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Article

Ex-post Evaluation Framework of Transportation Infrastructure Projects in Thailand Applying the OECD-DAC's Evaluation Criteria

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Abstract. Ex-post evaluations are conducted only on rare occasions despite their significant potential for utility. Such evaluations ascertain whether projects have fulfilled the anticipated benefits at the outset and discern which projects have outperformed or underperformed expectations, along with the underlying reasons. This paper describes the methodological framework chosen for the ex-post evaluation of completed transportation infrastructure projects. A comprehensive framework assessing the effects of a transport project across six dimensions: Relevance, Coherence, Effectiveness, Efficiency, Impact, and Sustainability has been formulated and elaborated as part of an ex-post evaluation methodology. This framework encompasses a classification of impacts associated with investment projects in the transportation sector. Then, the framework for the ex-post evaluation was applied to evaluate the case studies of seven highway projects executed by the Department of Highway, Ministry of Transport, Thailand. The ex-post evaluation results for these case studies found that seven projects were ranked at a very good level. The criteria of efficiency were the aspect with the highest score from the evaluation results, as four projects out of 7 had a total score of 4.00, reflecting the performance of the Department of Highways in using available resources in terms of time and budget efficiently in project development. The criteria of relevance and coherence, as the implementation of the Department of Highways project development, has been consistent with the national development plan, ministry level, and department level and linked to other essential development plans of the country. Meanwhile, effectiveness, impact, and sustainability were criteria with different scores for each project.

Keywords: Transport infrastructure, highway projects, ex-post evaluation, evaluation criteria.

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1. Introduction

Thailand is a country that wants to achieve sustainable economic and social stability; the government must establish clear development goals and directions. It is crucial to integrate development efforts across both the economic and social sectors by creating strategies that align with one another. These strategies should work towards the common goal of improving the population's quality of life. The Ministry of Transport plays a vital role in areas related to the economy, society, public well-being, and national security. Its investments in transportation infrastructure are highly anticipated by both the government and the public as a means to stimulate the economy, create jobs, distribute income, and enhance public safety and security.

The Department of Highways is an agency under the Ministry of Transport that has a role and responsibility in implementing infrastructure projects to develop highway networks covering areas nationwide in order to accommodate the demand for travel and road freight transport, which is continuously expanding. The goal is to provide people using highways with safety, convenience, and speed and to be able to connect to other forms of transportation efficiently. However, since the investment budget for government projects is limited, the economic value of these government investment projects must be considered in order to assess the ability to manage the budget, as well as to use it as a framework for deciding to select investment projects that are appropriate and consistent with investment policies to develop highway networks better, and to make investment projects beneficial and worthwhile. Therefore, project evaluation is essential in investing in projects that will create the most value and benefit the country. Mostly, the government evaluates government investment projects in terms of results according to the plan and project implementation objectives, such as the satisfaction of people in target areas and the results of the projects that occur. However, sometimes, such evaluations cannot reflect the financial and economic value of the investment in the project. Therefore, it cannot measure how worthwhile and beneficial the projects are to the country. In addition, the public and relevant agencies need help seeing the overall benefits of infrastructure projects.

Ex-post evaluation is a valuable tool as it incentivizes decision-makers to ensure good governance and to have a liability towards their decisions. Moreover, ex-post evaluation adds more transparency to the project's outcome. Thus, ex-post evaluation of projects should be assessed more systematically to be a guideline for other infrastructure projects. In particular, evaluation is beneficial for managing authorities to build internal capacity and improve the project selection process [1].

This study defines the methodological framework for the ex-post evaluation of completed transportation infrastructure projects. This framework encompasses a classification of impacts associated with investment projects in the transportation sector. Then, the framework for the ex-post evaluation was applied to evaluate completed projects of the Department of Highways to study and analyze the results and value of the project implementation by using mixed methods of quantitative analysis, that is Cost-Benefit analysis (CBA) and qualitative analysis. The evaluation criteria consist of six dimensions: Relevance, Coherence, Effectiveness, Efficiency, Impact, and Sustainability [2], which can be used for evaluating highway construction projects to consider the appropriate investment policy for transportation projects and to be consistent with sustainable public administration, including investment policies for national development. In this study, seven case studies (completed highway projects) have been conducted utilizing this framework, and the findings from these case studies are subsequently presented.

2. Literature Review

Ex-post evaluation of transportation infrastructure projects is crucial for assessing their efficiency and effectiveness post-implementation. This evaluation encompasses both operational success, which focuses on time and cost performance, and tactical success, which examines the achievement of project goals. For instance, a Norwegian highway project demonstrated operational efficiency with a 2.48% cost underrun while successfully reducing traffic accidents and congestion [3]. Methodologies for ex-post evaluation vary globally, with recommendations for assessments at multiple intervals post-operation to enhance accuracy and knowledge bases. Additionally, studies reveal frequent discrepancies in traffic flow and investment cost estimations, underscoring the importance of ex-post analyses for improving future project feasibility assessments [4]. Furthermore, significant overestimations in capital expenditure and traffic volumes were identified in Poland, highlighting the need for refined ex-ante evaluations [5]. Ex-post evaluations provide valuable insights for future infrastructure planning and investment decisions. Much research has been conducted to analyze ex-post evaluations for infrastructure projects, as shown in Table 1.

To systematically compare ex-post evaluations across different contexts, research articles included in Table 1 were selected based on the following criteria:

- Scope of Evaluation: The study must assess transport infrastructure projects post-completion, focusing on cost, time, safety, environmental, or socio-economic impacts.
- Methodological Approach: Only studies that employ structured ex-post evaluation methodologies, such as before-and-after analysis, benchmarking, or counterfactual comparisons, were included.
- Relevance to Policy and Planning: Selected studies must contribute to discussions on improving ex-ante forecasting accuracy, policy formulation, or transport project investment strategies.

Table 1. Related works.

Authors	Purpose	Methods	Results/Findings	Ref. no.
Gerard de Jong et al. (2019).	- Review literature on ex post project evaluations. - Present methodology for evaluating ten major transport projects.	- Ex post evaluation of completed transport infrastructure projects - Development of a conceptual framework and assessment methodology for evaluation	- Outcomes of ten major transport projects are reported. - Methodology for ex post evaluation is presented.	[1]
Mirhosseini et al. (2023)	- Evaluate project efficiency and effectiveness in highway construction. - Assess operational and tactical success of the project.	- Ex-post analysis in terms of the indicators of efficiency and effectiveness	- Project had 2.48% cost underrun despite cost increases. - Successfully reduced traffic accidents, congestion, and travel time.	[3]
Stepanovic et al. (2022)	- Analyze effects of large infrastructure projects. - Improve efficiency monitoring and cost-benefit analysis.	- Ex-post analysis - Traffic and economic analysis	- Traffic forecast error: -16.42%; investment costs exceeded by 9.3%. - Project's internal rate of return: minimum 7.03% economically feasible.	[4]
Pawel R. Kozubek (2020)	- Identify divergences in road investment properties. - Improve ex-ante analysis quality for investments.	- Ex-post analysis based on selected key parameters - Triple constraint theory considered for analysis of road investments	- Capital expenditure and traffic volumes were overestimated. - Most investments were completed on time, with few delays.	[5]
Vignetti et al. (2020)	- Evaluate ten major transport projects' ex-post performance. - Integrate quantitative and qualitative analysis for decision-making support.	- Mapping, measuring, understanding, and assessing project effects. - Integration of quantitative CBA with qualitative analysis.	- Positive socio-economic return of the investment. - Ex-post CBA supports decision-making processes and policy lessons.	[6]
Sada Hussain Shah (2023)	- Explore conceptual roots and practices of evaluation in development sector. - Analyze linkages between evaluation theory and practice.	- Abductive approach to evaluation practices and mandate. - Discussion of OECD/DAC evaluation criteria.	- Links evaluation theory and practice in development sector. - Highlights importance of OECD/DAC criteria in evaluations.	[7]
Sarmento, J.M., et al. (2017)	- Measure efficiency of highway projects in Portugal. - Analyze technical and technological efficiency over time.	- Data envelopment analysis (DEA) - Malmquist productivity and efficiency indices	- Most highways show reduced technical and technological efficiency over time. - Inefficiencies arise from increased costs and decreased traffic.	[8]
David Meunier et al. (2017)	- Present ex-post evaluation frameworks in Norway and France. - Compare results and provide feedback on ex-ante assessments.	- Standard ex-ante and ex-post evaluation methods. - Comparative analysis of Norwegian and French evaluation schemes.	- Present ex-post evaluation frameworks in Norway and France. - Compare results and provide feedback on ex-ante assessments.	[12]

Authors	Purpose	Methods	Results/Findings	Ref. no.
Sheng Kun et al. (2020)	- Analyze post-evaluation indicators for multi-energy infrastructure projects. - Guide future investment decisions and project management.	- Comprehensive overview of post-evaluation indicators. - Analysis of economic, social, and environmental impacts.	- Comprehensive overview of post-evaluation indicators for multi-energy infrastructure construction processes. - Thorough analysis of indicators for economic benefits, impact on society and environment, and sustainability.	[14]
Griskeviciute-Geciene, A. and Lazauskaite, D. (2011)	- Analyze ex-post assessment process of transport projects. - Determine impacts and long-term effects of projects.	- Economic analysis - Ex-post assessment	- Ex-post assessment determines transport project impacts on regional development. - Economic analysis shows positive results even in pessimistic scenarios.	[15]

While prior research has extensively examined ex-post evaluations of transport infrastructure, this study introduces several key differentiating factors, which represent an additional contribution to the field:

- Comprehensive Evaluation Dimensions: Many previous studies emphasize economic and operational metrics (e.g., cost and time efficiency). In contrast, this study integrates land use transformation, regional development, and social impacts—providing a more holistic assessment tailored to Thailand's infrastructure landscape.
- Application in an Emerging Economy Context: While most ex-post evaluations focus on high-income countries with well-established transport networks, this study applies a global evaluation framework in Thailand, offering insights into how methodologies should be adapted for developing transport systems.
- Multi-Project, Regional Representation: Unlike studies that typically assess a single or limited number of projects, this research systematically selects a diverse set of highway projects across different regions of Thailand, ensuring a balanced geographic representation of infrastructure impacts.
- Policy Integration: Many ex-post evaluations focus primarily on technical performance, while this study connects evaluation findings to local transport policy, advocating for the institutionalization of systematic ex-post assessments within Thailand's national infrastructure planning processes.

By addressing both methodological and policy-level gaps, this research extends the discourse on enhancing transport infrastructure evaluation and contributes to evidence-based policymaking for future projects.

3. Materials and Methods

This section offers a comprehensive and detailed overview of the various data sources and methodologies that have been meticulously employed within the context of this study, specifically aimed at the rigorous evaluation of the transportation infrastructure project situated in Thailand's diverse and rapidly developing landscape.

3.1. Methodology for Ex-post Evaluation

Evaluation is a systematic assessment of a project's efficacy intended for utilization by project proprietors, policymakers, and other involved parties. This process necessitates evaluation proficiency and rigorous scientific methodologies [9]. The timing of the evaluation within the project's lifecycle influences the approach taken and, consequently, the nature of the inquiries posed. These inquiries typically scrutinize the necessity of the project, the theoretical framework underpinning the project design, the execution phase of the project, cost-effectiveness, and the project's results [8-10]. A widely accepted and thorough evaluation framework model utilized by the United Nations and various pertinent organizations, which has received endorsement from the OECD-Development Assistance Committee (OECD-DAC), comprises six criteria, which is shown in Fig. 1 [11].

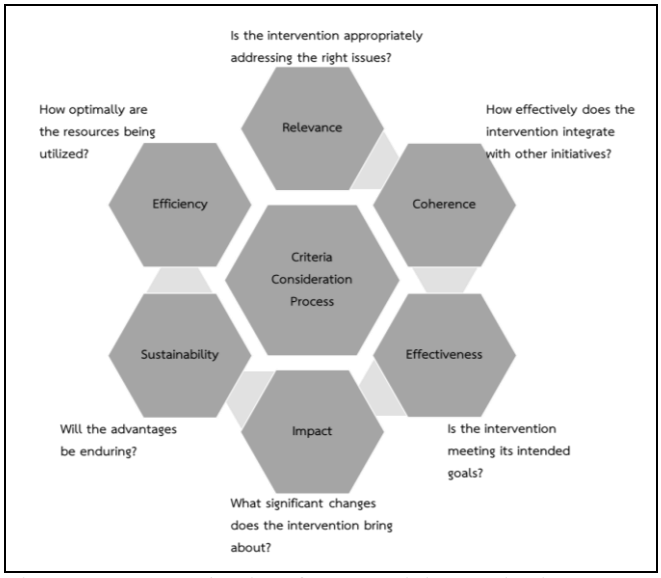

Fig. 1. Project evaluation framework in 6 Criteria..
Adapted from: OECD-Development Assistance Committee (OECD-DAC)

In this study, the evaluation process for completed transportation infrastructure projects has been defined. The evaluation weight must be 100 percent, with the weight proportion in each of the six criteria and the determination of indicators and scoring criteria. The indicators will be set to evaluate the project and reflect both short-term and long-term success. The determination of indicators at various levels must reflect the input factors, the efficiency of the project that relate to process, activities, and steps until the project outputs, and the desired outcomes or goals at different project stages. There are two main types of indicators, Cost-Benefit analysis (CBA) and qualitative analysis, which depend on the characteristics of the expected results of each project and the availability of resources. In addition, guidelines for monitoring and evaluating the project at the overall and individual levels, including obstacles/problems and solutions to the issues, must be established. Only projects that have been completed will be evaluated. Details of the indicators used in evaluating all six criteria according to the project evaluation process/steps mentioned above are shown in Table 2.

The ex-post evaluation for transportation infrastructure projects will be conducted by scoring according to the indicators in Table 2. Then, the overall evaluation score will be summarized, as shown in Fig. 2, to rank the evaluation of each project. The ranking results are set into four levels as follows:

- Very good level (A: Highly Satisfactory): Overall scores greater than or equal to 3.50 indicate that the project operation is well-aligned, has good project efficiency, and has no problems or obstacles in the project implementation.
- Good level (B: Satisfactory): Overall scores greater than 2.50 but less than 3.50 indicate that the project operation is well-aligned, has fair project efficiency, and there are no problems or obstacles in the project implementation.
- Fair level (C: Partially Satisfactory): Overall scores greater than 1.50 but less than 2.50 indicates that the project operation is fair, has fair project efficiency, and has problems or obstacles in the project implementation.
- Needs improvement level (D: Unsatisfactory): Overall scores less than or equal to 1.50 indicate that the project operation is not well-aligned and the project efficiency needs to be improved.

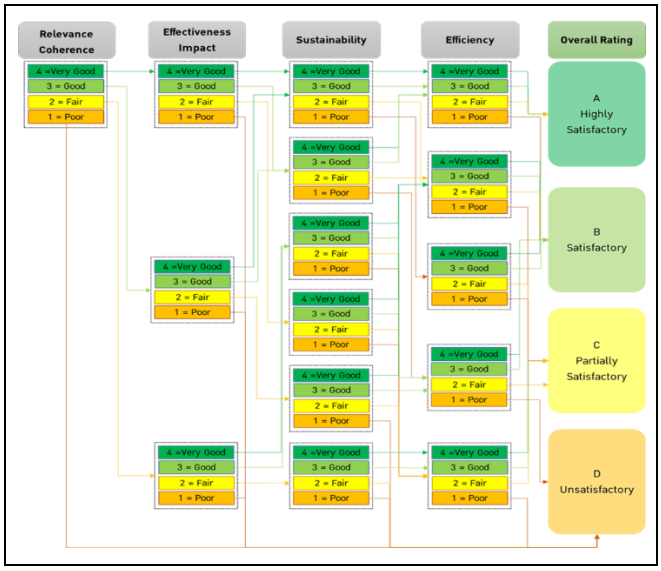

Fig. 2. Flowchart for evaluation rating.
Adapted from: Japan International Cooperation Agency (JICA)

Table 2. Indicators for ex-post evaluation.

Criteria	Indicator	CBA	Qualitative analysis	Description
Relevance	- Plans and policies of Ministry of Transport		☑	Consistency with plans and policies of institution
	- Problem solving		☑	Consistency of problem solving in area
Coherence	- Sustainable Development Goals (SDGs)		☑	Consistency with SDGs
	- National development plans		☑	Consistency with National Strategy (2018-2037)
	- The 13th National Economic and Social Development Plan (2023-2027)		☑	Consistency with the 13th National Economic and Social Development Plan (2023-2027)
	- Asian Highway network (AH)		☑	Links to Asian Highway network
Effectiveness	- Level of Service (LOS)	☑		Comparison of LOS in terms of increasing traffic flow or reducing traffic problems

Criteria	Indicator	CBA	Qualitative analysis	Description
	- Reliability of trip	☑	☑	Evaluation of travel time reliability in the project area by considering Planning Time Index
	- iRAP Star Rating	☑		Assessment of roadway components and traffic conditions related to the risk of death and severe injury in different types of crashes.
	- Number of accidents	☑		Assessment of accident rates in the 3 years before and 3-year period after the project.
	- Road users' satisfaction		☑	Evaluation of road user satisfaction using a 5-level Likert scale evaluation method. The questionnaire was used to collect data from a sample size calculated from the population size of road users (reference from traffic volume) and the citizens living in the project area. The sample size of each project is 210 samples.
	- Impact on the environment	☑	☑	Impact on air quality, noise and vibration, water quality, soil resource, flood control and drainage
	- Impact on landscape and cultural values	☑	☑	Assessment of the impact on landscape and cultural values, especially ancient sites and historical and archaeological sites in the project area.
Impact	- Impact on the local economy		☑	Assessment of the impact on business operations and livelihoods after completing the project.
	- Impact on the community		☑	Assessment of the impacts on communities along the project's side after completion.
	- Number of crimes in the area		☑	The trend of increasing crime in the area
	- Accessibility of healthcare and education		☑	Evaluation of accessibility to health and education systems in the project area after completion.
	- Assessment of road surface condition using assessment form		☑	Based on users' feelings and satisfaction regarding driving on the highway.
	- Assessment of road surface condition using measuring instruments	☑		Assessment of highway surface condition using a Laser Profilometer
	- Road roughness assessment using British Pendulum Tester (BPT)	☑		Evaluation of road friction or skid resistance using British Pendulum Tester (BPT)
Sustainability	- Number of complaints about highway damage/service complaints		☑	Collection of complaints about road surface conditions from the Department of Highways' complaints system to compare the number of complaints from highway users about damage to highways each year.
	- Proportion of complaints that received a response		☑	Proportion of the number of complaints responded to the total number of complaints each year.

Criteria	Indicator	CBA	Qualitative analysis	Description
	- Assessment of the availability/cleanliness of highway facilities		☑	Lane dividers/road edges/road markings, Directional signs/regulatory signs/warning signs, Light bulbs and lighting equipment, Landscaping/encroachment management
	- Processing time compared to contractual time	☑		Comparison of actual project construction duration performance with contract duration using data from project construction reports
Efficiency	- Actual budget compared to contracted budget	☑		Comparison of the efficiency of actual budget utilization in project construction with contract budget using data from project construction reports
	- Economic Analysis*	☑		Economic evaluation compares the project's costs and expenses with the project's benefits (B/C).

** It is a descriptive indicator and is not included in the evaluation score.*

While the OECD DAC criteria are extensively recognized and utilized in the assessment of international development initiatives and increasingly in other domains [13], their application in the transportation sector has been somewhat constrained. Nonetheless, the expanding strategic dimensions of transport investments indicate that ex-post evaluations ought to embrace a comparable approach. The evaluation criteria enumerated in Table 2 are comprehensive and necessitate operationalization to align with specific projects. For instance, political backing and societal endorsement are typically concerns that should be addressed when evaluating strategic effectiveness.

3.2. Selected Projects for Ex-post Evaluation

The assessments in this study integrate quantitative and qualitative data sources to evaluate highway projects in Thailand comprehensively. The Department of Highways, under the Ministry of Transport, systematically collects extensive quantitative data, which is readily accessible to researchers. Key metrics such as construction expenditures, time efficiencies, and traffic safety impacts are well-documented, allowing for a structured analysis. However, certain long-term effects of highway projects may take years to materialize or may not be systematically recorded. To address these gaps, qualitative methods, including interviews and observational studies are employed to complement the quantitative analysis. This methodological triangulation enhances data reliability and provides a more holistic understanding of project impacts.

The selection of highway projects for evaluation follows a structured approach to ensure representativeness and relevance. The study focuses on projects completed and operational for a maximum of 10 years, ensuring that the data reflects relatively recent developments while allowing sufficient time for initial operational effects to be observed. Additionally, geographic distribution is a key consideration, ensuring that the selected projects cover all regions of Thailand to provide a balanced representation of project implementation across the country.

The main selection criteria for the case studies are:

- Opening Year: Projects must have commenced operations between 2012 and 2022 to ensure an appropriate timeframe for evaluation.
- Geographic Distribution: Projects are selected from different regions of Thailand to ensure a diverse sample that captures regional variations in infrastructure impact.
- Highway Type: To maintain consistency in analysis, all selected projects belong to the same highway category. This study focuses specifically on bypass highways, which serve as case studies for evaluating their effectiveness and broader implications.

To evaluate the results of the Department of Highways' operations, 7 highway construction projects that the Department of Highways has completed, covering and distributing to all parts of Thailand, can be selected. The selection results can be summarized in Table 3, and the locations are shown in Fig. 3.

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Table 3. Selected Projects for Ex-post Evaluation.

ID no.	Project name	Project Description	Size (km)	Budget* (Million baht)	Opening year
BNO1501	Phitsanulok Bypass (South) Section 1, Control Section 0102 and Section 2, Control Section 0103	There is an original highway route.	21.850	598.125	2015
BCO1702	Highway No. 367, (Tha Lo Intersection - Kaeng Sean Intersection)	There is an original highway route.	13.154	138.615	2017
BSO1703	Highway No. 421	There is an original highway route.	10.000	306.447	2017
BNE1704	Highway No. 290	There is an original highway route.	28.567	978.906	2017
BNO1805	Chiang Rai Bypass, Section 1 (San Sai Noi - Pa O) and Section 2 (Pa O - Sanambin Intersection)	New highway route	21.039	1,790.970	2018
BNO1806	Mae Sot Bypass with the second bridge over the Moei River, part 4, part 8	New highway route	21.400	3,900.000	2018
BNE1907	Sisaket bypass, Muang Tai - Nong Phai route	There is an original highway route.	10.965	134.900	2019

* Budget at the time of decision to construction

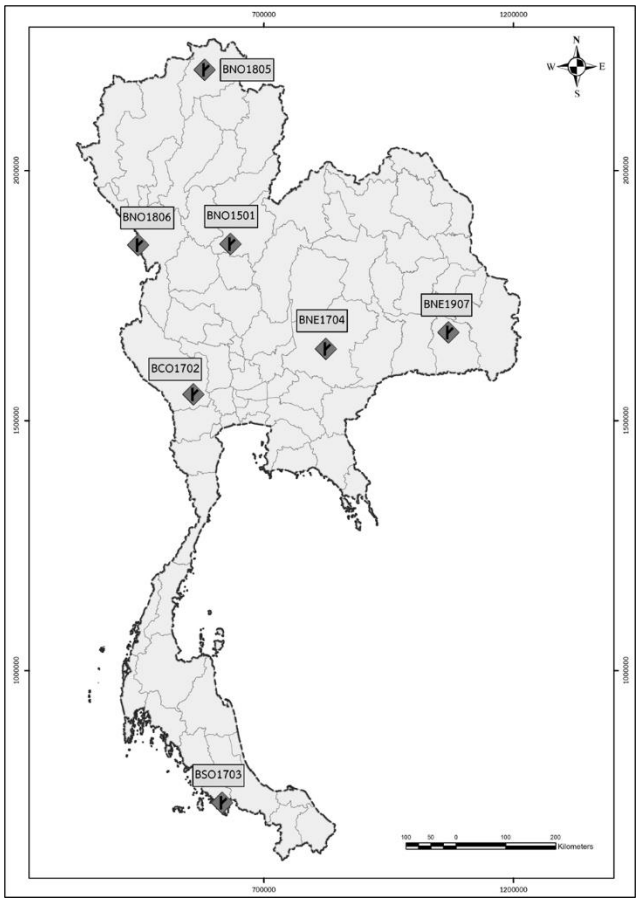

Fig. 3. Overview of the location of the selected projects.

4. Evaluation Results

The evaluation results according to the criteria of all six aspects for completed construction projects of the Department of Highways; when the results were summarized and ranked for evaluating the seven completed construction projects, it was found that seven projects were ranked at a very good level. The criteria of efficiency were the aspect with the highest score from the evaluation results, as four projects out of 7 had a total score of 4.00, reflecting the performance of the Department of Highways in using available resources in terms of time and budget efficiently in project development. The criteria of relevance and coherence, as the implementation of the Department of Highways project development, has been consistent with the national development plan, ministry level, and department level and linked to other essential development plans of the country. Meanwhile, effectiveness, impact, and sustainability were criteria with different scores for each project. However, the ranking results were still good for all seven projects. The summary of the overall evaluation ranking and the evaluation results of each indicator of each project can be summarized in Table 4. Tables 5-9 show the detailed evaluation results of selected project indicators for each aspect, i.e., relevance and coherence, effectiveness, impact, sustainability, and efficiency.

Table 4. Evaluation results of selected projects.

Criteria	Evaluation results						
	BNO1501	**BCO1702**	**BSO1703**	**BNE1704**	**BNO1805**	**BNO1806**	**BNE1907**
Relevance and Coherence	3.20	3.80	3.00	3.20	3.60	3.20	3.20
Effectiveness and Impact	2.97	3.73	2.99	3.07	3.37	3.07	3.51
Sustainability	2.93	3.47	3.73	2.93	3.73	3.47	3.47
Efficiency	4.00	4.00	2.67	4.00	4.00	3.33	3.33
Overall	**A**	**A**	**A**	**A**	**A**	**A**	**A**

Table 5. Evaluation results of selected projects in the aspect of Relevance and Coherence.

Indicator	Score						
	BNO1501	**BCO1702**	**BSO1703**	**BNE1704**	**BNO1805**	**BNO1806**	**BNE1907**
Plans and policies of Ministry of Transport	Consistency	Consistency	Consistency	Consistency	Consistency	Consistency	Consistency
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Problem solving	Consistency	Consistency	Partially	Partially	Consistency	Partially	Consistency
	Score 3	Score 3	Score 2	Score 2	Score 3	Score 2	3 Score
Sustainable Development Goals	Partially	Consistency	Partially	Partially	Consistency	Consistency	Partially
	Score 2	Score 3	Score 2	Score 2	Score 3	Score 3	Score 2
National development plans	Consistency	Consistency	Consistency	Consistency	Consistency	Consistency	Consistency
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
The 13th National Economic and Social Development Plan	Partially	Consistency	Partially	Consistency	Consistency	Partially	Partially
	Score 2	Score 3	Score 2	Score 3	Score 3	Score 2	Score 2
Asian Highway network	Inconsistence	Partially	Inconsistence	Inconsistence	Inconsistence	Inconsistence	Inconsistence
	Score 1	Score 2	Score 1	Score 1	Score 1	Score 1	Score 1

Table 6. Evaluation results of selected projects in the aspect of Effectiveness.

Indicator	Score						
	BNO1501	**BCO1702**	**BSO1703**	**BNE1704**	**BNO1805**	**BNO1806**	**BNE1907**
Level of Service (LOS)	LOS improved by 2 levels	LOS improved by 3 levels	Nothing	Nothing	LOS improved by 3 levels	Nothing	LOS improved by 3 levels
	Score 2	Score 3	Score 1	Score 1	Score 3	Score 1	Score 3
Reliability of trip	Planning Time Index decreased by 28.96%	Planning Time Index decreased by 54.18%	Planning Time Index decreased by 15.76%	Planning Time Index decreased by 15.76%	Planning Time Index decreased by 12.94%	Planning Time Index decreased by 15.47%	Planning Time Index decreased by 25.59%
	Score 2	Score 3	Score 1	Score 1	Score 1	Score 1	Score 2
iRAP Star Rating	3 stars for some users	3 stars for all users	3 stars for all users	3 stars for some users	3 stars for all users	3 stars for some users	3 stars for all users
	Score 2	Score 3	Score 3	Score 2	Score 3	Score 2	Score 3
Number of accidents	Not decreasing	Not decreasing	Not decreasing	Significantly decreased over 3 years	Significantly decreased 1-2 years	Significantly decreased 1-2 years	Not decreasing
	Score 1	Score 1	Score 1	Score 3	Score 2	Score 2	Score 1
Road users' satisfaction	User satisfaction is 66.36%	User satisfaction is 91.00%	User satisfaction is 85.68%	User satisfaction is 68.35%	User satisfaction is 77.20%	User satisfaction is 73.50%	User satisfaction is 85.52%
	Score 1	Score 3	Score 3	Score 1	Score 2	Score 1	Score 3

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Table 7. Evaluation results of selected projects in the aspect of Impact.

Indicator	Score						
	BNO1501	BCO1702	BSO1703	BNE1704	BNO1805	BNO1806	BNE1907
Impact on the environment	Positive impact 72.60%	Positive impact 84.54%	Positive impact 93.13%	Positive impact 81.87%	Positive impact 78.13%	Positive impact 97.29%	Positive impact 73.85%
	Score 2	Score 3	Score 3	Score 3	Score 2	Score 3	Score 2
Impact on landscape and cultural values	Positive impact 98.56%	Positive impact 98.79%	Positive impact 79.17%	Positive impact 92.22%	Positive impact 99.72%	Positive impact 98.61%	Positive impact 91.67%
	Score 3	Score 3	Score 2	Score 3	Score 3	Score 3	Score 3
Impact on the local economy	Positive impact 95.21%	Positive impact 97.27%	Positive impact 98.56%	Positive impact 92.50%	Positive impact 98.33%	Positive impact 97.14%	Positive impact 93.75%
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Impact on the community	Positive impact 84.17%	Positive impact 85.15%	Positive impact 72.50%	Positive impact 88.75%	Positive impact 91.67%	Positive impact 93.55%	Positive impact 83.17%
	Score 3	Score 3	Score 2	Score 3	Score 3	Score 3	Score 3
Number of crimes in the area	Positive impact 90.27%	Positive impact 99.39%	Positive impact 98.33%	Positive impact 94.17%	Positive impact 96.94%	Positive impact 98.88%	Positive impact 92.72%
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Accessibility of healthcare and education	Positive impact 91.25%	Positive impact 97.87%	Positive impact 98.56%	Positive impact 95.83%	Positive impact 96.67%	Positive impact 97.50%	Positive impact 90.00%
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3

Table 8. Evaluation results of selected projects in the aspect of Sustainability.

Indicator	Score						
	BNO1501	BCO1702	BSO1703	BNE1704	BNO1805	BNO1806	BNE1907
Assessment of road surface condition using assessment form	Road surface's satisfaction is 60.71%	Road surface's satisfaction is 91.60%	Road surface's satisfaction is 84.32%	Road surface's satisfaction is 65.20%	Road surface's satisfaction is 77.70%	Road surface's satisfaction is 75.00%	Road surface's satisfaction is 83.60%
	Score 1	Score 3	Score 3	Score 1	Score 2	Score 2	Score 3
Assessment of road surface condition using measuring instruments	Average critical IRI value is 2.83 m./km.	The average critical IRI value is 2.19 m./km.	The average critical IRI value is 2.94 m./km.	The average critical IRI value is 3.19 m./km.	The average critical IRI value is 1.80 m./km.	The average critical IRI value is 2.84 m./km.	The average critical IRI value is 2.42 m./km.
	Score 2	Score 2	Score 2	Score 2	Score 3	Score 2	Score 2
Road roughness assessment using British Pendulum Tester (BPT)	Critical BPN value averaged 47	Critical BPN value averaged 66	Critical BPN value averaged 72	Critical BPN value averaged 51	Critical BPN value averaged 77	Critical BPN value averaged 53	Critical BPN value averaged 79
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Number of complaints about highway damage/service complaints	No complaints	No complaints	No complaints	No complaints	No complaints	No complaints	No complaints
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Proportion of complaints that received a response	No complaints	No complaints	No complaints	No complaints	No complaints	No complaints	No complaints
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Assessment of the availability/cleanliness of highway facilities	Moderate	Moderate	Good	Moderate	Good	Good	Moderate
	Score 2	Score 2	Score 3	Score 2	Score 3	Score 3	Score 2

Table 9. Evaluation results of selected projects in the aspect of Efficiency.

Indicator	Score						
	BNO1501	**BCO1702**	**BSO1703**	**BNE1704**	**BNO1805**	**BNO1806**	**BNE1907**
Processing time compared to contractual time	No request for contract extension	No request for contract extension	The contract extension is 34.12%	No request for contract extension	No request for contract extension	The contract extension is 7.84%	The contract extension is 9.49%
	Score 3	Score 3	Score 1	Score 3	Score 3	Score 2	Score 2
Actual budget compared to contracted budget	Actual budget is less than contract budget	Actual budget is less than contract budget	Actual budget is less than contract budget	Actual budget is less than contract budget	Actual budget is less than contract budget	Actual budget is less than contract budget	Actual budget is less than contract budget
	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3	Score 3
Economic Analysis*	B/C=1.06	B/C=1.59	B/C=1.07	B/C=1.11	B/C=3.18	B/C=1.03	B/C=1.39
	N/A	N/A	N/A	N/A	N/A	N/A	N/A

** It is a descriptive indicator and is not included in the evaluation score.*

The evaluation of the relevance criteria of the seven completed highway projects found that they were consistent with the Thailand Transport System Development Strategy (2018-2037) [16]. The evaluation of the coherence criteria considered the linkage of the project development to essential plans and policies. Seven projects were linked to the Sustainable Development Goals (SDGs) in terms of developing quality infrastructure that is reliable and sustainable, resilient to change, or in terms of being a project that helps reduce the amount of CO_2 emissions in the transport sector in some way [17]. Seven projects were linked to the National Strategy (2018-2037), which is the development of infrastructure projects to increase the country's competitiveness in road transport because the project development can help increase the density of the road network [18]. However, only three projects were linked to the 13th National Economic and Social Development Plan because the projects are located in 4 special economic zones as specified by the National Economic and Social Development Board (NESDB) to focus on supporting investment in infrastructure and developing supporting factors in areas with potential [19].

The evaluation ranking of all seven completed highway projects in terms of effectiveness and impact criteria showed that the evaluation of the effectiveness of each project was different, depending on the project's quantitative and qualitative success. The evaluation of the effectiveness criteria can be divided into three main parts:

1) Effectiveness in the aspect of traffic, including level of service (LOS) and congestion [20]. From the evaluation, 4 out of 7 projects had at least 1 level of improved LOS, indicating increased travel flexibility from the project's increased traffic capacity. Meanwhile, the other three projects remained at the same service level because the original service level before the project development was at LOS A, which is a LOS that allows for smooth speed. Therefore, the project development could not improve the service level. However, when considering the trip's reliability, the traffic evaluation results found that the reliability of the trip Planning Time Index of each project was considered [21-22]. The results found that all seven projects had a Planning Time Index value that was at least 10.00 percent better than the value in the case of no project.

2) Effectiveness criteria in the aspect of safety, including the iRAP Start Rating assessment [23] and the assessment of changes in accident statistics, found that most of the four completed highway projects had a Star Rating assessment for both the passenger car and motorcycle users, which were considered groups, at a level of 3 stars or higher, which is the international safety standard. Similarly, regarding the trend of changes in accident statistics after the completed highway projects, three projects showed a significant decrease for at least 1 year compared to the accident statistics before the project construction. Therefore, in addition to facilitating and simplifying travel for the public using the service, the project development also helps increase safety in travel or using the service for the public.

3) Effectiveness criteria in the aspect of satisfaction are an assessment of the overall average satisfaction level of the users. The study found that most users were more than 70.00 percent satisfied with the five completed highway projects. Two projects had a satisfaction level lower than 70.00 percent due to damage to highway facilities, such as markings on the road surface and traffic signs.

The assessment of the impact criteria of completed highway projects has similar results, with the impacts that people experience being more positive than negative. The impacts on the physical environment, such as dust, noise, drainage systems, and the impacts on the communities surrounding the project area due to the change in travel patterns, are less assessed than other aspects. This is because these are the aspects where the impacts on the people can be seen directly and most clearly. However, the Department of Highways, community leaders, and relevant agencies responsible for such impacts can respond to and solve the problems to reduce the impact on the people.

The sustainability assessment ranking is an important indicator that affects the assessment score, which is road surface quality. Most completed highway projects have a moderate or higher satisfaction score, with two projects having a satisfaction score of less than 70 percent. However, the satisfaction score is still close to 70 percent,

the specified standard. The satisfaction assessment results are consistent with the IRI assessment, where most projects have a moderate assessment result, except for the Project ID: BNO1805, Chiang Rai Bypass, Section 1 (San Sai Noi - Pa O) and Section 2 (Pa O - Sanambin Intersection), which have a good critical IRI value. Because they are new construction projects, the IRI value is higher than that of other projects. However, it can be seen that no project has an IRI value that needs improvement, which is reflected in the assessment results of complaints about highway quality, which found that all seven projects had no complaints about road surface quality from the public throughout the 5-year data collection period. Regarding the availability and cleanliness assessment of highway facilities, all seven projects have ready facilities for service, guideposts, and traffic signs that are not damaged and can be seen or read along the route. The traffic lights are not damaged along the route, including the management of roadside landscape maintenance, and illegal signs are trimmed neatly, not encroaching on the road area. Even if there is damage, such damage does not affect the users' perception, visibility, or safety. That is, even though the traffic signs or traffic signs are blurred in some areas, they can still be seen. The lighting system at risk and at dangerous points can still provide service, and the landscape along the highway does not obstruct the driving vision of the users.

The efficiency assessment is like an assessment of the value of the project development results with the resources and time used in the operation, namely financial or budget resources and time resources or time used in construction. Seven completed highway projects could allocate budgets for construction or development effectively, i.e., the actual construction budget was less than the budget specified in the contract. Meanwhile, the construction time allocation of most highway projects was completed within the specified time frame and without contract extension. There were two projects: BNO1806, Mae Sot Bypass with the second bridge over the Moei River, part 4, part 8 and BNE1907, Sisaket bypass, Muang Tai - Nong Phai route, which requested a contract extension of no more than 10 percent of the original contract period. The Project ID: BSO1703, Highway No. 421, also requested a contract extension of more than 10 percent of the original contract period.

5. Conclusion

This study has demonstrated that ex-post evaluation is a critical tool for assessing the actual performance of transport infrastructure projects, identifying discrepancies between projections and real-world outcomes, and refining future decision-making processes. Given the persistent gaps between ex-ante forecasts and actual results—such as cost overruns, traffic demand mismatches, and unintended externalities, it is essential to investigate underlying causes to improve ex-ante methodologies. Systematic before-and-after analyses offer a practical mechanism to reconcile expected and realized project impacts, thereby strengthening the reliability and credibility of transport project evaluations [24-25].

To enhance the precision, breadth, and legitimacy of transport project assessments, this study has proposed a comprehensive evaluation framework that moves beyond conventional Cost-Benefit Analysis (CBA) [11]. The framework provides a holistic evaluation of infrastructure performance by integrating economic efficiency, social and environmental impacts, land use changes, and regional development considerations. Such an approach aligns with international best practices, where countries like the UK, the Netherlands, and Japan have progressively adopted multi-dimensional evaluation criteria in their transport appraisal systems [26-28]. The increasing recognition of non-economic factors in transport policy—such as equity, sustainability, and resilience—suggests that similar adaptations are necessary within Thailand's transport evaluation system.

From a policy perspective, this study highlights the need for Thai transport authorities to institutionalize ex-post evaluations as a standard practice within project life cycles. While the Department of Highways collects extensive quantitative data, systematic post-completion reviews remain underutilized. Lessons from international experiences indicate that integrating ex-post evaluations into national transport policies can improve accountability, adaptive policymaking, and better-informed investment strategies [29]. To support this, regulatory frameworks should mandate the documentation of ex-ante assumptions, counterfactual scenarios, and long-term externalities to facilitate more robust and transparent assessments.

The findings from this study indicate that only a minority of projects excel across all evaluation dimensions. However, even projects that demonstrate inefficiencies in resource utilization may still achieve acceptable performance when assessed against broader social and regional development criteria. This reinforces the argument that transport project success is multi-faceted, requiring evaluation frameworks that extend beyond economic cost-effectiveness. Future research should address the practical challenges associated with conducting ex-post evaluations, such as ensuring data availability, developing standardized performance indicators, and improving methodological consistency.

By embedding evidence-based learning into Thailand's transport infrastructure planning, policymakers can enhance project transparency, improve forecasting accuracy, and optimize future investments. Expanding the scope of evaluations to align with global best practices will contribute to more resilient, equitable, and sustainable transport infrastructure in Thailand and beyond.

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