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Structure of Infrastructure Project Selection Criteria in Indonesia: A Systematic Approach

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Abstract Infrastructure project selection is a challenging decision-making problem. While previous literature has pointed out relevant criteria for infrastructure project selection, these criteria need to be contextualized for the effective selection of appropriate projects. This paper aims to identify these criteria in an Indonesian context. A systematic literature review was adopted to identify infrastructure project selection criteria from both local and international practices. It was coupled with twenty semi-structured interviews to draw knowledge and experiences from the Indonesian experts. Finally, a questionnaire survey was distributed and the data was analyzed using factor analysis to obtain the underlying structure of infrastructure project selection criteria. The review of literature outlined 23 selection criteria, out of which 19 criteria were considered important in the Indonesian context. Factor analysis further produced a structure of selection criteria that comprises of five major components: technical criteria, administrative criteria, strategic fit criteria, risks & politics criteria, and innovation. This study contributes by structuring infrastructure project selection criteria that also marks the transitional change from a conventional to a modern decision-making technique as adopted in Indonesia. Thus, it provides a useful reference for decision makers in making a context-based infrastructure project selection.

Keywords Decision-Making Process, Indonesia, Infrastructure, Selection Criteria, Systematic Research Approach

1. Introduction

As the largest economy in Southeast Asia, the Indonesian government is fully aware of the reciprocal relationship between infrastructure development and economic growth. However, there has been an infrastructure deficit as well as challenges such as limited investment resources and poor budget allocation. To address these issues, it is imperative that government agencies in Indonesia continually explore new breakthroughs. One possible breakthrough is the need to explore innovative project selection in infrastructure decision-making process for infrastructure project selection. The selection of infrastructure projects in Indonesia is not yet managed optimally with many internal and external challenges including poor identification of strategic needs, coordination problems, politicized decision-making, and the absence of infrastructure project selection framework[1]. Better approaches to decision-making practices for infrastructure project selection are, therefore, indispensable for achieving strategic objectives of infrastructure development. The development of many modern decision-making techniques may provide an opportunity for developing a Decision-Making Framework (DMF) for infrastructure project selection.

As a decision-making tool, a DMF will consist of (1) identification of project proposals, (2) establishment of

selection criteria, and (3) establishment of priority list based on the assessment. This paper focuses on the second step, i.e. establishment of key criteria in selecting infrastructure projects. Identifying the appropriate key selection criteria is perhaps the most crucial step in developing this framework. These criteria will be used to assess the project proposals[2] and may include financial criteria, technical criteria, risk-related criteria, resources-related criteria, contractual conditions criteria, and qualitative criteria[3]. Other previous studies have also discussed different types of selection criteria which may differ one another[4,5] depending on the study context.

Due to its importance, the establishment of selection criteria should follow a systematic process. This paper aims to analyze these criteria comprehensively using a mixed method approach. Thus, the validity and transparency of criteria establishment for infrastructure project selection can be ensured. The main contribution to the body of knowledge is the use of a mixed method approach to identify the underlying structure of infrastructure project selection criteria in the Indonesian context. These criteria can then be integrated into a DMF for further studies. Meanwhile from a practical perspective, this study provides a useful reference for decision makers—particularly from the relevant ministries, in selecting their preferred infrastructure project proposals.

2. Literature Review

This study conducted a comprehensive literature review to investigate existing project selection criteria within the infrastructure sector. It focused on identifying infrastructure project selection criteria that may enhance the decision-making process by relevant infrastructure agencies. This review has identified two research gaps within this study area. First, a study that analyzes the criteria for selecting infrastructure projects within a decision-making context is required. There has been a considerable amount of research on project selection criteria within the infrastructure sector [4-8]. According to Frame[3], these criteria can be grouped based on their commonalities such as technical criteria, risk-related criteria, financial criteria, and qualitative criteria. Other studies provide different set of criteria depending on the decision-making context involved [4-5]. These criteria are used as evaluating criteria when assessing project proposals[2].

While helpful, these criteria must be selected and refined in a specific decision-making context in order to be appropriately used as a tool in making selection decisions. Similar to this, Eid and El-adaway[9] argues that in the development of a proper DMF, accurate representation of the decision-making context is required. However, acquiring the right information about the influencing criteria within a specific decision-making context is not easy. Previous study has found the positive relationship between contextual information and decision judgments[10]. A comprehensive study is required to obtain this contextual information.

On the other hand, the establishment of selection criteria is crucial to provide a transparent decision-making process[11]. Therefore, the establishment of these selection criteria should follow a systematic process to ensure their validity and transparency[8]. It can be qualitative and quantitative in nature[12]. While there have been previous similar studies, most of them focus on the selection technique rather than on identifying the appropriate selection criteria for infrastructure project selection[8]. Therefore, efforts should be made to obtain an extension of the sample to increase the generalizability of the results and to confirm their application to specific contexts only[13]. This study provides an answer to these existing gaps by carrying out a context-based research that adopted a mixed-method approach as a way to improve the quality of the identified selection criteria.

3. Methodology

As a systematic research, this study adopts both incremental qualitative and quantitative approaches to identify and establish the criteria relevant to Indonesian decision-makers. It started with identification of selection criteria for infrastructure project proposal based on qualitative approaches, i.e. systematic literature review followed by semi-structured expert interviews. The identified selection criteria were then reviewed, combined and discussed with other academics before they were included in the survey. The questionnaire was then developed and tested to five pilot respondents to ensure its face and content validity. The feedbacks were reviewed and used to refine the survey form. Then, questionnaires were distributed using both online and offline means that allowed researchers to capture opinions from a wider group of respondents regarding the use and importance of the preliminary set of criteria. Finally, the gathered data was analyzed and discussed in this paper.

3.1. Systematic Literature Review

A systematic literature review was carried out to identify infrastructure project selection criteria from both local and international practices. It consisted of five steps as prescribed by Chan and Owusu[14]. Table 1 presents these steps and the strategies adopted in this study. A total of 34 selection criteria used in making decision regarding infrastructure project investment was identified[8]. These findings were discussed further in the context of selecting infrastructure projects in Indonesia through expert interviews.

3.2. Semi-Structured Expert Interviews

Insights from expert respondents were obtained through semi structured interviews. The interview tactics consists of eight steps as shown in Table 2 below. Since it is crucial to design the right interview questions, a matrix form of interview questions development is presented in Table 3. Twenty interviews have been conducted with respondents mainly from the Indonesian Ministry of Public Works and Housing, the Ministry of Transportation, and the Ministry of National Development Planning. Consolidation of interview analysis and literature review results in 23 selection criteria for infrastructure project proposals in Indonesian context. These criteria were used as input in the questionnaire survey distributed to a wider group of respondents in Indonesia.

Table 1. Systematic literature review adopted in this study

Step	Strategies	Outcomes
1.Searching for literature sources	Locate peer-reviewed journals with virtual libraries Use only trusted online sources	Target journal sources were ASCE library, Emerald Insight, Taylor & Francis, ScienceDirect, Wiley Online Library, and SAGE Other online sources including government agency and institution websites
2.Searching for related literature	Use keywords to perform search engines	Keywords used: selection criteria, decision criteria, decision parameters, infrastructure projects Retrieved 105 publications
3.Selecting relevant literature	Visual examination through skimming	Read the abstract or summaries Selected 30 publications for analysis
4.Analyzing the content	Use thematic content analysis	Grouped the findings based on common themes Synthesized to establish patterns and relationships
5.Reporting the findings	Discuss the findings	34 criteria used to select infrastructure projects from local and international perspectives

Table 2. Interview tactics adopted in this study

Step	**Strategies**	**Outcomes**
1.Interview draft development	Design interview questions & protocol	A list of interview question was developed Interview protocol was developed
2.Pilot interview	Conduct a pilot interview	A pilot interview has been conducted to ensure the clarity of interview questions and protocol and feedbacks were used to improve the questions
3.Sample size determination	Establish respondent criteria Use saturation technique	Expert criteria used were: construction professionals, a minimum of 5-years of experience, majored in construction-related discipline, and having experience in infrastructure project planning Keep doing interviews until reached saturation
4.Execution	Conduct the actual interviews	20 interviews have been conducted within 4 months Average interview duration is 48.45 minutes Average working experience is 13.63 years
5.Transcription	Transcribe the records	20 interview transcripts were done
6.Translation	Translate the interview transcripts	20 interview translations were done from Bahasa Indonesia into English
7.Analysis	Use NVivo software Use thematic coding analysis	Interview transcripts were transferred to NVivo 12 Observed and coded the interesting responses and then grouped them into categories based on common themes Established relationships between categories
8.Discussion	Synthesis and reporting	23 criteria used to select infrastructure projects in the Indonesian context

Table 3. Interview questions development matrix

No	**Interview Questions**	**References**
1	What is your current practice in making decisions related to infrastructure project selection?	[15-17]
2	Is there any procedure, technique, tool, etc. available to help you make decisions or select the project proposals?	[18-20]
3	What are the criteria for selecting and prioritizing infrastructure project proposals?	[3-5]
4	How do you assess these criteria?	[21-23]

Table 4. Preliminary selection criteria

Code	Criterion	Description
F1	The Needs	related to the strategic need and purpose of a proposed project
F2	Conformity	related to the conformity of the proposed project to the National Development Goals and commitments, applicable laws & regulations
F3	Risks	related to the proposed project's level of risks and uncertainties involved
F4	Urgency	related to the urgency of the proposed project to be executed immediately
F5	Private Sector & Community Involvement	related to the level of private sector & public involvement, as well as public attitudes regarding the proposed project
F6	Good Governance	related to the level of good governance implementation of the proposed project
F7	Local Government Issues	related to the local government issues, including the local gov proposals, local gov commitment, local capabilities, etc.
F8	Government policies	related to projects supporting policies taken to solve actual problems that exist in society, including government priority/policies, etc.
F9	Politics	related to the political issues/influences and impacts of a proposed project
F10	Innovation	related to the degree of innovation/added value of the proposed project throughout its life cycle, VE implementation
F11	Design Readiness	related to the readiness of design principles, including life time expectancy, aesthetics requirements, design for safety, functionality, scope of work, constructability, etc.
F12	Funding & Financing	related to the sources of funding, funding schemes, allocation for contingencies, etc.
F13	Preliminary & Feasibility Studies	related to the preliminary and feasibility studies of a proposed project including economic feasibility, financial feasibility, investment studies, socio-cultural impact studies, etc.
F14	Technology Readiness & Transfer	related to the readiness of technology as well as technology transfer of the proposed project
F15	Land Acquisition	related to the readiness to acquire land needed for the proposed project
F16	Team Member & Stakeholder Coordination	related to the degree of alliance among all key stakeholders and team members of a proposed project
F17	Operational & Maintenance Readiness	related to the desired level of operational & maintenance (OM) of the proposed project, including OM schedules, OM planning & control, OM budgets, etc.
F18	Contractual Conditions & Procurement System	related to the contractual conditions and procurement system that will be adopted by the proposed project
F19	Project Scheduling & Programming	related to the readiness of project scheduling and programming, including the availability of preliminary master schedule, etc.
F20	Project Resources Management	related to the resources handling and utilization, including work force, materials, equipment, etc.
F21	Planning Integration	related to the planning integration of a proposed project with other programs planning, including the strategic plans, connectivity plans, priority regions, future expansion, etc.
F22	Existing Infrastructure & Utilities	related to considerations of the existing infrastructure and utility impacts on the proposed project
F23	Sustainability & Environmental Issues	related to the sustainability issues and environmental impacts of the proposed project

3.3. Questionnaire Surveys

Finally, a questionnaire survey was developed and distributed to a larger group of respondents. Findings from literature review and interviews were used as a basis to develop the survey (Table 4). The survey was conducted within four months (July to November 2019) to respondents who met the following criteria: (1) professionals working in the construction industry, (2) having construction-related educational background, and (3) having been involved in infrastructure projects. It was distributed using both online and offline platforms. Online distribution used a web-based survey tool provided by RMIT University called Qualtrics. Meanwhile, offline distribution was also conducted by distributing the survey directly to the respondents in three different events in Indonesia: one international conference and two professional workshops.

The questionnaire consists of three parts: respondent profiles, project profiles, and selection criteria. In the first and second parts, general information was obtained to understand the respondent and project profiles. The third part contains 23 criteria for infrastructure project selection. Here, participants were requested to provide their opinions on a Likert scale of 1 to 10 with "1" being the least important and "10" being the most important. There are 302 responses in total, but only 104 responses are complete and valid for data analysis. This indicates 34.44% of response rate which is within acceptable range to represent the sample[24]. This number is also acceptable for conducting factor analysis[25]. Table 5 below presents the survey respondent profiles.

Table 5. Questionnaire respondent profiles

Profiles	Number	%		Profiles	Number	%
Level of Education				Affiliation		
Bachelor/Diploma	68	65%		Ministries & Gov. Agencies	42	40%
Master	26	25%		Contractors	11	11%
Doctoral	6	6%		Consultants	18	17%
Others	4	4%		Others	33	32%
Total	104	100%		Total	104	100%
Working Experience				Current Job Position		
<5 years	48	46%		Staff/executor	50	48%
5-10 years	30	29%		Junior manager/supervisor	16	15%
10-20 years	12	12%		Senior manager/supervisor	13	13%
>20 years	14	13%		Head of department/director	12	12%
Total	104	100%		Others	13	13%
				Total	104	100%

Table 6. Total variance explained (Extraction Method: PCA)

Comp.	Initial Eigenvalues			Extraction Sums of Sq. Loadings			Rotation
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	10.314	44.841	44.841	10.314	44.841	44.841	8.663
2	2.010	8.739	53.580	2.010	8.739	53.580	8.452
3	1.629	7.081	60.661	1.629	7.081	60.661	6.514
4	1.218	5.292	65.956	1.218	5.292	65.956	2.046
5	1.035	4.499	70.455	1.035	4.499	70.455	1.985

4. Results

Since variables used to evaluate alternatives may sometimes be mutually dependent[26], the preliminary selection criteria could present dependencies which ultimately impact the decisions[7]. Therefore, factor analysis was used to explore the key selection criteria by eliminating these potential interdependencies. It reduces and groups the criteria identified from a large number to a smaller and more critical set[6]. The analysis consists of five steps as below.

4.1. Data Suitability Assessment

A total of 23 selection criteria were used as variables which were represented by the codes F1, F2… F23 as shown in Table 4. A preliminary analysis was done to assess the data suitability for conducting a factor analysis. It can be done by examining the value of the KMO measure of sampling adequacy and Bartlett's test of sphericity[6]. The KMO value for this dataset was .891 which is beyond the minimum requirement of .50. Based on the KMO index acceptability level, it falls into the range of being "great". Meanwhile, the result of Bartlett's test of sphericity was 1,590.89 (p-value <.01). Therefore, the data is suitable for factor analysis.

4.2. Factor Extraction Determination

Communalities reflect the degree of variables variance accounted for by all the factors. Communalities below 0.4 are low and variables below this value may be removed. The lowest communalities value for this dataset was .599 (F14), thus all variables were retained. Next, to determine the number of factor extraction, the criterion defined by Kaiser was used. The analysis extracted five factors for which Eigenvalues were greater than 1 (important). These five factors explained 70.45% of the variance (Table 6).

4.3. Factor Rotation Determination

This study applied promax oblique rotation for the problem because factors are expected to be correlated. Since the sample size is slightly more than 100, this study selected 0.512 as the suppressed factor loading. The analysis presents both the pattern and structure matrices. The pattern matrix is preferable for interpretation. It was found that F13, F19, F20, and F22 are not compiled in any factor (due to the suppressed factor being 0.512). On the other hand, F10 is the only variable representing

Component 5.

4.4. Interpretation

Next step is to interpret the factors. It is done by looking at the factors with their associated variables. Table 7 presents the extracted factors and their associated variables. There are 19 key criteria grouped into five components: technical criteria, administrative criteria, strategic fit criteria, risks & politics criteria, and innovation. These five components represent the key criteria used for selecting infrastructure project proposals.

Table 7. Extracted factors

Components	Codes	Variables/Selection Criteria	Factor loading
1 (Technical criteria)	F15	Land Acquisition	.997
	F12	Funding & Financing	.970
	F11	Design Readiness	.954
	F16	Team Member & Stakeholder Coordination	.817
	F18	Contractual Conditions & Procurement System	.762
	F17	Operational & Maintenance (OM) Readiness	.530
2 (Administrative criteria)	F8	Government policies	.829
	F7	Local Government Issues	.826
	F6	Good Governance	.807
	F14	Technology Readiness & Transfer	.680
	F5	Private Sector & Community Involvement	.673
	F21	Planning Integration	.542
3 (Strategic fit criteria)	F1	The Needs	.898
	F4	Urgency	.870
	F2	Conformity	.835
	F23	Sustainability & Environmental Issues	.670
4 (Risks & Politics criteria)	F3	Risks	.818
	F9	Politics	.671
5 (Innovation criterion)	F10	Innovation/Added Value	.832

4.5. Reliability Analysis

The reliability of the derived factors was checked separately with respect to their associated variables. Hence, the reliability analysis was performed for each component and the results are .917, .855, 817, and .446 for component 1 to component 4 respectively. Component 5 is not required to undergo the reliability test since it has only one variable. The results indicate that all components with the exception of component 4 exhibit good reliability (Cronbach's alpha above .7). Unlike the other three components, reliability test of component 4 indicates bad internal consistency and thus, variable F3 and F9 are potential problems. However, some experts in previous studies suggest to simply report the Cronbach's alpha without deleting the variables with poor consistency. Kline[27] argues that this kind of result is expected to happen for social science data.

5. Discussion

Infrastructure project selection in Indonesia is an annual decision-making process conducted as a means to provide inputs for the national budget. Due to its importance, the process of infrastructure project selection should be carried out objectively and transparently. This study helps to achieve this by assisting the decision makers in identifying 23 factors that influence the infrastructure project selection in Indonesia. These factors were analyzed using factor analysis to refine their level of importance and resulted in 19 key selection criteria. These key criteria were further structured into five major components as presented in Table 7.

Component 1 consists of six factors: land acquisition, funding & financing, design readiness, team member & stakeholder coordination, contractual conditions & procurement system, and operational & maintenance readiness. Land acquisition is still a major challenge in Indonesia since for infrastructure projects that require a considerable amount of land. Funding & financing are important in ensuring capital to fund infrastructure projects. When selecting a project proposal, funding sources from non-governmental budgets are encouraged. Innovative financing schemes such as PPP, credit enhancement tools, new bond instruments have become an important consideration when selecting project proposals. Meanwhile, coordination can be defined as the task of managing dependencies between activities[28]. It is a crucial criterion in selecting project proposals since many problems can be resolved if the stakeholders & team members are actively engaged in FEP and fully integrated into the project team[29]. Design readiness ensures the success of proposed projects. It includes the availability of drawings, specifications, methods, and constructability strategies. OM readiness is also important as a criterion in selecting infrastructure projects in Indonesian context. These factors are all closely related to the technical and operational management of infrastructure projects. Therefore, this component can be termed as technical criteria.

Component 2 includes six factors: government policies, planning integration, private sector & community involvement, local government issues, good governance, and technology readiness & transfer. Government policies play an important role in the development of construction

industry in Indonesia. On the other hand, Indonesia is currently promoting planning integration policy to achieve full coordination between various planning. It is an act of integrating planning processes to ensure various infrastructure projects can become an integrated development in the region. Private sector and community/public involvement are two external forces that may influence the project success. Private sector involvement is encouraged especially in assisting the government to finance infrastructure projects. On the other hand, assessment of public perceptions is an essential consideration in the implementation of infrastructure financing policies. It involves public knowledge, awareness, attitude, and perceptions towards the proposed projects. Public opposition to controversial projects has been found as a primary challenge in project development[30]. Other issues arise such as the local capacity to choose the appropriate projects or to identify their real needs; the local preferences for an alternative, and the local limited resources. Meanwhile, good governance is related to the level of good governance implementation of the proposed project. It may include several aspects such as transparency, accountability, participatory, effectiveness, and equitability. On the other hand, it is important to consider technology readiness and transfer during project selection. These factors all emphasize the administrative policies adopted in Indonesia when selecting infrastructure project proposals.

Component 3 comprises of four factors: the needs, urgency, conformity, and sustainability & environmental issues. Consequently, this component can be considered as strategic fit criteria. First, decision makers have to choose the projects that better fit the needs of their countries or cities. It assesses the level of necessity for proposed projects by asking why these projects are important. Meanwhile, urgency relates to the urgent necessity of a project to be done immediately. Conformity is related to the fulfilment of standards, rules and requirements by the proposed projects. It reflects the project's compliance to NDG, commitments and applicable laws in Indonesia. On the other hand, there is an increased concern about the sustainability and environmental issues in Indonesia. Appropriate infrastructure projects are needed to achieve sustainable development[31]. Hence, decision makers should also consider sustainability and environmental impacts from construction activities.

Component 4 has two factors: risks and politics. Risks and politics are two barrier factors that may influence the selection of infrastructure projects. Infrastructure projects are large and complex projects characterized by high degree of risks and uncertainties involved such as political risks, legal risks, demand risks, financial risks, technical risks, contract risks, and market risks. Thus, it is necessary for the decision maker to ensure that these risks are identified and mitigated during FEP phase. Similarly, tenure and steadiness of political officials are major barriers that can disrupt project development and even result in project cancelations[30].

Component 5 only consists of one factor, i.e. innovation. It refers to the process of creative thinking that generates added values. The degree of innovation influences the success of a project. It is discovered that limited opportunity for innovation can be a major barrier for private sector involvement[30]. The process of innovation was mainly done during the planning phase. It involves creativity manifestation, conceptualization, and strategizing which happens during the planning phase.

In addition to the above discussion, the findings of this study are useful for implementation of infrastructure project selection problems. Parts of these findings have been applied to real project case studies in Pakistan[32] and Indonesia[33].

6. Conclusions

A study which comprehensively identifies and structuring the criteria for infrastructure project selection in Indonesia—the largest economy in Southeast Asia, is not recorded previously. Using a systematic research approach, this study has successfully established 19 key criteria for infrastructure project selection in Indonesian context which are further grouped into five components: technical criteria, administrative criteria, strategic fit criteria, risks & politics criteria, and innovation. These final criteria were established from a bigger set of criteria which have been refined using factor analysis. This identification serves as an initial step in a change of Indonesian decision-making process for infrastructure project selection. The findings help reform the decision-making approach from a conventional to a modern decision-making technique by establishing key selection criteria that can be used as input in the development of a DMF based on MCDM techniques.

Due to a context-based development, this study is limited to infrastructure project selection by Indonesian decision makers, primarily the Ministry of Public Works and Housing. Nevertheless, the methods in identifying and structuring these selection criteria could be adopted by other countries. Overall, this study contributes by establishing criteria for infrastructure project selection which can be used to assist decision makers in making rationalized decisions instead of intuitive decisions. Further research may focus on the development of a DMF or support system that includes the identified criteria to be implemented directly by relevant decision makers. In addition, other influencing factors such as corruption and external influences should also be further investigated through in-depth qualitative analysis.

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