Similarly, the main transit system offers three alternatives under the Smart plan development: road system, railway system, and road with railway system. Following the same impact assessment process, road with railway system was the appropriate alternative at the program level. However, this program level had been considered for the future phase. For the first phase, the road system was used for IEE study.

IEE was carried out under the feasibility study concept consisting of engineering, economic, and environment with social dimensions. Only environmental with social dimension was studied. Assessing the alternative had employed the same procedure of SEA. Indicators included hydrology, air quality, noise and vibration, erosion and sedimentation, terrestrial ecology, land use, transportation, and safety. Noting that impact score of alternatives had to bring to combine with other 2 dimensions (engineering and economic) to make decision on feasible alternative for further detail design. EIA study for the feasible alternative as project would be required by regulation. Following the SEA steps, the appropriate alternative plan was the Smart Plan (Smart and environmentally friendly mass transit development plan), the appropriate alternative program identified was the road and railway system. IEE study for the road system would be brought to combine with engineering and economic dimensions for final decision. Conclusively, this paper would like to present how EA applied to the strategic level; SEA plan and program, and IEE for the project level.

5. Recommendation

This paper outlines the application of the SEA at the plan and program levels, following IEE applied at the project level. SEA study focused primarily on the development and assessment of alternatives under the economic, social and environmental dimensions. While this study did not follow the entirety of the SEA process, it does provide a detailed look at the key steps relevant to the mass transit system within the broader context of "The Roadmap Developing for Intelligent and Environmentally Friendly Transportation of Uttaradit Province". This SEA application was carried out concurrently with other studies, engineering, economics, social participation, and town planning. Stakeholder participation in the full study was facilitated through periodic participation sessions which employed brainstorming and consultations with researchers, advisers, and SEA experts. To better understand the SEA process, it is necessary to consult the SEA Guidelines developed by the National Economic and Social Development Council, 2024. In addition, IEE applied for this study had employed the concept of feasibility study. SEA and IEE application would be the study model for other strategic development plans.

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