A FRONT END PLANNING DECISION-MAKING FRAMEWORK FOR INFRASTRUCTURE PROJECT SELECTION AND PRIORITISATION IN INDONESIA

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I certify that except where due acknowledgment has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

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Yathā mayhaṃ manoratho nipphanno, evaṃ tumhākaṃpi nipphajjatū"ti.
As my wish has been achieved, likewise, hopefully your wishes are achieved.

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ABBREVIATIONS AND ACRONYMS

AHP	Analytic Hierarchy Process
AHP OS	Analytic Hierarchy Process Online System
APWA	American Public Works Association
Bappenas	*Badan Perencanaan Pembangunan Nasional* (National Development Planning Agency)
BPIW	*Badan Perencanaan Infrastruktur Wilayah* (Regional Infrastructure Planning Agency)
CCO	Contract Change Orders
CDIA	Cities Development Initiative for Asia's Framework
CEM Framework	Cause, Effect and Mitigation Framework
CII	Construction Industry Institute
DG	Decision Gates
Ditjen BM	*Direktorat Jenderal Bina Marga* (Directorate General of Highway)
Ditjen CK	*Direktorat Jenderal Cipta Karya* (Directorate General of Human Settlement)
Ditjen Perumahan	*Direktorate Jenderal Perumahan* (Directorate General of Housing)
Ditjen SDA	*Direktorat Jenderal Sumber Daya Air* (Directorate General of Water Resources)
DMF	Decision-Making Framework
DMT	Decision-Making Tool
DPR	*Dewan Perwakilan Rakyat* (Indonesia's House of Representatives)
DSS	Decision Support System

EFA	Exploratory Factor Analysis
ELECTRE-III	Elimination and Choice Corresponding to Reality III
FEP	Front End Planning
IAAF	Infrastructure Australia's Assessment Framework
IIAF	Infrastructure Investor Assurance Framework
KPPIP	*Komite Percepatan Pembangunan Infrastruktur Prioritas* (Indonesia's Committee for Acceleration of Priority Infrastructure Delivery)
MADM	Multi-Attribute Decision Making
MCDM	Multi-Criteria Decision Making
MNDP	Ministry of National Development Planning (*Kementerian Perencanaan Pembangunan Nasional/Bappenas*)
MODM	Multi-Objective Decision Making
MPWH	Ministry of Public Works and Housing (*Kementerian Pekerjaan Umum dan Perumahan Rakyat*)
MSI	Measurement Scale Independence
MT	Ministry of Transportation (*Kementerian Perhubungan*)
Musrenbang	*Musyawarah Perencanaan Pembangunan* (Planning Development Forum)
NCHRP	National Cooperative Highway Research Program
NDEG	National Development Evaluation Guideline
NSFDSS-I	Non-Structural Fuzzy Decision Support System-I
NSFDSS-II	Non-Structural Fuzzy Decision Support System-II
PAF	Project Assessment Framework
PLTU	*Pembangkit Listrik Tenaga Uap* (Steam Power Plant)

PPK	*Pejabat Pembuat Komitmen* (Commitment Maker Officers)
Renstra	*Rencana Strategis* (Strategic Plans)
SAW	Simple Additive Weighting
SIR	Superiority and Inferiority Ranking
SOEs	State-Owned Enterprises
SPAM	*Sistem Penyediaan Air Minum* (Drinking Water Supply System)
WPS	*Wilayah Pengembangan Strategis* (Strategic Development Areas)

ABSTRACT

The selection and prioritisation of infrastructure projects is an important part of the strategic decision-making process that aligns organisational objectives with project strategies. Organisations undertaking infrastructure development, such as governments or ministries, have to invest many resources to ensure the project success. The Front End Planning phase is crucial, particularly in relation to the project approval and final investment decision, considering that incorrect approaches in the decision-making process can lead to project failure and the organisation's strategic objectives being missed. Therefore, in situations involving complex and uncertain decision-making processes, such as infrastructure project selection and prioritisation, a Decision-Making Framework (DMF) is required to direct the decision-making process. Furthermore, organisations have limited investment resources so there is a need for infrastructure projects to be selected and prioritised based on a particular set of criteria by the decision makers. The selection of these criteria must be done comprehensively by considering the decision-making context to better mimic the decision-making situation and process.

This research aims to develop a model of a DMF for infrastructure project selection and prioritisation that integrates multiple decision criteria in the Indonesian context. It employs a mixed method approach using a multi-sequenced technique. The first sequence captured the current practices and developed the conceptual DMF model. In the second sequence, semi-structured expert interviews were employed to investigate the current decision-making practices related to infrastructure project selection and prioritisation in Indonesia. The third sequence examined the appropriate decision criteria in infrastructure project selection and developed a Decision-Making Tool (DMT) to be incorporated into the proposed DMF model. Finally, the developed DMF was validated through several evaluation strategies including real case study implementations, parallel-forms reliability tests and sensitivity analysis.

This study has succeeded in developing a DMF that can be used by decision makers to assess infrastructure project proposals and make appropriate decisions regarding investment resources allocation. The developed DMF consists of two major aspects that complement each other, i.e. the framework process and the DMT. The framework process has four stages, namely: data input, data analysis, project assessment and final results. Meanwhile, the DMT was developed using a multi-criteria decision-making technique—NSFDSS-II—to facilitate decision makers in assessing the performance of each project proposal.

Throughout the investigation of the actual practices within the infrastructure management agencies, this research provides contributions to the existing knowledge of infrastructure project planning and decision-making practices, including establishment of the Indonesian development planning hierarchy, identification of factors influencing decision makers during the infrastructure project selection process, establishment of necessary selection criteria in accordance with the decision-making context, and development of a technical DMF that is able to provide assessment of the multi-dimensional process of infrastructure project selection and prioritisation. Other findings such as identification of decision approach characteristics, identification of challenges in infrastructure project selection, establishment of key features for the infrastructure project selection framework and elaboration of the changing paradigm provide an advanced apprehension of strategic decision-making issues in the Indonesian context.

In addition to its contributions to knowledge in this field, this research offers a practical guide for Indonesian practitioners by providing a ready-to-use tool for selecting and prioritising infrastructure project proposals. This DMF was designed to improve the decision makers' ability to identify, evaluate and recommend infrastructure investment decisions by infrastructure management agencies such as the relevant ministries. It will be very useful for decision makers in managing infrastructure assets and budget allocation to assist those involved in three major functional areas, namely: (1) planning and program development, (2) budgeting and financing, and (3) engineering (construction and operations). The use of this DMF promotes objectivity and transparency in the decision-making process of infrastructure project selection and prioritisation. While its primary use is to guide future investment decisions, it can also be utilised to assess the performance of past decisions. Hence, it can serve for review purposes against previous budget management policies.

Keywords: *Indonesia, infrastructure, multi-criteria decision-making, NSFDSS-II, project selection and prioritisation.*

CHAPTER 1. OVERVIEW OF THE STUDY

1.1 Introduction

Infrastructure development has considerably contributed to Indonesia's overall national development. In the last few decades, the Indonesian government has implemented various policies to support infrastructure growth such as the acceleration of national strategic projects and the infrastructure equalisation program throughout Indonesia. Nevertheless, there are many challenges confronting the progress of these initiatives in infrastructure development. This is particularly prominent during the Front End Planning (FEP) phase where decision makers are confronted with the challenging responsibility of selecting the most appropriate infrastructure proposal for implementation. This decision is often made in a context where many worthy infrastructure projects are simultaneously competing for limited budget allocation. The lack of guidance of a Decision-Making Framework (DMF) that encompasses clear selection criteria and decision parameters in assessing infrastructure project proposals compounds the challenges involved in choosing appropriate infrastructure project proposals.

This chapter discusses the research background that emphasises the need of developing a DMF that can assist Indonesian decision makers in assessing infrastructure project proposals during its FEP phase. It is followed by the problem statement and the context of the study. Next, the research aim, questions and objectives are established, followed by research contributions and delimitations. The last two sections explain the structure of this thesis and summary of this chapter.

1.2 Background of the Study

As a major economic power in Southeast Asia, the development of Indonesian infrastructure and macro-economics should occur simultaneously, as infrastructure development can lead to economic expansion through its multiplier effect. Economic expansion raises the need to expand the existing infrastructure to distribute the flow of goods and services across the country. The Indonesian government is fully aware of this reciprocal relationship and is actively seeking for ways to improve its infrastructure sector in order to attract foreign investments and create a better business climate for industries. However, there has been an infrastructure deficit in the last few decades as evidenced by the inadequacy of roads, ports, airports, bridges and other strategic infrastructure in Indonesia. The quality of existing infrastructure is also often no longer appropriate.

In addressing these complex issues, the current government is looking for new breakthroughs to improve Indonesia's infrastructure development. In this context, the government has significantly raised the budget allocation for infrastructure development since 2015 as shown in Figure 1.1 (Directorate General of Budget 2020). Another breakthrough is to make a number of State-Owned Enterprises (SOEs) the main infrastructure developers, such as Trans Sumatra Toll Road Project by PT. Hutama Karya (HK), Soekarno-Hatta Airport Rail Link Project by PT. Kereta Api Indonesia (KAI) and Kalibaru Port Project by PT. Pelindo II.

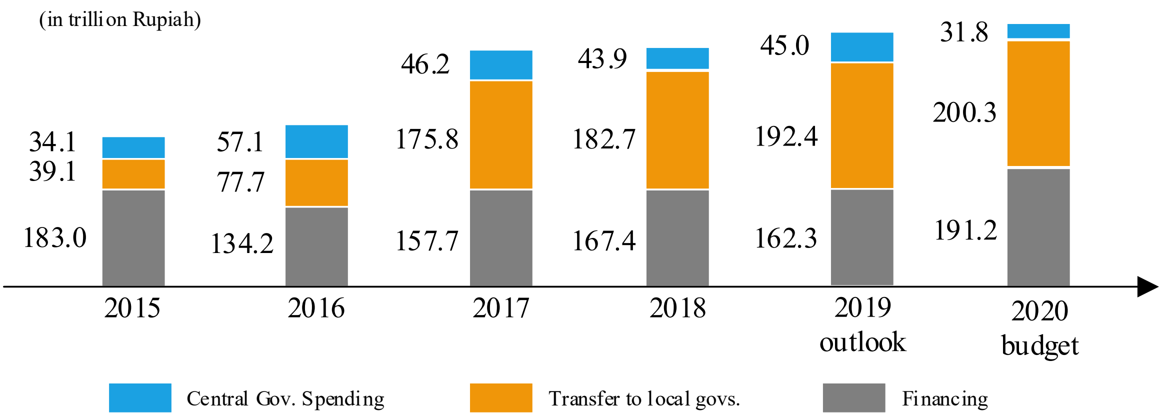


Figure 1.1 Indonesia's infrastructure budget allocation

The Indonesian government has also gazetted the infrastructure development into the list of National Strategic Projects that was revised through Presidential Decree No. 3 of 2016 J.O Presidential Decree No. 58 of 2017. This list consists of 245 projects and two programs with an estimated total investment of IDR 4,197T (USD 309B). These strategic projects cover 15 sectors and the majority of them are related to infrastructure development, i.e. 74 road projects, 54 dam projects, 30 area development projects, 23 railway projects, 12 energy projects, ten port projects, nine water management projects, eight airport projects, seven irrigation projects, six smelter projects, four technology projects, three housing projects, three cross-border post projects, one agriculture/marine project and one sea embankment project. The increasing number of infrastructure projects is expected to stimulate Indonesia's economic growth.

Nevertheless, the Indonesia infrastructure development is confronted with poor Front End Planning (FEP), lack of project funding, improper investment, unsustainable development, regulatory barriers and poor coordination. Adiguna, Dewanti and Odoki (2017) stated that lack of investment fund in road development has resulted in high congestion while lack of budget for maintenance has resulted in the decay of the existing road network. Similarly, KPPIP (2016) mentioned that problems in the preparation phase are often due to poor quality of project planning and limited funding allocation. It also highlighted that further improvements related to regulatory, fiscal and institutional aspects are still urgently needed. All of this has contributed to the poor infrastructure quality and performance in Indonesia as noted in the Global Competitiveness Reports (GCR) from 2012 to 2019 (Figure 1.2) compiled by the World Economic Forum (Schwab 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019).

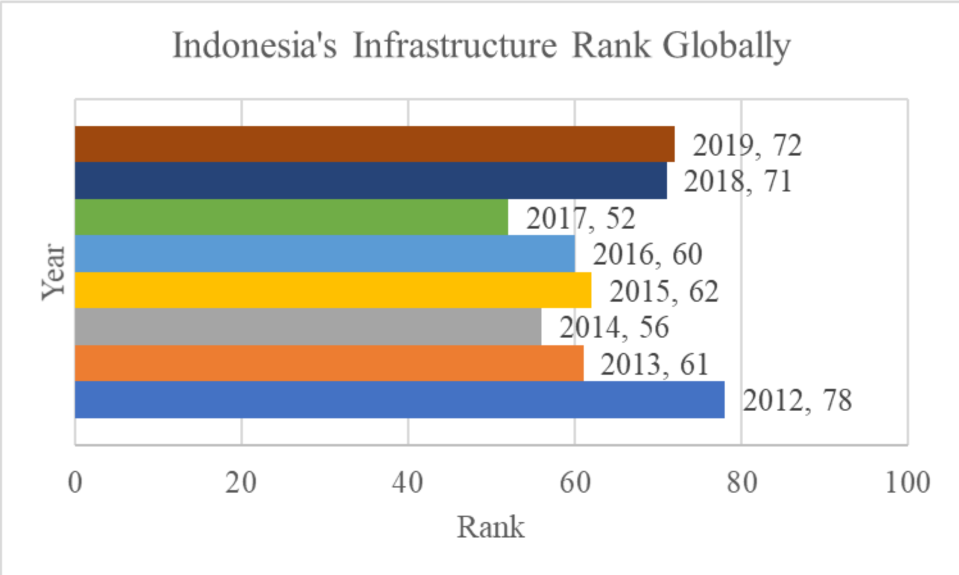


Figure 1.2 Indonesia's infrastructure rank globally

Among those challenges, previous research has shown that an adequate FEP phase has a vital role in better project performance (Griffith et al. 1999; Safa et al. 2013) while a poor FEP phase will lead to project failure. A number of problems related to poor infrastructure performance in developing countries such as lack of analysis regarding the problems and alternatives, unclear infrastructure effects, lack of coordination, miscalculation of costs and overstated benefits (Fay & Yepes 2003; Flyvbjerg 2007; Priemus 2010a) are related to poor FEP. The poor quality of the FEP phase in infrastructure planning eventually results in poor decisions which subsequently have a wider economic impact to the nation (Giang & Pheng 2015). It is therefore crucial for government in Indonesia, and many developing countries, to spend enough resources on the FEP phase. However, Hwang and Ho (2012) noted that professionals in the construction industry do not fully understand the importance of the FEP phase, making it a worthy topic to be studied.

FEP is "the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximise the chance for a successful project" (CII 2014). The final stage of FEP is a decision-making stage that will lead to a final investment decision. While the effect of this stage is crucial, few research projects have been done in this area (Haji-Kazemi, Andersen & Krane 2013; Ceelen 2014). Making an investment decision for infrastructure projects requires full considerations from decision makers and project executives. It is crucial to be able to make an accurate and timely decision so that decision makers do not lose their resources and opportunities. They are required to think creatively in selecting the right infrastructure projects so that available resources are fully utilised for investment in the most appropriate ones. This generates a need for systematic procedures, decision-making frameworks and measures that will foster an improved decision-making process (Mihai, Binning & Dowling 2000).

1.3 Statement of the Problem

Infrastructure project selection and prioritisation is an exacting decision-making process, especially for developing countries such as Indonesia that have limited investment resources to provide infrastructure while also having many competing project proposals, all aimed to accelerate economic growth. Thus, decision makers are required to innovatively allocate these limited investment funds to the most appropriate infrastructure projects so that the strategic objective can be achieved.

The decision to invest in a project occurs in the FEP phase. It is an important phase that defines project scope, selects project portfolio, ensures project preparedness and makes the final decision of project approval. One of the key reasons of project failures is attributed to the lack of attention from decision makers and project teams towards the complexity of the FEP phase (Shenhar & Dvir 2007). The lack of emphasis on FEP includes top management teams not fully understanding project investment decision factors or not having access to such information (Okeke 2011), decision makers making decisions based on feelings rather than facts or analysis (Jeston 2008), project executives rarely performing a risk management strategy (Chenger 2012), and a lack of formal decision-making methods (Cooper 2008). This results in an improper project selection process that ultimately leads to inappropriate decisions and the wrong projects being approved.

To facilitate good infrastructure investment decisions despite constraints due to a limited budget, it is pertinent to have a Decision-Making Framework (DMF) that integrates multiple decision parameters. To ensure that infrastructure projects deliver maximum value in terms of time, cost and quality, as well as social and environmental benefits, these decision parameters should include project costs and benefits, financial capability, technical capability, risk, environmental and safety criteria.

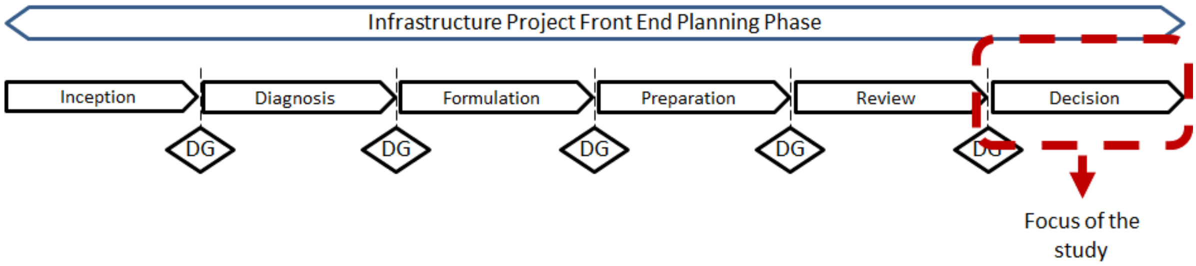


Figure 1.3 Focus of the study

This research highlights the need of an effective DMF model that integrates multiple decision criteria to guide decision makers in the infrastructure project selection and prioritisation process. It focuses on the last stage of the FEP phase (the 'Decision'), where the decision making about project approval is made and committed, as shown in Figure 1.3. The infrastructure sector in the construction industry can benefit from a practical tool to assist in selecting and prioritising project proposals so as to maximise project performance as well as project success. Since a good DMF will produce good decisions, this research pays close attention to how to develop a good DMF and how to validate it.

1.4 Research Context

This research examines infrastructure project selection and prioritisation in the context of the Front End Planning (FEP) phase. It is conducted in a developing country, i.e. Indonesia, which is the largest economy in Southeast Asia. Specifically, this research seeks to develop a DMF model that can be used by decision makers in the relevant ministries such as the Ministry of Public Works and Housing (MPWH) and the Ministry of Transportation (MT). Figure 1.4 illustrates the overall research context of this study.

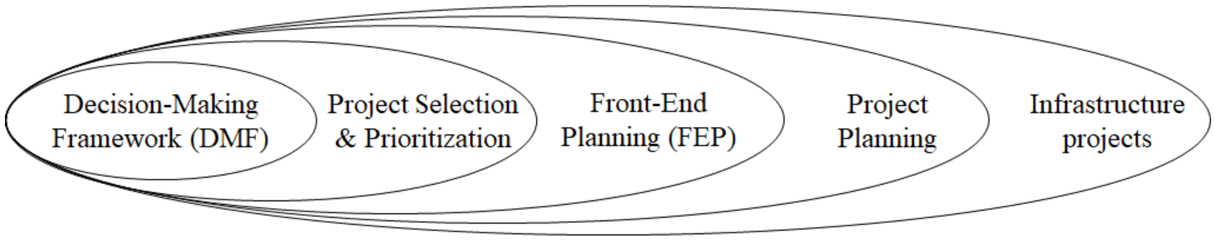


Figure 1.4 The development of research topic in cluster

So far, several studies have attempted to define the definitions of DMF or at least explain the scope of DMF among others:

- A vital managerial tool used to objectively capture diverse views before arriving at congruent decision (Nnaji et al. 2018).
- A DMF consists of a primary approach containing the major decision-making categories and minor approaches linking the subcategories to the main structure (Al-Ali & Filion 2015).
- A tool that allows managers to consider multiple project portfolio selection procedure where individual projects in the portfolio may have interdependencies with each other (Pendharkar 2014).
- A tool to clarify how and when specific participants become involved in key decisions at each stage in a building's life-cycle (Nibel et al. 2005).

Considering the wide scope of the above definitions, this study adopts the definition conveyed by Hansen, Too & Le (2020c) as follows:

> *A structured and systematic approach to problem-solving and decision making in complex situations that serve as a guide for decision makers in attaining their organisational objectives*.

The focus of this research is to provide a DMF model that can be used to:

1. Select and prioritise the most appropriate infrastructure project proposals
2. Support the decision-making process for project approval
3. Provide a strong rationale from the DMF's outputs through the integration of an MCDM technique
4. Communicate and align between the decision makers and other stakeholders involved

This framework will be developed based on the following characteristics:

1. Easy to understand
2. Practical to use
3. Detailed enough to be effective
4. Identify challenges and risks
5. Evaluate decision parameters
6. Relevant and statistically valid
7. Employ an MCDM technique
8. Proven through case study implementations

1.5 Research Aim, Questions and Objectives

The aim of this research is '***to develop a model of Decision-Making Framework for infrastructure project selection and prioritisation that integrates multiple decision criteria***'. It is developed based on the Indonesian context.

To achieve the above research aim, several research questions have been developed:

RQ 1. What are the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection?

RQ 2. What are the key features of a good DMF for infrastructure project selection?

RQ 3. What are the appropriate decision criteria in selecting infrastructure projects?

RQ 4. How can a DMF for infrastructure project selection be developed and to what extent can it be implemented?

From the above research questions, this research has the following objectives:

Obj. 1. To assess the current FEP practices and extent of FEP significance in infrastructure projects

Obj. 2. To investigate the key features of a good DMF for infrastructure project selection

Obj. 3. To examine the appropriate decision criteria in selecting infrastructure project proposals

Obj. 4. To propose a DMF that enhances decision-making efficacy for infrastructure project selection and to investigate the effectiveness of the proposed framework

1.6 Research Contributions

The output of this research is a model of a Decision-Making Framework for infrastructure project selection and prioritisation that is developed for the Indonesian context. The major contribution of this study is the identification, weighting, ranking and validating of infrastructure project selection criteria in the Indonesian context which can assist decision makers to accurately perform FEP regarding the project investment decision problem. Overall, the developed DMF advances the project investment evaluation process by establishing the hierarchical structure of decision problems, compartmentalising the process into four sequential stages, and bridging the gap between infrastructure assessment constraints and overall project selection criteria.

Research contributions to the knowledge

This research can serve as an innovation as opposed to the traditional infrastructure investment planning and decision making that has been applied in developing countries. The result of this study is a model of a Decision-Making Framework (DMF) for infrastructure project selection and prioritisation that integrates multiple decision criteria such as strategic fit, risk, environmental and public involvement criteria. There is no research that holistically and comprehensively develops a DMF for infrastructure project selection and prioritisation in the Indonesian context. The DMF development provides an accurate representation of the decision-making contexts to better mimic the decision actions. Furthermore, this research also contributes by delivering several factors that may influence decision makers in making infrastructure investment decisions.

On the other hand, the application of Non-Structural Fuzzy Decision Support System II (NSFDSS-II) in the development of a DMF for infrastructure project selection and prioritisation has not been studied previously. This method is suitable for answering decision-making problems under complex situations involving uncertainty, multiple decision makers, incomplete information, multiple criteria and alternatives. The comprehensive approach applied in this research can serve as a reference for other similar studies in the development of a DMF model. Finally, this research can be used as a basis for further studies such as the development of Decision Support System (DSS) software.

Research contributions to the practice

The implementation of this framework is expected to advance the quality of the decision-making process for infrastructure project selection and prioritisation. The methodologies and framework developed in this research can be employed by infrastructure management agencies of developing countries (e.g. Ministry of Public Works and Housing, Ministry of Transportation, infrastructure consultants, etc.) in selecting and prioritising infrastructure project proposals. By using this framework, it is expected that decision makers—the infrastructure management agencies—can make solid and valid decisions related to investment in the most appropriate infrastructure projects. The consistency of the decision outputs has been validated in this research through several evaluation strategies such as case study implementations, parallel-forms reliability tests and sensitivity analysis. Thus, this research provides an evidence-based DMF to be used by practitioners.

1.7 Research Delimitations

This research aims at developing a Decision-Making Framework for infrastructure project selection and prioritisation. To achieve this goal, it is essential to make delimitations that are within the researcher's control. These delimitations are discussed as follows.

(1) The focus of this research is directed at infrastructure project proposal assessment in general. The data collected come from various stakeholders involved in infrastructure project planning such as ministries and professionals. Since it is developed for all types of infrastructure projects, the result could be generalised, but some of the identified selection criteria and their associated weights may vary and not be relevant for specific types of infrastructure.

(2) Given the breadth of the infrastructure project planning and selection process in Indonesia, this research limits the scope of study to the ministerial level planning.

(3) Since the research context is for the development of a DMF in Indonesia, the data were collected from the Indonesian construction industry. Thus, the results are mainly applicable to the Indonesian context only, although the DMF development itself can be replicated to other countries.

1.8 Structure of the Thesis

This thesis comprises of the following ten chapters:

Chapter 1 presents an introduction to this research subject, which includes the study background, problem statement, research context, research aim, research questions and objectives, research contributions, description of research delimitations and finally a brief description of the content of each chapter in this thesis.

Chapter 2 reviews the available relevant publications in various fields such as infrastructure development in Indonesia, Front End Planning (FEP), decision-making process, Multi-Criteria Decision-Making (MCDM) techniques and Decision-Making Frameworks (DMF) related to the infrastructure project selection and prioritisation process.

Chapter 3 explains the research methodology and design adopted in this study, which includes detailed discussion around the research philosophy, paradigm, approach and methods as well as research operations.

Chapter 4 discusses the development of a conceptual DMF model for infrastructure project selection and prioritisation. It includes the necessary steps to develop a conceptual DMF model and identification of the required dimensions in a DMF model.

Chapter 5 presents qualitative findings regarding the current practices, issues and challenges of infrastructure project planning, particularly on the project selection and prioritisation process in three different ministries in Indonesia.

Chapter 6 provides quantitative findings regarding the establishment of selection criteria for infrastructure project selection and prioritisation in the Indonesian context. Exploratory Factor Analysis was used to validate the identified selection criteria (from the literature review and interview analysis) and to refine these criteria into several key selection criteria.

Chapter 7 focuses on determining the weighting of each selection criterion for infrastructure project proposals. It employs the Delphi method as a means for conducting pairwise comparisons, followed by NSFDSS-II analysis to obtain the weights of the selection criteria.

Chapter 8 presents the proposed DMF for infrastructure project selection and prioritisation, which consists of two major aspects, i.e. the framework process and the Decision-Making Tool (DMT).

Chapter 9 examines the effectiveness of the developed DMF through several evaluation strategies such as real case study implementations, parallel-forms reliability tests and sensitivity analysis.

Chapter 10 provides discussion and reflections that includes linking theory to practice; highlighting the connections between this research objectives, its findings and the literature; evaluating what have been found in this study; and explaining the relevance of this study. This chapter also presents several research limitations and recommendations for future studies.

Chapter 11 summarises the main discovery of this research against the objectives of this research.

1.9 Chapter Summary

The first chapter outlined the research rationale and context. It also presented the aim and objectives of this research. Research contributions were explained, which included two aspects, i.e. contributions to the knowledge and contributions to the practice. This was followed by a description on the research delimitations that are within the researcher's control. The organisation of this thesis was then briefly outlined. The next chapter reviews the relevant literature used as a basis for understanding this research position in relation to the available knowledge.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The key intention of this study is to develop a Decision-Making Framework (DMF) for infrastructure project selection and prioritisation. The DMF is intended to assist decision makers or the FEP team in making decisions regarding the selection and prioritisation of infrastructure project proposals so that the allocation of available funds becomes more appropriate and optimal. For this reason, this chapter provides the results of a comprehensive literature review of fundamental concepts on infrastructure projects, FEP and decision-making processes. In addition, this chapter also provides an account of previous studies and existing DMFs. Finally, this chapter offers a gap analysis to emphasise the significance of this study's objectives.

2.2 Infrastructure Definition and Classification

Infrastructure services are the foundation for all economic activities that play a vital role in improving people's welfare. The existence of good infrastructure will support the national economic growth by acting as a catalyst in the process (Ma'ruf & Daud 2013); it can therefore be said that infrastructure as physical asset of a nation is vital in providing services to community activities. This is also known as '*public works*'.

However, these terms have been defined in many ways, including:

- *Public works* is "the combination of physical assets, management practices, policies, and personnel necessary for government to provide and sustain structures and services essential to the welfare and acceptable quality of life for its citizen" (the American Public Works Association/APWA 2020, para. 2).
- *Infrastructure* is "(1) the basic structure of an organisation, systems etc., or (2) the stock of fixed capital equipment in a country including factories, roads, schools etc. considered as a determinant of economic growth" (the New Collins Dictionary and Thesaurus 2020, para. 2).

- The Wiley Dictionary of Civil Engineering and Construction, *infrastructure* is "public and private services such as water, telephone, electricity, cablevision, gas, and sewage disposal" (Webster 1997).
- The US National Research Council (1987) defines the term *public works infrastructure* as "… both specific functional modes – highways, streets, roads, and bridges; mass transit; airports and airways; water supply and water resources; wastewater management; solid-waste treatment and disposal; electric power generation and transmission; telecommunications; and hazardous waste management – and the combined system these modal elements comprise. A comprehension of infrastructure spans not only these public works facilities, but also the operating procedures, management practices, and development policies that interact together with societal demand and the physical world to facilitate the transport of people and goods, provision of water for drinking and a variety of other uses, safe disposal of society's waste products, provision of energy where it is needed, and transmission of information within and between communities."

Similarly, experts have different opinions regarding infrastructure classifications. According to Penn and Parker (2011), infrastructure can be grouped into three major parts:

1) Structural infrastructure which includes the institutional buildings, bridges, dams, embankments, retaining walls, etc.
2) Transport infrastructure which includes the roads, mass transits, aviation, waterways, ports, tunnels, and railways.
3) Environmental and energy infrastructure which includes the energy generation and distribution, water supply and distribution, waste water treatment and drainage, storm-water, and solid and hazardous waste treatment.

According to van der Mandele, Walker and Bexelius (2006), infrastructure can be divided into three groups, namely: (1) transport infrastructure, (2) utility infrastructure and (3) information infrastructure. Meanwhile, Uddin, Hudson and Haas (2013) classify infrastructure based on their primary functions and services into seven groups, i.e. (1) transportation, (2) water and waste water, (3) waste management, (4) energy production and distribution, (5) buildings, (6) recreation facilities and (7) communication.

Too (2009) provides a complex classification of infrastructure that comprises several sub classifications with a more broad definition, which include personal infrastructure (related to human capital), physical infrastructure and institutional infrastructure (related to institutional capital). The physical infrastructure is then grouped based on its objectives into three sub classifications, namely: social infrastructure (related to the construction of facilities for social activities such as education and health), technical infrastructure (related to the construction of facilities to support the socio-economic activities) and trade infrastructure (related to the construction of infrastructure for business activities such as factories and offices). Finally, the technical infrastructure is grouped in accordance with van der Mandele et al.'s (2006) classification above.

In this research, infrastructure refers to all of these combined facilities that provide essential services to the public, which include but are not limited to transportation, water supply, waste disposal, energy and housing. This definition includes the provision of physical systems that are used to provide services for the public through certain procurement systems that have socio-economic impacts. In general, the provision of infrastructure is carried out by infrastructure management agencies, both public agencies and private enterprises. In this research, more emphasis is given to the provision of vital infrastructure assets by relevant ministries, such as the Ministry of Public Works and Housing (MPWH) and the Ministry of Transportation (MT).

2.3 Infrastructure Development in Developing Countries

For many developing countries, infrastructure development is a basic necessity to support the economy of the nation. It plays a vital role in accelerating economic development (Prasetyo & Firdaus 2009; Sumadiasa, Tisnawati & Wirathi 2016) as well as social development (Too 2009). Therefore, many countries are trying to invest billions of dollars in building new infrastructure. When investments are used to build various infrastructures, such as roads, bridges, ports, airports, etc., it is expected that these will improve the living standard of the relevant inhabitants. Thomas (2002) stated that it has become the main goal of many developing countries to improve the lives of their people. It can be contended that investment in infrastructure development has short-term and long-term socio-economic impacts that will affect the region and the country where it is located. From an industry perspective, a viable infrastructure will open new markets, reduce logistic and production costs, increase productivity, create a better standard of living, reduce poverty and preserve the environment (Reungsri 2010).

Unfortunately, for many developing countries, investing in the right project is a challenge rather than to do the project right. Billion-dollar infrastructure investment has not always been maximised, as is demonstrated by many failed and cancelled infrastructure projects in these countries. This certainly causes economic, social and environmental losses as the result of improper project planning. Previous research has recorded failed and cancelled infrastructure projects that caused major losses both developing and developed countries (Mansfield, Ugwu & Doran 1994; Frimpong, Oluwoye & Crawford 2003; Carrero et al. 2009; Hoe 2013; Al-Hazim, Salem & Ahmad 2017; Hansen, Too & Le 2018b).

Meanwhile, previous studies also indicate that infrastructure development and economic growth in developing countries do not always display a positive association. Reungsri (2010) found that investment in the infrastructure sector in Thailand has a mixed impact on economic growth. Similar results have also been demonstrated in other developing countries (Cavallo & Daude 2011). Devarajan, Swaroop and Zou (1996) found that infrastructure development actually has a negative influence on economic growth when used in excess. Similarly, Flyvbjerg (2008) noted that transport infrastructure projects around the world often experience cost overruns, benefit shortfalls and inaccuracy problems. According to Giang and Pheng (2015), this happened mainly in consequence of the low efficiency and quality of infrastructure planning and investment in developing countries.

In fact, current infrastructure projects operate in a challenging business environment due to globalisation, privatisation and deregulation (Too 2012) which make it more difficult to manage. This challenge occurs in many developing countries especially Indonesia where infrastructure projects are often criticised for delays, cost overruns, low safety standards and poor quality.

2.3.1 Historical Overview of Infrastructure Development in Indonesia

The trend of infrastructure development in Indonesia has been ongoing since the Dutch colonial period. The term "***pekerjaan umum***" (*En*. public works) is actually adapted from the Dutch "*openbare werken*" and has been used officially since 1942 when the Indonesian territory came under Japanese occupation. According to Idris (1970), the history of infrastructure development in Indonesia can be divided into three periods, namely:

1. The Dutch colonial era
2. The Japanese occupation era
3. The Indonesian independence era, which then divided into three phases:
   a. 1945 – 1949
   b. 1949 – 1950
   c. Post-1950

The Public Works/*Openbare Werken* during the Dutch colonial era were undertaken by the *Departement van Verkeer en Waterstaat*. This department dealt with infrastructure development for: (a) *Landsgebouwen* (buildings), (b) *Wegen* (roads), (c) *Irrigatie en Assainering* (irrigation and waste water drainage), (d) *Waterkracht* (hydropower), (e) *Constructive bureau* (bridges), (f) *Havenwezen* (ports), (g) *Electriciteitswezen* (electricity), and (h) *Luchvaart* (civil aviation).

During the Japanese occupation (1942 – 1945), *Departement van Verkeer en Waterstaat* in Bandung was renamed *Kotubu Bunsitsu*. At that time, it became common to use the term "*pekerjaan umum*" (public works) alongside the Japanese term "*doboku*". This change of power also influenced the replacement of Dutch-led personnel entirely with entirely Japanese and Indonesian personnel. The public works system was thus influenced by both the Dutch and Japanese systems.

The development of infrastructure in the early days of Indonesia's independence (1945 – 1949) was performed by the Ministry of Public Works and Transportation led by a Minister and an Undersecretary Minister. The Ministry of Public Works, which was originally located in Bandung, was moved to Purworedjo and Yogyakarta because Bandung at that time was controlled by British/NICA. The Ministry of Public Works consisted of seven bureaus, four departments and five agencies.

Phase 1949 – 1950 illustrated the end of political conflict between Indonesia and the Netherlands as well as the end of the Dutch *de jure* rule over the territory of Indonesia marked by the transfer of sovereignty in December 1949. After undergoing various consolidations, the Ministry of Public Works and Power was established in Jakarta. This ministry consisted of six bureaus, one department and five agencies.

The phase post-1950 illustrated the consolidation of the ministry from the colonial era into a fully independent sovereign period. The legal basis of the ministry began to be perfected. It was the duty of this ministry to provide public facilities and infrastructure to support the nation's economic activities. In 2014, one more function was added to the Ministry of Public Works, i.e. the development of public housing—causing its name to be changed to the Ministry of Public Works and Housing. This ministry covered three areas of infrastructure, namely: transportation (through *Ditjen Bina Marga*), building and settlements (through *Ditjen Cipta Karya* and *Ditjen Perumahan*), and water resources (through *Ditjen SDA*). Figure 2.1 shows the current organisational structure of this ministry.

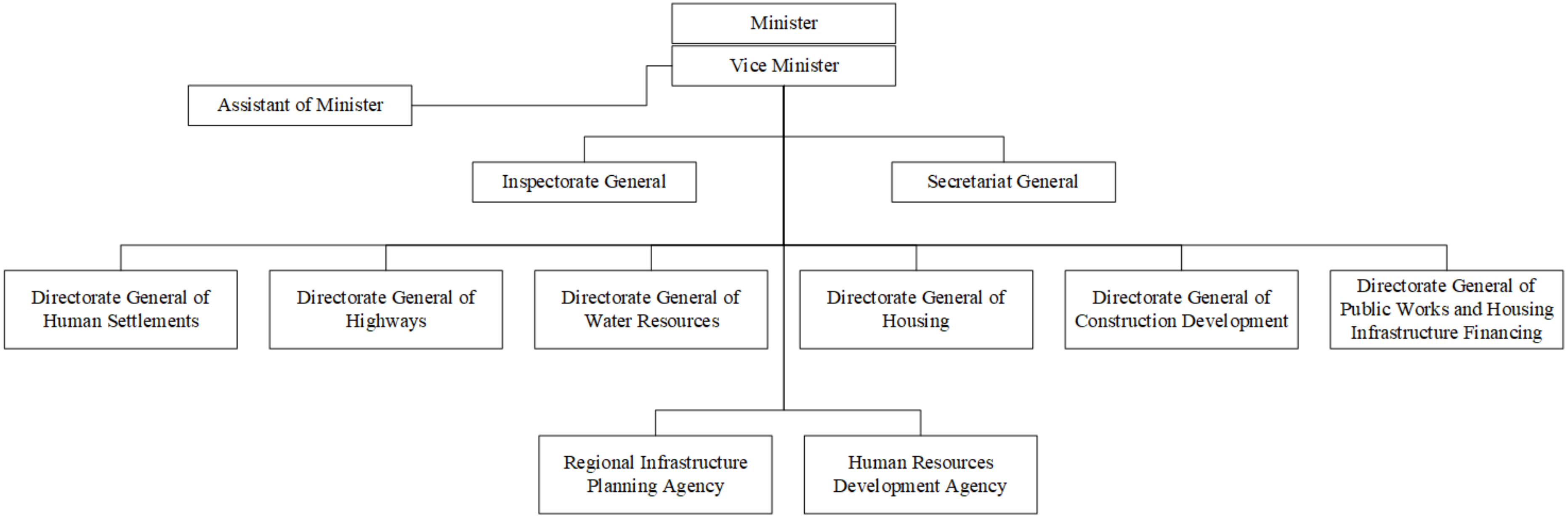


Figure 2.1 Organisational structure of the Ministry of Public Works and Housing

As the largest country in Southeast Asia, Indonesia has experienced some remarkable achievements in its infrastructure development. A chronological summary listing Indonesia's infrastructure milestones based on published literature and other sources is given below.

1957 Indonesia started the planning of a new city named Palangka Raya. It was to become the capital of Central Kalimantan Province (previously Central Borneo). The first president, Soekarno, initiated the construction of the city, which was planned as the new capital of Indonesia to replace Jakarta.

1957 – 1965 The Ministry of Public Works started the construction of the first dam in Indonesia, i.e. Jatiluhur Dam. It is a multi-purpose embankment dam located on the Citarum River in West Java, Indonesia. It is still the largest earth-fill dam in the country and it helps irrigate 240,000 ha of rice fields.

1961 – 1975 The National Monument (*Ind*: Monas) was built to symbolise the fight for Indonesian independence. It is an obelisk monument with a 132 m tower located in the centre of Merdeka Square in Central Jakarta. It is topped by a blaze statue enclosed with gold foil. Below is the National History Museum, which has dioramas displaying the scenes from the Indonesian history.

1965 The Indonesian government began the development of Trans-Sumatran Highway project. It is a primary road in the Sumatra island connecting Banda Aceh in the north to Bandar Lampung in the south, measuring 2,508.5 kms. It consists of four parts and forms the whole section of the Asian Highway Network route AH25.

1973 – 1978 The Jagorawi Toll Road was developed as the first toll road in Indonesia. The construction cost IDR 350 million per kilometre. With a length of more than 60 km, it connects the capital city of Jakarta to Bogor and Ciawi in West Java.

1980 – 1985 The construction of Soekarno-Hatta International Airport Phase I was completed with a capacity of 9 million passengers per annum. Currently, the airport is still completing its Phase 4 development allowing passenger capacity of 43 million per annum. It is the busiest and largest airport in Indonesia, as well as being the world's busiest airport in the southern hemisphere.

2003 – 2009 Suramadu Bridge is a cable-stayed bridge connecting the island of Java and the island of Madura in Indonesia. At 5.4 kms in length, it is the longest cable-stayed bridge in Indonesia and the first bridge to cross the Madura Strait. It has three spans and two lanes in each direction.

2012 – 2013 Bali Mandara Toll Road was constructed to connect Denpasar and South Kuta, Nusa Dua and Ngurah Rai International Airport in Bali. It is the first toll road bridge built over water stretching across the Gulf of Benoa with a length of 12.7 kms. This project become a source of pride for many Indonesians as it was 100% made in Indonesia without the use of foreign loans, imported materials or technology.

2013 Jakarta Mass Rapid Transit (Jakarta MRT) is a rail-based MRT that planned stretches over 110.8 kms consisting ten lines. The construction process of the first MRT transport in Indonesia started in 2013. The operation of Phase I was officially opened in March 2019 consisting of 13 stations.

2014 The ground-breaking of Trans-Sulawesi Railway project was conducted on August 18, 2014 in Siawung Village, Barru Regency. It is an under-construction railway network connecting the island of Sulawesi, Indonesia. The project is divided into three phases with a total length of 2,000 kms from Makassar to Manado.

2015 The controversial infrastructure project of Jatigede Dam, which began in 2008, was finally completed. It is an embankment dam on West Java. Besides its primary purpose for irrigation, it is also used for flood control, water supply and hydroelectric power generation. The initial idea traces back in 1963. It became controversial due to the relocation of people living in the zone.

2016 Trans-Kalimantan Highway Southern Route is a 3,901 km national road that became the backbone highway system in Kalimantan, Indonesia. It connects East Malaysia and Brunei with major Indonesian cities in Kalimantan.

2018 The Trans Papua Road Project, located on the largest island of Indonesia, is partially completed. The project itself consists of seven segments in Papua Province and four segments in West Papua Province. The roads stretch from Sorong City to Merauke City, with a total length of 4,325 kms. It also includes an 884 km border road of Indonesia and Papua New Guinea.

2019 To this point, there had been 30 national strategic projects completed, consisting of four airports, four dams, nine roads, six regions, two trains, one port, two smelters and two technology projects. However, due to the COVID-19 outbreak in early 2020, many of the national strategic infrastructure projects experienced a slowdown.

2.3.2 The Legal Basis of Infrastructure Development in Indonesia

In recent years, the Indonesian government has invested heavily in infrastructure development. Hence, it is important that the foundation of infrastructure development refers to the applicable legislation. Here are some important regulations related to the implementation of infrastructure development in Indonesia.

Law No. 11 of 2020 on Job Creation

The latest update on the Indonesian construction services is provided in Law No. 11 of 2020 concerning job creation. Due to its length and coverage of many other sectors, this law is also referred to as an omnibus law. Construction service activities are one of the clusters regulated in this law. With the enactment of this law, as an implementing regulation, Government Regulation No. 14 of 2021 has been issued regarding changes to Government Regulation No. 22 of 2020. This Government Regulation has come into force since its enactment on 2 February 2021, while Government Regulation No. 22 of 2020 is declared still applies as long as it does not conflict with Government Regulation No. 14 of 2021.

Apart from various controversies that have arisen from the enactment of Law No. 11 of 2020, it has several positive impacts on the construction sector, including:

- Ease of public services in the construction sector by eliminating construction service business permits
- The empowerment of the national construction service development board (LPJK) is being further enhanced
- Implementation of online single submission (OSS)
- Strengthen the role of the national construction service community in the implementation of the construction work competency certification system and business entity certification
- There are efforts to consolidate construction work competency certification as well as data integration

Law No. 2 of 2017 on Construction Services

Indonesian infrastructure development is based on Law No. 2 of 2017, which replaced Law No. 18 of 1999 on Construction Services. This update applies to all construction projects in Indonesia, including infrastructure projects. Some important matters governed by this law are:

(a) The division of responsibilities between the central and local governments in the execution of construction services
(b) The definition, type and classification of construction services
(c) The provision regarding construction contract and operation
(d) The affirmation of legal protection for construction labours
(e) The encouragement of community/public roles and participation
(f) The establishment of an integrated construction information system
(g) The dispute resolution methods in construction industry

This law is complemented by its derivative in the form of a Government Regulation No. 22 of 2020 concerning Implementation of Law No. 2 of 2017 concerning construction services.

Presidential Decree No. 122 of 2016 on the Amendment of Presidential Decree No. 75 of 2014 on the Acceleration of Priority Infrastructure Delivery

In addition to Law No. 2 of 2017 which regulates general construction services, the Indonesian government has also issued a decree related to priority infrastructure that should be accelerated in its implementation, i.e. Presidential Decree No. 75 of 2014 on the Acceleration of Priority Infrastructure Delivery. This decree was later amended to Presidential Decree No. 122 of 2016. Some important matters in this decree are:

(a) The definition, criteria and types of priority infrastructure
(b) The funding mechanism for priority infrastructure
(c) The establishment of KPPIP or the Committee for Acceleration of Priority Infrastructure Delivery

Presidential Decree No. 58 of 2017 on the Amendment of Presidential Decree No. 3 of 2016 on the Acceleration of National Strategic Projects

Through Presidential Decree No. 3 of 2016 which was later amended to Presidential Decree No. 58 of 2017, the Indonesian government provides guidance on accelerating the implementation of national strategic projects. This guideline covers technical and administrative matters such as licensing, spatial planning, land acquisition, government guarantee and legal dispute resolution in the development of national strategic projects. In addition, this decree also contains a list of National Strategic Projects which consists of 245 projects and two programs.

The existence of these regulations acts as a foundation for the notion that infrastructure development is needed to provide support for social and economic growth in Indonesia. As the policymaker, the government has a crucial role in the execution of infrastructure development program. However, until nowadays, the Indonesian infrastructure development is still encountered several barriers, especially related to limited investment resources and poor project planning.

2.3.3 The Significance of Infrastructure Development in Indonesia

Previous research on the relationship between Indonesia’s infrastructure development and economic growth have been conducted. Ja'far (2007) found that infrastructure development has a positive role for Indonesia’s economic growth by creating jobs in the construction sector (for short-term benefit) and supporting the productivity of related sectors (for medium and long-term benefit). The negative impact arising from a lack of infrastructure availability is the isolation of communities with a high poverty level (Prapti, Suryawardana & Triyani 2015). Thus, it can be argued that infrastructure development becomes an answer for many problems faced by the Indonesian government in increasing economic growth and the life quality of its people. Table 2.1 shows several studies related to the correlation between infrastructure development and economic growth in Indonesia.

Table 2.1 Several previous studies related to infrastructure development in Indonesia

Author(s) & Year	Research Title	Methodology	Findings
Prasetyo and Firdaus (2009)	Pengaruh Infrastruktur pada Pertumbuhan Ekonomi Wilayah di Indonesia (Influence of Infrastructure on Regional Economic Growth in Indonesia)	Uses infrastructure data from 26 provinces in Indonesia. The model is built based on the Cobb-Douglas production function	Infrastructure has influenced economic growth, with electricity being the biggest impactor on economic growth, followed by paved roads and clean water access
Hapsari (2011)	Pengaruh Infrastruktur terhadap Pertumbuhan Ekonomi di Indonesia (Influence of Infrastructure on Economic Growth in Indonesia)	Uses panel data from 2004 to 2009 regarding 26 provinces in Indonesia. Tests include the BLUE (Best Linear Unbiased Estimator), Chow Test and Hausman Test	Road and electricity infrastructure have a significant impact on economic growth, while telephone and water supply infrastructure have no significant effect
Maryaningsih, Hermansyah, and Savitri (2014)	Pengaruh Infrastruktur terhadap Pertumbuhan Ekonomi Indonesia (Influence of Infrastructure on Indonesia's Economic Growth)	Adopts the Solow growth model and β-convergence model	Road infrastructure and electricity are the two most significant influencers on Indonesia's GDP growth
Fahmi (2016)	Pengaruh Infrastruktur Secara Spasial terhadap Konvergensi Pertumbuhan Ekonomi di Indonesia (Influence of Infrastructure Spatially on the Convergence of Economic Growth in Indonesia)	Conducted on the basis of annual per capita income data from 31 provinces and analysed using a spatial cross-regressive model with fixed effect method	Road infrastructure has a positive impact on economic growth and investment. It also showed a positive effect spatially on the economic growth of contiguous regions
Sumadiasa et al. (2016)	Analisis Pengaruh Pembangunan Infrastruktur Jalan, Listrik dan PMA terhadap Pertumbuhan PDRB Provinsi Bali Tahun 1993-2014 (Analysis of the Influence of Road Infrastructure, Electricity and PMA on GDP Growth of Bali Province Year 1993-2014)	Uses data from Bali province. Data analysis uses path analysis technique	The development of road infrastructure in Bali province has a positive but not significant impact on GDP growth, while electricity has a positive and significant impact

All of these studies demonstrate the importance of infrastructure development to Indonesia's economic growth. Nevertheless, Kurniawan (2009) states that there are several factors that hinder the performance of national construction services in Indonesia, namely:

(a) Internal factors
   1. The national construction services are still weak in terms of management, capital and technology mastery, and lack skilled human resources
   2. There is still no synergy between national construction service providers in terms of quality and qualification due to its fragile business structure

(b) External factors
   1. Unbalanced working relationship between service users and service providers
   2. Unstable supports from various sectors that affect the performance of national construction services either directly or indirectly

2.4 Infrastructure Management

Efficient management of infrastructure requires the integration of various aspects of infrastructure assets management. Infrastructure is often regarded as a government asset due to its vital role in advancing the national economy. As an asset, the management of an infrastructure project not only involves the initiation, planning, execution and closing phase, but also its operational phase. Asset management itself is not a new term. It has been widely used for many years in many fields, including the property sector, manufacturing, information technology and finance, as well as the infrastructure sector. However, in some sectors the assets are usually easier to convert into profit or money and have a shorter life expectancy than in the infrastructure sector (InfraGuide 2005).

According to NCHRP (2006), there are five functions of infrastructure management, namely: (1) planning, (2) programming, (3) construction program delivery, (4) maintenance and operation, and (5) system monitoring. The planning function involves identification of future needs and development of strategies; undertaking of studies on particular needs that require project investments; and addressing strategic issues. The programming function involves allocation of resources such as funding, human, equipment, etc. Construction program delivery implements the programs that have been planned and approved. The maintenance and operation function involves the routine maintenance and operation of services to the existing facilities, while system monitoring traces system conditions and service performances. In this research, focus will be given to the planning aspect of infrastructure management, especially on infrastructure FEP.

2.4.1 Infrastructure Project Life Cycle

All projects have a project life cycle that embodies the path the project takes start to finish. Typically, such life cycles are sequential and provide the basis for managing projects. A simple project life cycle usually includes four phases, namely: (1) initiation phase, (2) planning phase, (3) execution phase and (4) closure phase. Nevertheless, this project life cycle can be modified in accordance with the type and nature of existing infrastructure projects. For instance, the project life cycle for transport projects has six phases, namely: needs assessment, feasibility/scoping, preliminary design, detailed design, construction, and operation and maintenance (Le et al. 2009).

Besides having a project life cycle, all projects are also managed with five project management processes—namely: initiating, planning, executing, monitoring and controlling, and closing—that can be applied at any stage of the project. A decision to determine the project continuation can be done at the end of each of these project phases (Newell & Grashina 2004). Figure 2.2 illustrates the overall project life cycle and processes.

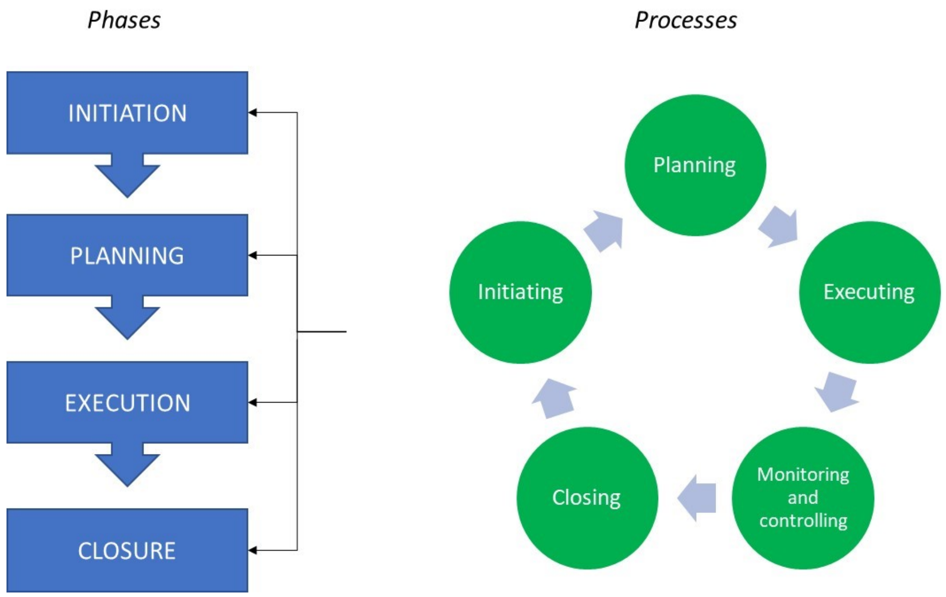


Figure 2.2 Project life cycle and processes

According to Newell and Grashina (2004), the initiation phase or the beginning of the project is the phase that involves the greatest probability that a project will not be completed. This phase starts with a person's desire to build something. This person will decide based on their previous experience, knowledge and judgment while also completing some feasibility assessment of the project. Next, the planning phase begins, followed by the execution and closure phase. Ideally, as the project moves to the next phase, the project definition degree should increase, which makes the project ready to execute, while simultaneously, the amount of influence the initiator has over the project outcomes decreases. Thus, the greatest opportunity to influence a project exists within the initiation phase and to certain extent of the planning phase (Newell & Grashina 2004) as illustrated in Figure 2.3. Due to its comparatively large influence, it is important to study this phase.

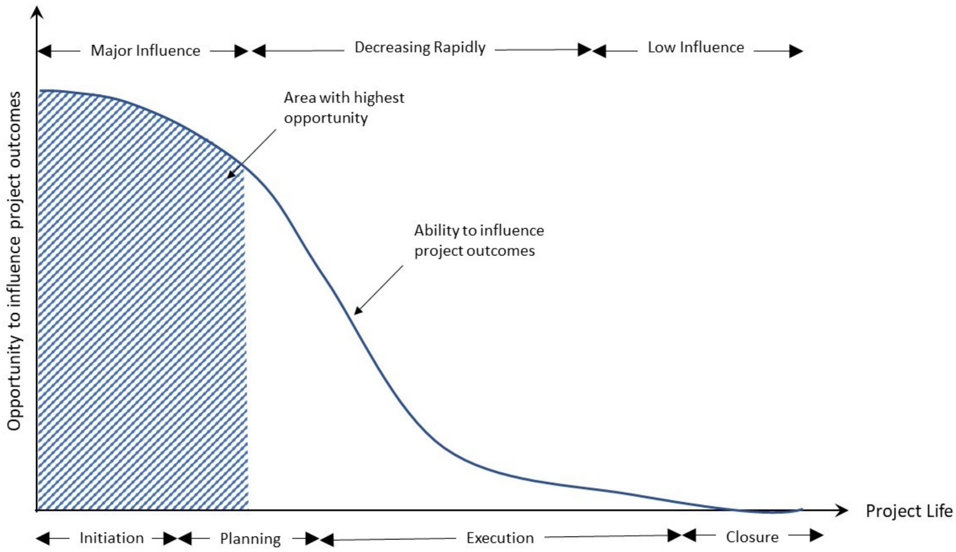


Figure 2.3 Ability to influence project outcomes over project life cycle

2.4.2 Infrastructure Project Planning and Investment

As discussed, there is a connection between infrastructure development and economic growth in developing countries like Indonesia. The findings imply that infrastructure development is one of the most important and inseparable parts of government policy making. To that end, infrastructure development needs to be continuously encouraged and managed through a good planning system so that investments are provided for the most appropriate projects. In Indonesia, infrastructure investment planning is carried out at the national level in accordance with applicable laws and guidelines.

However, there are several issues related to deficiencies in infrastructure project planning including lack of capacity for estimation and monitoring of projects' rates of return, politicised decision making, lack of transparency and accountability, and institutional planning weaknesses (Dang & Pheng 2015). Moreover, Dang and Pheng (2015) identify some difficulties in the execution of infrastructure plans in developing countries, namely: lack of political commitment, corruptions, problems with land acquisition, inadequate capacity of domestic construction companies, and institutional and legal weaknesses in infrastructure development.

These concerns related to infrastructure project planning and the execution of infrastructure plans may influence the efficiency and quality of infrastructure projects (Kenny 2009; Dabla-Norris et al. 2012). This brings out the significance of FEP phase in generating an outcome in the form of the Final Investment Decision.

2.5 Infrastructure Project Front End Planning

The Front End Planning (FEP) phase plays a crucial role in infrastructure project selection and prioritisation. It is perhaps the most important phase of a project. It starts with project initiation and ends with a decision about whether to fund or not. This decision often determines the success of a project because it affects all subsequent actions of that project. Unfortunately, the FEP phase often receives insufficient attention as decision makers are not attentive of the process and significance of this phase.

2.5.1 What is Front End Planning?

FEP is “the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximise the chance for a successful project” (CII 2014). It starts from the initiation phase of a project, followed by information gathering, stakeholders’ consolidation, project scope definition, and ends with a final decision regarding the project’s approval for investment (Ceelen 2014; Motta et al. 2014). In various literature, FEP is also referred to as *‘pre-project planning’, ‘front end loading’, ‘fuzzy front-end’, and ‘quality at-entry phase’* (CII 1994; Kim & Wilemon 2002; Nobelius & Trygg 2002; Jergeas 2008; Iluz & Shtub 2015). It is at this phase that the selection of infrastructure project portfolios is done in accordance with the organisation’s strategic objectives.

Although similar, the FEP phase has several characteristics that differentiate it from the common ***project planning*** phase. While both phases play a critical role in a project’s success, there is little research that clearly and properly distinguishes the two. A comparison between project planning and the FEP phase is provided in the Table 2.2 (Hansen, Too & Le 2018a).

Table 2.2 Comparison of project planning and Front End Planning

Element	Project planning	Front End Planning
Characteristic	Second phase of project life cycle	Initiation phase and part of planning phase
Engagement period	From the end of initiation phase up to the beginning of execution phase	From the initiation phase up to a decision to proceed the project is concluded
Major output	Project plans	Final decision of project investment
Focus	Planning to prepare	Planning to decide
Significance	Important to prepare for the next project phase, i.e. the execution phase	Important to restrict the project from wasting time, money and other resources in doing the wrong project

Project planning indicates the establishment of a detailed set of directions by the project team in order to produce successful project delivery (Meredith & Mantel 2009). It follows the project initiation phase and involves organising and formulating a set of plans to direct the project team. Thus, the major output of project planning is project plans including a project overview, objectives, approaches, contracts, schedules, estimations, risk plans and evaluation methods (Meredith & Mantel 2009). These plans will be utilised to direct project execution (Liang & O'brien 2016).

On the other hand, FEP begins with the initiation phase and ends with, to a certain extent of the project planning phase. Its focus is more on strategic decision making, so the major output of FEP is the project approval and final investment decision (Motta et al. 2014). Thus, it is known as the most critical point. Figure 2.4 illustrates the position of FEP in the project life cycle (Hansen, Too & Le 2018a).

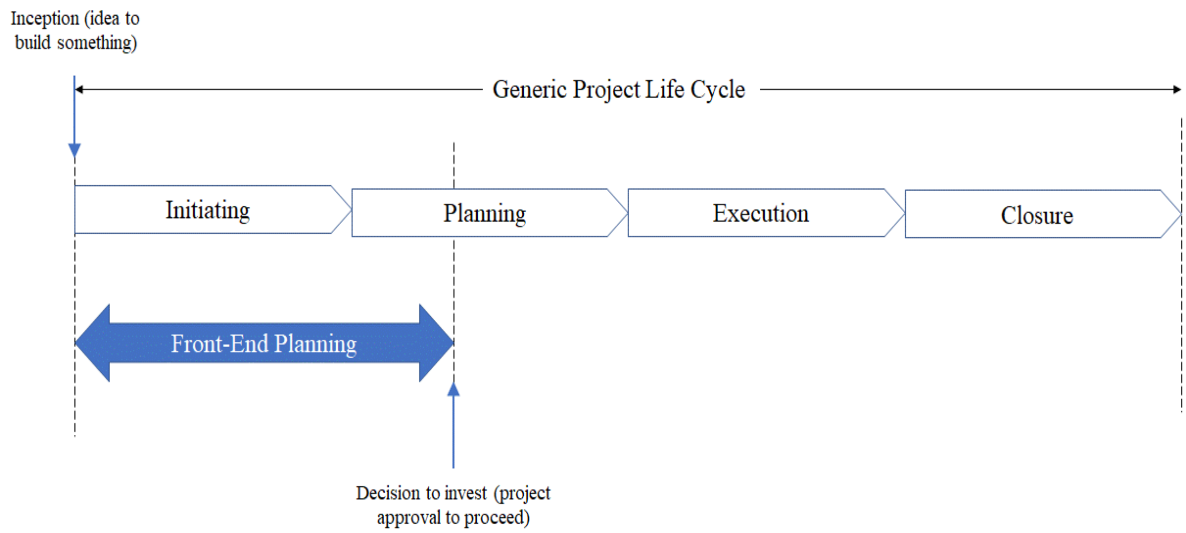


Figure 2.4 Position of Front End Planning in a project life cycle

2.5.2 The Significance of Front End Planning

Previous research has indicated the significance of the FEP phase in construction projects (Gibson & Hamilton 1995; Griffith et al. 1999; Safa et al. 2013). Edkins et al. (2013) believes that it is a phase where project values are being developed. The purpose of conducting this phase is to establish project strategies, consolidate project goals, designate team responsibilities, and improve communication (Forgues & Koskela 2009). Meanwhile, an insufficient FEP phase will result in unclear project scope definition, unsteady project team organisation, inadequate project requirements, unclear roles and responsibilities within the project organisation, and inadequate project plans (Hansen, Too & Le 2018a).

Previous research has examined the relationship between the impact of the FEP phase and overall project performance. A quantitative study conducted by Menches et al. (2008) found that projects with better FEP resulted in better project performance. On the other hand, insufficient FEP phase is deemed as a major factor, producing a 60-85% impact on cost overruns (Schoenhardt, Pardais & Marino 2014).

Thus, it is crucial to provide sufficient resources on the FEP phase for infrastructure projects in view of the complexity and risk involved (Jergeas 2008; Haji-Kazemi, Andersen & Krane 2013). By investing more resources in the FEP phase, project success rate will increase (George, Bell & Back 2008; Hanna & Skiffington 2010; Hwang & Ho 2012; Liu et al. 2013; Oh et al. 2016). The main value of the FEP phase is to acquire the greatest opportunity to influence project performance as early as possible (Hansen, Too & Le 2018a).

2.5.3 Front End Planning Stages

According to CII (2014), the FEP phase has three stages as shown in Figure 2.5. From this figure, it can be seen that the FEP phase starts with project feasibility and ends with the detailed scope. Although this model is frequently used, it does not illustrate the overall key features of the FEP phase. Thus, based on CII's model and the previously identified FEP key features, a new model of FEP stages is proposed as shown in Figure 2.6 (Hansen, Too & Le 2018a).

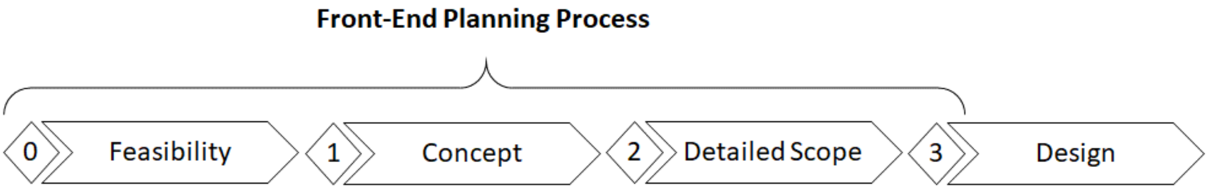


Figure 2.5 CII's FEP stages

The proposed FEP model consists of six key stages. A decision gate (DG) is provided at the end of each stage to ensure that a process within a stage has met its objectives (Hansen, Too & Le 2018a). The model starts with the inception stage in which the idea or intention to create something occurred (Newell & Grashina 2004). It is followed by the diagnosis stage in which the owner will analyse the current situation and assess the necessity of a project. Next, the formulation stage refers to a process of framing all the early preparation to gain the utmost benefits. It involves the establishment of project charter and organisation. Here, it is crucial to select people with adequate knowledge and expertise so that the FEP can effectively assist the next stages (Oh et al. 2016).

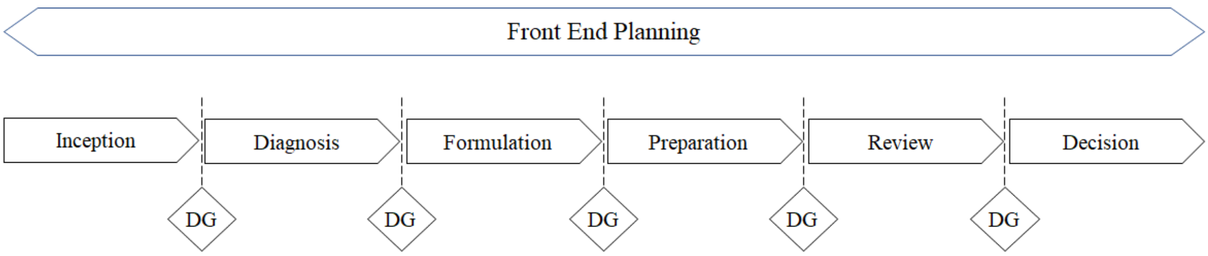


Figure 2.6 Proposed FEP stages

The fourth stage is preparation in which the project team arranges FEP information such as targets, risks, project scope, etc. Here, clarifying project scope becomes important since a poorly-defined scope is a common cause for project failure. It is followed by the review stage in which decision makers offer examination and justification of the results of the previous stage. The last stage of the FEP phase is decision-making of project approval and investment decision. Here, the decision may be that a project proposal is approved, rejected or needs to be modified. To facilitate understanding, these six stages are summarised in Table 2.3 (Hansen, Too & Le 2018a).

Table 2.3 FEP stages and activities

FEP Phases		FEP Activities	Questions to ask
Prefeasibility	**Inception**	Searching new possibilities and generating idea to build something	Where do we stand today?
	Diagnosis	Analysing the current situation in construction sector and its environment and assessing needs	Do we need this project?
Feasibility	**Formulation**	Organising project team, developing project charter, analysing technology, evaluating sites, preparing conceptual scopes, analysing alternatives	What should we do first? Which directions should we go? Which technology should we adopt?
Basic engineering	**Preparation**	Planning targets, identifying project risks, defining detailed project scope, developing preliminary designs, etc.	How (at what pace/ what cost/ which specific measures/ etc.) shall we get there?
	Review	Reviewing and justifying the outcomes from previous phases	Are we moving to the right direction? Is there any adjustment needed?
Decision -making	**Decision**	Making decision whether to proceed with/ to invest in the project or not, approving project execution plans	Are we making the right decision?

2.5.4 Why is Front End Planning important for Strategic Decision-Making?

The FEP phase is an important phase in defining project scope, selecting the project portfolio, ensuring project preparedness and making the decision about project approval. It ends with project approval and final investment decision. While this phase is crucial, little research has been done in this area (Haji-Kazemi et al. 2013; Ceelen 2014). It should be noted that one of the main reasons of common project failures is the lack of attention from decision makers and project teams towards the complexity of the FEP phase (Shenhar & Dvir 2007). Okeke (2011) reported that 80% of top management teams do not fully understand project investment decision factors or did not have access to such information.

Another study showed that in the decision-making process, more than 50% of decision makers did so based on feelings rather than facts or analysis (Jeston 2008). Other studies indicate that project executives rarely implement a risk management strategy (Chenger 2012) and many do not utilise a formal decision-making technique (Cooper 2008). This leads to an inadequate project selection process that ultimately leads to inappropriate decisions and the approval of the wrong projects. For example, Cantarelli et al. (2010) found that political explanations are the most dominant reasons for project failures in terms of cost overruns in large-scale transportation projects. They identify the grounds of cost overruns such as lack of coordination, lack of long-term commitment, lack of discipline, political pressure and asymmetric information.

Considering the importance of the FEP phase for the success of a project, this study focuses on the final stage of the FEP phase, namely decision making related to infrastructure project selection and prioritisation. As this is a decision-making process, a framework or model is needed to assist decision makers or the FEP team in making final investment decisions.

2.6 What is Decision Making?

Effective decision making is “the process through which alternatives are selected and then managed through implementation to achieve business objectives” (Harvey & TIS 2007). This is a systematic process that has predefined elements and follows a sequence of steps (Drucker 1967). It is a commitment to action that follows a pattern (Langley et al. 1995; Parkin 1996; Mintzberg & Westley 2001). Many experts also describe ***decision making*** as a cognitive process that involves assessments of consequences and uncertainties (Brunsson 1982; Brindle 1999; Müller, Martinsuo & Blomquist 2008).

In terms of how decisions are made, Mintzberg and Westley (2001) propose three decision-making approaches, namely: ‘thinking first’, ‘seeing first’, and ‘doing first’. Table 2.4 describes the quality features of these three major approaches.

The ‘thinking first’ approach is also referred to as a rational decision-making approach. It follows a systematic process of define → diagnose → design → decide. The ‘seeing first’ or creative decision-making approach follows four steps in creative discovery of preparation → incubation → illumination → verification. Finally, the ‘doing first’ approach believes that by doing something, the necessary thinking could follow. In other words, it is based on experimentation. The process of ‘doing first’ follows three steps of enactment → selection → retention. The ‘thinking first’ approach correlates with science, ‘seeing first’ with art and ‘doing first’ with craft (Mintzberg & Westley 2001).

Table 2.4 Characteristics of three major approaches to the decision-making process

Elements	Thinking First	Seeing First	Doing First
Characteristics	Science Planning Verbal Facts	Art Visioning/Imagining Visual Ideas	Craft Venturing Visceral Experiences
Process	define → diagnose → design → decide	preparation → incubation → illumination → verification	enactment → selection → retention
Suitability	• The issue is clear • The data are reliable • The context is structured • Thoughts can be pinned down • Discipline can be applied	• Creative solutions • Commitment is the key • Communication across boundaries is essential	• The situation is novel and confusing • Complicated specifications • A few simple relationship rules

In infrastructure project selection problems, the rational or 'thinking first' is the dominant approach, as decision makers understand the issue of selecting and prioritising projects, data are provided and reliable, context is structured and discipline—such as Multi-Criteria Decision-Making (MCDM) techniques—can be applied in the process.

As a rational process, decision making is strongly related to strategy (Kolar 2017). In an organisational context, decision making is strategic in nature characterised by complexity, plurality and dynamic process (Denis, Langley & Rouleau 2007; Buijs, Eshuis & Byrne 2009; Klijn & Snellen 2009). Thus, ***organisational strategic decision making*** is "an effortful social phenomenon carried out among and between organisational actors, which is also seen as large, expensive, and precedent setting producing ambiguity about how to find a solution and uncertainty in the solution's outcomes" (Nutt & Wilson 2010; Kolar 2017).

In public organisations, decisions usually have broader implications (Kolar 2017). Rainey, Ronquillo and Avellaneda (2010) conducted an extensive study of the decision-making process in public organisations. Their finding suggest that the decision-making processes of public organisations vary little from those of private organisations. The public organisations work under the authority of government and collect funding through taxes and budgetary allocations, while private organisations receive their income through selling products and services to customers. Thus, public organisations are subject to more politically restricted controls, while private organisations have a lesser amount of authority but also have to rely on creative ways to generate income. They also stated that public organisations tend to engage in routine and rational decision-making processes. Table 2.5 conveys some notable differences between strategic decision making performed by public and private organisations (Rainey, Ronquillo & Avellaneda 2010).

Table 2.5 Differences between public and private organisations' decision making

Public Organisations	Private Organisations
Operate under authority of government	Operate under authority of private owners and shareholders
Are subject to more control	Are subject to less control
Politically constrained	Innovatively constrained
Consider implications for broad populations and constituencies	Consider implications for private organisations' benefits
Subject to more public scrutiny such as media and interest groups	Subject to private owners and shareholders

2.7 Decision Analysis

The main reason of doing decision analysis is not to solve a decision problem but to provide insight and encourage creativity to assist decision makers in making better decisions (Keeney 1982). Howard (1988) defines ***decision analysis*** as "a systematic procedure for transforming opaque decision problems into transparent decision problems by a sequence of transparent steps". It is an integrated discipline in investigating the theories, procedures and methods for describing a problem in a formal manner to assist decision makers in finding the best course of action. Decision analysis focuses on five fundamental aspects of decision problems (Keeney 1982): (1) an apparent need to achieve certain objectives, (2) several alternatives, (3) the consequences associated with alternatives, (4) uncertainty about the consequences of each alternative, and (5) the possible consequences are not equally valued.

2.7.1 Decision Analysis Elements

There are five elements of decision analysis as proposed by Miser and Quade (1985), namely: decision objectives, decision alternatives, alternative outcomes, the decision rule and decision model. ***Decision objectives*** are the desire the decision makers want to achieve. ***Decision alternatives*** refer to the actions to achieve those objectives. They may take various forms such as hedging and risk-sharing. ***An alternative outcome*** is the result or consequence following the execution of the alternatives. It can be in the forms of project returns, benefits or costs. An instruction to evaluate and rank alternatives based on the criteria is called the ***decision rule***.

Finally, a ***decision model*** is an abstraction of the real-world practice by considering the factors relevant to the problem.

Alternatively, Clemen and Reilly (2004) propose four elements of decision analysis, namely: values and objectives, alternatives, uncertain events and consequences. Meanwhile, Ayyub and Haldar (1985) describe the elements of decision analysis, which include decision variables, alternatives, consequences, risk estimation and decision criterion. Although these three classifications are different, they can be merged with each other as they hold similar meaning. Only one element cannot be merged: the decision model. Table 2.6 shows the equivalent relationship between each of the proposed elements of decision analysis (Ayyub & Haldar 1985; Miser & Quade 1985; Clemen & Reilly 2004).

Table 2.6 The equivalent relationship between each elements of decision analysis

Miser and Quade	Clemen and Reilly	Ayyub and Haldar
Objectives	Values & objectives	Variables
Alternatives	Alternatives	Alternatives
Outcomes	Consequences	Consequences
-	Uncertain events	Risk estimation
Rule	-	Criterion
Model	-	-

2.7.2 Decision Analysis Types

Based on the nature of the decision analysis, decision problems can be grouped into two categories, i.e. (1) decision making under certainty, risk and uncertainty, and (2) mono-criterion and multi-criteria decision making (Knight 1921).

Decision making under certainty refers to a situation where the decision is made in conditions in which the state of nature is known by the decision makers. In this situation, each alternative can have only one possible outcome. However, in reality, there is typically a lack of certainty or inadequate information involved in the process, making this unrealistic. Decision making under risk refers to a situation where the decision is made in conditions in which each alternative could have different possible outcomes and the probability of this is known by the decision makers. Here, risk exists along with the alternative chosen. Meanwhile, decision making under uncertainty refers to a situation where the decision is made in conditions in which the alternative outcome is uncertain and the probability is not known by the decision makers (Knight 1921; Su 2013).

Mono-criterion decision making refers to a situation where the decision is made with only one objective or criterion (Su 2013). However, problems encountered in the real world are mostly complex and dynamic. According to Hipel, Radford and Fang (1993: cited in Singh & Tiong 2005), a complex decision problem involves:

- multiple criteria – both qualitative and quantitative
- multiple decision makers
- uncertainty and risk
- incomplete information, imprecise data and vagueness surrounding the decision-making process

In multi-criteria decision making, several objectives or criteria have to be considered simultaneously (Su 2013). In practice, infrastructure project selection is regarded as a complex multi-criteria decision making (MCDM) problem in which multiple decision makers evaluate the projects' attributes against a number of decision criteria.

2.7.3 Decision Analysis Methodology

Keeney (1982) divides the decision analysis methodology shown in Figure 2.7 into four steps:

1. problem structuring
2. possible impacts of each alternative assessment
3. preferences (values) determination
4. alternatives evaluation and comparison

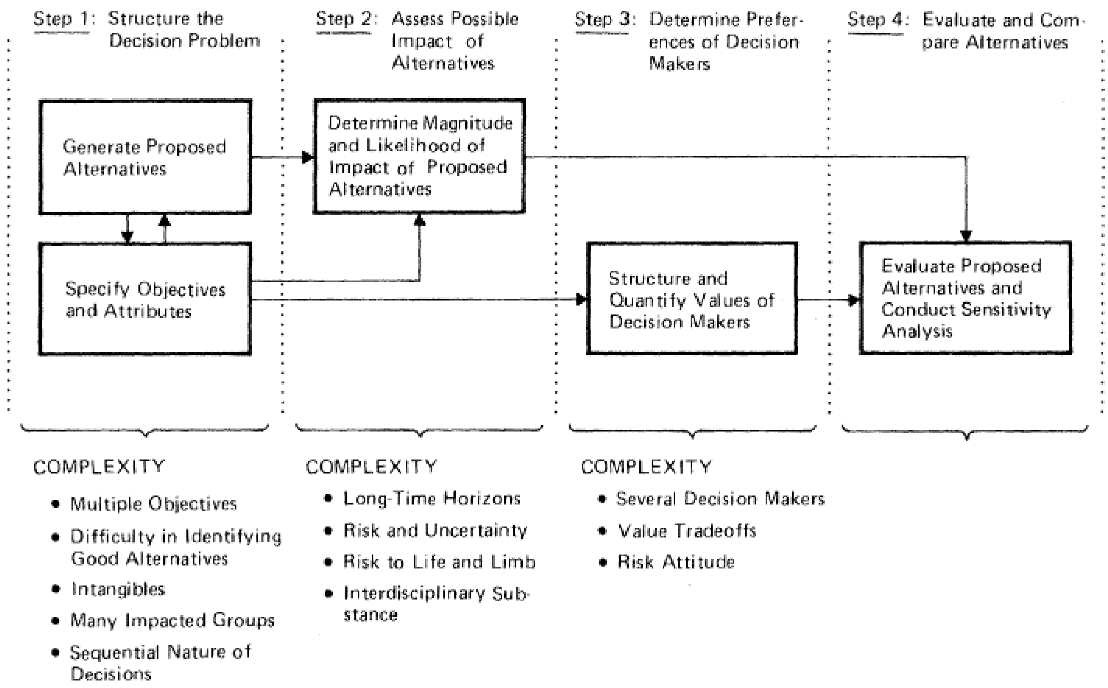


Figure 2.7 Schematic representation of the decision analysis steps

Problem structuring includes the identification of objectives and alternatives. There are two main problems related with generating alternatives. Firstly, there may be many potential alternatives and secondly, sometimes there may seem to be a complete lack of reasonable alternatives. Meanwhile, identifying objectives starts with the generation of an unstructured list of possible consequences of the alternatives. If the objectives are clearly identified, possible consequences of the problem can be described (Keeney 1982).

In the second step, the impact of each alternatives is being assessed. The assessment of the impact of the alternatives will generate a choice of the best consequences. Next, the preferences determination takes in the development of a model of values to assess the alternatives. This is achieved through an arranged discussion to measure value judgments about possible consequences. It evokes pertinent information about value trade-offs, equity concerns and risk attitudes. To evaluate the overall decision, a sensitivity analysis of the value judgments can be conducted. The last step is the alternatives evaluation and comparison. The information gathered must be synthesised in a logical manner to assess the alternatives. The sensitivity of the decision will then be examined through quantification (Keeney 1982).

2.8 Theoretical Framework of the Decision-Making Process

In the previous section, several elements of decision analysis were described in accordance with the research of Miser and Quade (1985), Ayyub and Haldar (1985), Clemen and Reilly (2004) and Su (2013). These elements can be linked to each other to form a decision-making framework for solving relevant problems. A decision-making model proposed by Bakht and El-Diraby (2015) can be seen as the theoretical framework for this research. This model illustrates the major elements of a decision problem and the relationship among them. The three central components in this model are the decision makers, decision tools and selection techniques. Here, it is critical to distinguish the term decision tool and selection technique. ***Decision tools*** denotes any means used to evaluate consequences of an alternative, while ***selection techniques*** refers to the techniques used as the basis for selecting one alternative among others (Bakht & El-Diraby 2015). Figure 2.8 illustrates this model.

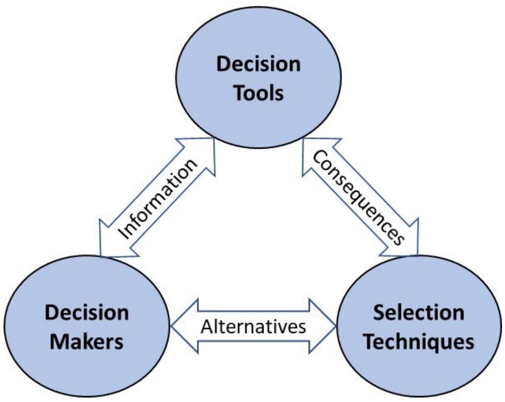


Figure 2.8 Major components of decision making

2.8.1 Decision Makers in Infrastructure Project Selection

The Cambridge Dictionary defines a decision maker as "a person who decides things, especially at a high level in an organisation" (https://dictionary.cambridge.org/dictionary/english/decision-maker retrieved on 28 June 2018). Decision makers are those at the policy level or involved in strategic management that have the power to influence and make strategic decisions. In infrastructure projects that use public funds, the decision makers are those who work in the government agencies or departments that decide whether or not the proposed infrastructure project should be made. In Indonesia, these government agencies or departments include the Ministry of Finance, the Ministry of Public Works and Housing, and the Ministry of Transportation.

The role of decision makers is to assess the infrastructure project proposals at several phases (gateways) during its development. They have to be satisfied that sufficient analysis and appropriate advice have been carried out before allowing the project to proceed. Bakht and El-Diraby (2015) classify ***decision makers*** into three classes based on the cardinality and connectivity among them, i.e. a single decision maker, a hierarchy of decision makers, and a network of decision makers. The evolution of decision makers from individual decision makers to a hierarchy and a network of decision makers also reflects the trend in decision makers studied from the 1960s to the 2000s. Bakht and El-Diraby (2015) also predict the future of the decision makers network as a heterogeneous mix of professionals and non-professionals. According to Keast and Hampson (2007), this interorganisational networked-based arrangement can enable innovation and diffusion within the construction sector. However, the heterogeneity of a network of decision makers and a lack of structured inputs will result in disordered situations (Taylor & Bernstein 2009; Bakht & El-Diraby 2015).

2.8.2 Selection Techniques

According to Bakht and El-Diraby (2015), a shift from judgmental to rational, and later to emergent-based ***selection techniques***, happens due to the complexity of engineering problems and the evolution of decision maker types. The judgmental selection technique relies on the expert judgment in a subjective or semi-subjective manner, while the rational or axiomatic selection technique relies on formal techniques and mathematical models of decision making. Later, due to changes in the decision-making process, emergent-based selection technique is adopted to match the chaotic nature of network-based decision making and to deal with the intricacy of network-based decision makers. In an emergent-based selection technique, the interactions of multiple decision contributors will result in the final consensus.

The term ‘selection technique’ is also used by Oyetunji and Anderson (2006). To select the best alternative among others, this technique usually compares the consequences of each alternative under the decision criteria. It varies from simple methods such as a pros and cons decision technique to more formalised and objective techniques such as the Analytical Hierarchy Process (AHP) or Bayesian networks (Bakht & El-Diraby 2015). Table 2.7 presents several common methods used in evaluating project alternatives.

Table 2.7 Common methods in evaluating project alternatives

Methods	Descriptions	Supporting Data
Cost-benefit analysis	Considering alternative priorities based on impacts, benefits and costs	Specialised data regarding average costs and impacts for different alternatives
Life-cycle cost analysis	Considering activities of each alternative profile over time	Specialised data regarding annual costs, net present value and service lives for different alternatives
Engineering judgment	Using expert judgment in estimating costs and impacts of each alternative	Knowledge-based data from experts regarding costs and impacts of different alternatives
Multi-criteria decision making	Evaluating the alternatives according to established criteria or objectives	Established set of criteria or objectives, performance measures, weights and impacts
Simulation optimisation	Optimisation using simulation analysis to identify deficiencies and solutions without explicitly evaluating each possibility	Varies depending on the simulation optimisation methods adopted such as stochastic optimisation, heuristic methods, statistical methods, etc.

2.8.3 Decision-Making Tools

Bakht and El-Diraby (2015) define decision tools as "any means used to evaluate consequences of an alternative based on the input information, a set of assumptions, and a behaviour model. This can be as simple as a mathematical regression or as complex as a multiagent simulation". They have analysed the decision tools in construction discipline and developed the framework at four layers, i.e. (1) epistemology, (2) nature of the model and parameters, (3) analysis approach and (4) solution and application tools.

There are five main schools of epistemology as described by El-Diraby (2012), namely: (a) rationalism, (b) empiricism, (c) positivism and logical positivism, (d) phenomenology and (e) constructivism. The origin and the main assumption of the model is further divided into (a) models derived based on field experimentation and (b) models developed by logical analysis and reasoning. Meanwhile, the parameters can be categorised as deterministic, probabilistic and chaotic. The analysis approach has four categories, i.e. statistics, stochastic (if parameters have a probabilistic or chaotic behaviour), complexity (involves multitudes of nodes) and semantic (integrates agents and information resources). Finally, application tools refer to applying the models at the practical level. These tools are utilised to assess the alternatives and may include empirical equations, statistical regression, optimisation techniques and metaheuristic methods such as mathematical programming (MP), genetic algorithm (GA), ant colony optimisation (ACO), artificial neural networks (ANN) and even ontologies (Bakht & El-Diraby 2015).

2.8.4 Integrating Theoretical Framework in This Study

The above theoretical framework provides a theoretical structure that support assumptions in this research. It introduces three major components in the decision-making process, namely: the decision makers involved, the types of selection techniques, and the variety of Decision-Making Tools (DMTs) that can be applied. This study utilises these theories to develop a DMF for infrastructure project selection and prioritisation in the Indonesian context.

First, this research utilises existing theories to define decision makers involved in the selection and prioritisation process of infrastructure projects in Indonesia. Out of the three existing classes of decision makers, this study assumes that the selection and prioritisation process for infrastructure projects in Indonesia involves a network level decision maker. This is because the planning and selection process for infrastructure projects in Indonesia is carried out at various levels (from the planning development forum at the local to the national level and planning at the ministerial level, to the selection and approval by the House of Representative/DPR) which involves a heterogeneous mix of professionals. Given the breadth of the infrastructure project planning and selection process in Indonesia, this research limits the scope of the study to ministerial level planning.

Second, this research applies a rational type of selection technique since infrastructure projects are complex in nature and the selection and prioritisation process must be justified through an objective and rational process. As a rational technique, it relies on formal decision-making techniques and models. Given that the selection and prioritisation process of infrastructure projects involves multiple criteria and alternatives, this research employs a Multi-Criteria Decision-Making (MCDM) technique as the basis for developing the DMF. In addition, a rational selection technique can provide strong accountability for the decision outputs considering infrastructure projects are mainly funded using public funds.

Finally, this research involves dealing with multiple criteria in infrastructure project selection and prioritisation identified and measured comprehensively in the Indonesian context. Apart from having different weights, these criteria are also limited by decision parameters depending on the perspective being assessed, such as cost effectiveness, time effectiveness, and project complexity. Therefore, this research applies NSFDSS-II as the basis for calculating the weight of these criteria under three constraints in the development of a Decision-Making Tool (DMT)—an integral part of DMF for infrastructure project selection and prioritisation in the Indonesian context.

2.9 Multi-Criteria Decision-Making Techniques

Since infrastructure projects are typically large-scale and complex projects, there are many criteria in selecting and prioritising infrastructure project portfolios. With so many factors or criteria, it is thus necessary to apply Multi-Criteria Decision-Making (MCDM) techniques in infrastructure project portfolios appraisal. MCDM techniques are designed to solve decision problems where several perspectives or factors must be taken into account (Tam, Tong & Zhang 2007). One of the advantages of applying MCDM techniques is its ability to include criteria that cannot be simply expressed in economic value or the criteria are qualitative in nature (Gühnemann, Laird & Pearman 2012; Annema, Mouter & Razaei 2015).

There are several types of MCDM classifications by experts. Triantaphyllou (2000) classifies MCDM into two groups based on the size of the set of alternatives, i.e. Multi-Attribute Decision-Making (MADM) techniques and Multi-Objective Decision-Making (MODM) techniques. MADM techniques are designed to find solutions to problems with a pre-defined distinct set of alternatives, while MODM techniques are used for problems where the alternatives are not pre-defined.

Belton and Stewart (2002) propose classification based on the range of application. They classify MCDM techniques into three groups, i.e. Value Measurement Models, Goals or Reference Level Models and Outranking Models. The Value Measurement Models focuses on numerical scores to signify the degree to which one alternative may be chosen over another. Meanwhile, the Goals or Reference Level Models focuses on establishing desirable goals level for each criterion and looking for the alternatives that are closest to reaching these goals. The Outranking Models stresses on pairwise comparison with the purpose of establishing the strength of evidence favouring selection of one over another.

Tam, Tong and Zhang (2007) introduced another MCDM techniques classification, organising techniques into two categories based on the input for the decision-making process. The first category operates on the basis of decision makers' judgment and preferences. This includes the

Analytical Hierarchy Process (AHP) and Non-Structural Fuzzy Decision Support System (NSFDSS). The second operates on qualitative and quantitative input from real-world data. This includes Elimination and Choice Corresponding to Reality III (ELECTRE III) and Superiority and Inferiority Ranking (SIR). Explanations regarding these techniques are provided below.

2.9.1 Analytical Hierarchy Process (AHP)

This technique was established by Saaty in the 1970s. The basic concept of this technique is that it organises perceptions, judgments and memories into a hierarchy of forces (Saaty 1994). It is a technique to rank options based on the decision maker's judgment (Nydick & Hill 1992). According to Tam, Tong and Zhang (2007), this technique is a tool for dealing with complex, unstructured and multi-attribute decisions.

As the name of this technique suggests, the decision maker first defines a hierarchical structure representing the multi-criteria problem. It has at least three levels of hierarchy, i.e. the goal, the criteria and the alternatives. In its operational theory, it has four main parts namely: (1) pair-wise comparison, (2) determination of consistency ratio, (3) determination of weights of alternatives and decision criteria and (4) calculation of final comparison scores (Tam, Tong & Zhang 2007).

2.9.2 Non-Structural Fuzzy Decision Support System I (NSFDSS-I)

This technique was developed by Chen (1998). It aims to obtain the best solution among a number of alternatives. It involves three principles, namely: decomposition, comparative judgment and synthesis of priorities. The decomposition structures a multi-criteria problem into elements of different levels. The comparative judgment is used to create pair-wise comparisons of the relative importance of elements. Meanwhile, priorities are synthesised by multiplying local priorities with the priority of their corresponding criterion and weighting each element to the criteria it affects (Tam, Tong & Zhang 2007).

In its operational theory, NSFDSS has five main steps, i.e. (1) pair-wise comparison, (2) consistency checking and output matrices, (3) priority ordering and assignment of priority score, (4) derivation of weights and (5) determination of results (Tam, Tong & Zhang 2007). According to Tam et al. (2002a), this technique has three advantages, i.e. (1) breaking the problem down into many pair-wise comparisons, (2) applying logical consistency checks and (3) using semantic operators that integrate the strength of fuzzy set theory. However, its ability to assess the relative importance of various elements/alternatives is weak (Tam, Tong & Zhang 2007). Thus, NSFDSS-II has been developed to refine Chen's model (Tam et al. 2002a; Tam et al. 2002b).

2.9.3 Non-Structural Fuzzy Decision Support System II (NSFDSS-II)

This technique was developed based on Chen's NSFDSS-I model. Similar to NSFDSS-I, it follows the principles of decomposition, comparative judgment and synthesis of priorities. In its operational theory, the first three steps in both NSFDSS-I and NSFDSS-II are identical. However, in step 4—derivation of weights—NSFDSS-II conducts two normalisation processes, i.e. normalisation of decision criteria priority score and normalisation of alternatives/elements priority score. Thus, it allows the decision makers to outline the importance of decision criteria within the system and the importance of each element under different decision criteria (Tam, Tong & Zhang 2007).

In step 5—determination of the results—NSFDSS-II calculates the contribution of each element for a particular problem. The calculated importance of each element is then subjected to the final priority ordering. The most important element has the highest weight in the system. This allows decision makers to assign resources based on the priority of each element (Tam, Tong & Zhang 2007).

2.9.4 Elimination and Choice Corresponding to Reality III (ELECTRE-III)

This technique was developed by Roy (1968). It has five versions, i.e. ELECTRE-I, II, III, IV, and TRI, with ELECTRE-III being the most common one. ELECTRE-III is a non-compensatory MCDM technique that utilises numerous mathematical functions to show the degree of dominance of one alternative over the others. Using a pair-wise basis, it facilitates comparisons between alternative schemes (Tam, Tong & Zhang 2007).

The foundation of this technique is the application of outranking concept, which was formulated by Roy (1968). According to Rogers, Bruen and Maystre (2000), there are two types of criteria that influence the selection of the ELECTRE version to be employed. These two types of criteria are: (a) true criterion and (b) pseudo-criterion. The first one is considered as the conventional preference structure that has no thresholds involved. The latter involves a two-tier threshold approach (Rogers 2000).

2.9.5 Superiority and Inferiority Ranking (SIR)

This technique was established by Xu (2001). It uses mathematical functions to rank the various alternatives (Tam, Tong & Zhang 2007). Using the concepts of superiority and inferiority scores as defined by Rebai (1993, 1994), this technique allows inaccurate information in the system. A 'superiority and inferiority' matrix is formed once the assignment of thresholds and weights to each decision criterion has been completed. This will construct the outranking relationships between alternatives within the system which can be exploited by aggregation methods (Tam, Tong & Zhang 2007).

Previous studies comparing these MCDM techniques expose that no technique is inherently better and in only few cases will different techniques produce different results (Ozelkan & Duckstein 1996; Hajkowicz & Collins 2007; Hajkowicz & Higgins 2008). Nevertheless, the use of a multi-criteria approach in the decision-making process may enhance transparency, auditability, analytic rigor and conflict resolution (Dunning, Ross & Merkhofer 2000). Su (2013) provides the following steps in using an MCDM analysis:

1) identifying the decision context, including the decision makers, stakeholders and decision constraints
2) identifying the decision criteria
3) eliciting the relative importance of criteria weights
4) generating a set of candidate decision alternatives
5) evaluating the performance values of decision alternatives against the criteria
6) applying suitable techniques for MCDM
7) performing sensitivity analysis
8) making the final decision

Table 2.8 presents several applications of the above MCDM techniques in solving construction management problems.

Table 2.8 List of different MCDM techniques applied to selection problems

MCDM techniques	Examples of application	Project case study
AHP	Tam, Tong and Zhang (2007): construction methods	A case study for choosing the best construction methods in a high-rise commercial project in Hong Kong
	Vargas (2010): general projects	A case study of project portfolio selection for ACME Organisation
	Inti and Tandon (2017): contractor selection	A fabricated case study for selecting a contractor from six alternatives
NSFDSS	Tam et al. (2002b): site layout optimisation	A case study to optimise site layout planning where temporary facilities should be placed
	Yau and Chan (2008): urban regeneration project	A case study to choose between rehabilitation and redevelopment of urban decay in Hong Kong
NSFDSS-II	Tam et al. (2002a): safety management system	A case study of safety management system evaluation in a 7-storey high primary school in Hong Kong
ELECTRE-III	Rogers and Bruen (2000): route selection	A case study to choose route for Dublin Port Motorway
	Tam, Tong and Zhang (2007): construction methods	A case study to select pavement structures to be used
	Marzouk (2010): contractor selection	A fabricated case study to select a capable contractor out of five contractors based upon five decision criteria
SIR	Tam, Tong and Wong (2004): construction methods	A case study to select concrete pump from 10 alternatives based upon nine decision criteria
	Rouhani (2017): IT software	A case study to evaluate and select IT service management software packages in a local Iranian IT company

2.10 Decision-Making Frameworks for Infrastructure Project Selection

In the construction management discipline, the decision-making process has been widely studied. Several previous studies have tried to examine and develop various decision-making frameworks in the construction sector (Piyatrapoomi, Kumar & Setunge 2004; Nnaji et al. 2018). These DMFs are required to bridge the effective decision-making process between multiple decision makers involved. It can be defined as a structured and systematic approach to problem-solving and decision making in complex situations that serves as a guide for decision makers in attaining their organisational objectives (Hansen, Too & Le 2020c).

A DMF is a crucial managerial tool utilised to capture various views objectively before arriving at an agreed decision (Nnaji et al. 2018). It assists decision makers in making high-quality decisions (Chen et al. 2008). While the use of DMFs has been recommended in the construction industry (Piyatrapoomi et al. 2004; Nnaji et al. 2018), some experts argue that generally the construction sector lacks effective mechanisms for supporting decisions (Li, Irani & Love

2000; Chen et al. 2008). Arif (2013) argues that some frameworks or tools have limitations that have further created gaps to fill. On the other hand, NCHRP (2005) found that many of the existing tools are not being optimally used due to poor capabilities of the tools, poor credibility during data input and organisational factors.

Governments in several countries have promoted the use of DMFs in managing their infrastructure project assessment by supporting the development of DMTs. Table 2.9 summarises some DMFs that have been developed in various countries to assess and select infrastructure project portfolios.

Table 2.9 Several Decision-Making Frameworks (DMFs) for infrastructure project selection

No	Country	Framework's Name	Developed by	Outcomes	Approach	DM Technique used
1	Australia	Assessment Frameworks (2018)	Infrastructure Australia	Infrastructure Priority List	Has five stages, i.e. problem identification and prioritisation, initiative identification and options development, business case development, business case assessment, and post completion review.	Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) and Multi-Criteria Analysis (MCA)
2	Australia	Infrastructure Investor Assurance Framework (2016)	NSW Treasury	Framework principles, framework arrangements	Seven gateway reviews applied, i.e. project justification, strategic assessment, business case, pre-tender, tender evaluation, pre-commissioning and post-implementation	CBA, MCA
3	UK	UK Investment Plan (2014)	The Treasury's Infrastructure Unit of UK	Infrastructure Priority List	There are five criteria: strategic importance, capital value, regional priority, demonstrator, and unlocking investment	Economic Impact Analysis, MCA
4	Multi-nationals	City Infrastructure Investment Programming & Prioritisation Toolkit (2010)	Cities Development Initiative for Asia	Infrastructure project prioritisation	Uses a systematic approach to prioritisation with a broad base of criteria to form a basis for objective infrastructure decision making. The toolkit has three components, i.e. financial capacity analysis, project prioritisation, and programming for investment. In prioritising projects, this toolkit utilises the scoring methodology by going through a list of questions for each project.	Prioritisation Scoring
5	Indonesia	KPPIP Infrastructure Assessment	Indonesia's Committee for Acceleration of Priority Infrastructure Delivery (KPPIP)	Infrastructure Priority List	The three categories of criteria used by KPPIP in their project selection and evaluation are basic criteria, strategic criteria and operational criteria.	Prioritisation Scoring

The Assessment Framework (2018)

The Assessment Framework was developed by Infrastructure Australia. It consists of five parts, namely: introduction, stages, templates and checklists, technical notes and appendices. It provides capabilities for:

- Identifying problem identification and prioritisation
- Considering project initiatives for inclusion on the Infrastructure Priority List
- Developing the preferred options in a business case
- Facilitating evidence-based development of infrastructure projects

The strength of this framework lies in its simplicity, with are only five stages, namely: problem identification, initiative identification, business case development, business case assessment and post completion review. On the other hand, there are several aspects that can be improved from this framework, including among others:

- Details of each stage make it a very long and complicated process
- Lack of several important selection criteria, such as private and public sector involvement, political environment and funding problems
- Too many detailed checklists and templates are provided and used
- Designed specifically to be used by Infrastructure Australia

The Infrastructure Investor Assurance Framework (2016)

This framework was developed by Infrastructure NSW, a coordination agency under the Minister for Transport and Infrastructure in NSW. The application of this framework provides a risk-based assurance procedure to identify the level of confidence by increasing the transparency of project delivery, improving public confidence in infrastructure and contributing to economic growth through the delivery of productive infrastructure. Its strength lies in its focus on the "investor perspective" and the involvement of investors at all stages of the capital investment lifecycle. Thus, this framework is intended as a tool for external independent assurance based on risk. It is not an audit, approval or authorisation process, so it does not cover several key criteria for infrastructure project selection and prioritisation that should be carried out by an implementing agency.

UK Investment Plan (2014)

This document sets out the top priority infrastructure investments in the UK. It allows the government to focus on the delivery of those investments based on several main criteria. Investments are grouped by sector and are chosen based on one or more of the following criteria: strategic importance (delivers a significant contribution), capital value, regional priority, demonstrator (is innovative and could improve future expansion) and unlocking investment (allows private sector investment). The output of this procedure is a list of the top 40 infrastructure investments which is refreshed on an annual basis to reflect changes in project status and its conformity with the government's priorities. Thus, this document does not explain in detail the decision-making process of infrastructure project selection and prioritisation and only outlines five selection criteria to prioritise infrastructure investments (without further explanation on the judgment and selection process).

City Infrastructure Investment Programming and Prioritisation Toolkit (2010)

This document was designed by Cities Development Initiative for Asia (CDIA) to assist cities and municipalities across Asia in urban infrastructure planning, prioritisation and programming. It consists of a manual and an Excel workbook as a technical decision-making tool. It has three components, namely: investment budget analysis, project prioritisation and project programming. This framework has several strengths, some of which are:

- It uses a systematic approach to prioritise projects with a broad base of criteria
- It provides a simple prioritisation and programming activity that does not require hefty manuals or external consultants, nor is it time consuming
- It is user-friendly format where the model is a computer-based one that uses a widely compatible software
- It is intended as a technical decision-making tool in the annual budgeting exercise, which can be updated on an annual basis

Apart from the above capabilities, this framework has some limitations:

- It does not serve as a comprehensive assessment of a project's social or environmental impact
- It is not developed based on a decision-making context, which can affect the quality of the decision output when it is used in a certain context
- While it provides an example of project prioritisation exercises to illustrate the use of this tool, it is not an evidence-based framework that needs to be validated and evaluated through actual case study implementations

Indonesian Approach for Infrastructure Project Selection and Prioritisation

In Indonesia, the government established a board similar to Infrastructure Australia that is is tasked with selecting a list of projects that are considered strategic and urgent, and providing facilities for project implementation. This board was known as Indonesia's Committee for Acceleration of Priority Infrastructure Delivery (KPPIP). From mid-2016 until the beginning of 2017, it evaluated and selected national strategic projects as stipulated in Presidential Decree No. 58 of 2017 concerning the Amendment of Presidential Decree No. 3 of 2016 on the Acceleration of the Implementation of National Strategic Projects. The three categories of criteria used by KPPIP (2016) in their project selection and evaluation were basic criteria, strategic criteria and operational criteria as presented in Figure 2.9.

Figure 2.9 Three categories of criteria used by KPPIP

In performing its duties, KPPIP employed a three-level infrastructure prioritisation approach to prioritise infrastructure projects from thousands of proposed projects (Marcelo et al. 2016). There were four indicators of project scoring, i.e. project purpose (25%), feasibility of implementation (30%), socio-economic impact (30%) and environmental impact (15%). Next, the committee would conduct discussions based on the scoring and ranking outcomes. However, there was no clarity regarding the weighting of these criteria, so this may have affected the quality of the decisions.

In addition to national strategic projects managed by KPPIP, the Indonesian government through the Ministry of National Development Planning (MNDP) also issued a National Development Evaluation Guideline (NDEG) through the Minister of National Development Planning Regulation No. 1 of 2017. This guideline was designed to provide guidance for government agencies and other parties who need to evaluate development policies, programs or activities. Under this guideline, an ex-ante evaluation is performed before planning documents are established. The purpose of the ex-ante evaluation is to select the best alternative policy from the various alternatives available, and to ensure the planning documents are structured, coherent and systematic. The mechanism of the ex-ante evaluation process can be seen in Figure 2.10. The weakness of this selection procedure is the unavailability of explanations related to the quantitative selection process of project proposals by considering multiple selection criteria.

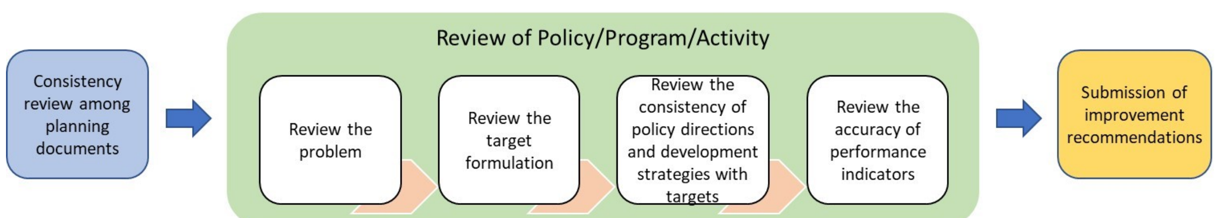


Figure 2.10 Ex-ante evaluation process

At a ministerial level such as MPWH, the planning and implementation of the ministry's infrastructure projects refer to the ministry's strategic plan document that contains the infrastructure project plan for five years. The formulation of the ministry's strategic plan is a long and sustainable process that includes participating in the planning development forums (*musrenbang*) at various levels from the sub-district, district and provincial level to the central level. In relation to the preparation of this strategic plan, the regional infrastructure planning agency (BPIW), as part of the MPWH is tasked with drafting a technocratic design that will become the MPWH strategic plan. The formulation of this technocratic design is based on the Strategic Development Regions (WPS) approach to facilitate the management and development of regions in Indonesia. The selection of strategic infrastructure projects based on the WPS concept rests on the principles of (1) efficiency based on the capacity and function of the built physical environment, (2) benefits on an economic scale, (3) synergy in providing transportation infrastructure for connectivity both nationally and internationally, (4) reducing the gap between the supply and demand of renewable energy for electricity, (5) meeting the basic services needs of settlements that are appropriate for the community and creating cities without slums, (6) increasing the reliability and sustainability of water resource services both for the fulfilment of drinking water, sanitation, and irrigation to support water and food security, and (7) taking into account the National Spatial Plan (RTRWN) at each WPS (PUPR 2015).

Areas for Improvement

A review of the above frameworks and procedures is useful for identifying various issues that can be used as a direction in developing an efficient DMF. In general, there are several areas for improvement that can be considered in the development of a DMF for infrastructure project selection and prioritisation:

- Rather than developing a complicated and sophisticated DMF, it is better to develop a simple and practical DMF for infrastructure project selection and prioritisation. In doing this, it is essential to consider the decision-making context in which the developed DMF will be applied.
- Consequently, identification of the necessary criteria required in the selection and prioritisation process of infrastructure projects needs to be carried out comprehensively against a particular decision-making context so that the developed DMF can analyse the selection problem appropriately and provide appropriate decisions.
- DMF development must fulfil supporting elements such as transparency and audit process so as to guarantee accountability of the decision outputs.
- A practical tool should be developed as an integral part of the DMF to facilitate decision makers in providing judgment input during the project selection and prioritisation analysis.

- To ensure the effectiveness of the developed DMF, it is important to validate it through actual case study implementations and other strategies so as to provide a proof-based framework.

In addition to several DMFs for infrastructure project selection and prioritisation that have been implemented by several governments, there are also several research publications related to the development of DMF for infrastructure project selection as presented in Table 2.10. It provides a summary of academic papers by explaining the approach taken as well as their strengths and weaknesses.

Table 2.10 Summary of previous research projects and publications on DMF for infrastructure project selection

Author(s) & Year	Research Title	Summary
Piyatrapoomi et al. (2004)	Framework for Investment Decision Making under Risk and Uncertainty for Infrastructure Asset Management	• This paper investigates current practices of decision making under risk and uncertainty for infrastructure projects • The finding shows that many Western countries employ scenarios in investigating the effects of risk and uncertainty of infrastructure project investments • It develops a risk assessment framework for the decision-making process of infrastructure project investments • It employs scenario and sensitivity analysis to assess risks and uncertainties • It does not yet include risk into the investment decision-making process
Berechman and Paaswell (2005)	Evaluation, Prioritisation and Selection of Transportation Investment Projects in New York City	• This paper presents a prioritisation methodology for transportation investment projects developed by the authors • It mostly employs Cost-Benefit Analysis (CBA) to develop the Goal Achievement Matrix (GAM) • The critical component of the GAM is the weights • The weights are developed using a modified Delphi approach • It is an evidence-based framework through case study implementations • It lacks the engagement of the set of regional players in setting a vision and choosing strategies
Mawdesley, Hernandez, and	A Decision-Making Model for Infrastructure	• This paper presents the process in selecting investment projects with focus on the

Al-Jibouri (2005)	Projects Selection in Developing Countries	characteristics of infrastructure projects in developing countries • It develops a computer system used for implementing the model • It mostly employs Cost-Benefit Analysis (CBA) • It provides a proof-based methodology
Kimley-Horn and Associates (2008)	Highway Project Prioritisation Methodology	• This framework was prepared for Fredericksburg Area Metropolitan Planning Organisation, Virginia • It employs a prioritisation scoring that can assess quantitative and qualitative factors • However, it does not present a detailed analysis of how the weighting of each factor was obtained
North Central (2010)	Project Prioritisation Process & Scoring Methodology	• This paper presents a methodology to prioritise transportation projects conducted by North Central Pennsylvania • North Central formed a Project Prioritisation Committee to develop project selection criteria • A group-enabled decision-making software called Decision Lens was used for weighting purposes • The software subjected each criterion to rigorous pairwise comparisons • It is time consuming
WBG (2014)	Prioritising Projects to Enhance Development Impact	• While it does not present a practical tool or framework for infrastructure project selection, this paper establishes ten infrastructure prioritisation principles • In principle two: robust and transparent selection criteria, it encourages the use of Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA)
Marcelo et al. (2016)	Prioritising Infrastructure Investment: A Framework for Government Decision Making	• This paper presents an Infrastructure Prioritisation Framework that contemplates project outcomes in two dimensions: social-environmental and financial-economic • The framework proposed is a quantitative multi-criteria prioritisation approach • The results are displayed graphically • Several improvements include sectorial rebalancing, private participation, integrated planning, and case study implementations
Marcel, Ioan, and Alina (2016)	Improved Prioritisation Criteria for Road Infrastructure Projects	• This paper suggests a methodology for assessing infrastructure projects based on prioritisation criteria • Four dimensions are established: absorption, impact, legitimacy and capacity • However, it does not present a detailed analysis on how the weighting of each indicator was obtained

Nnaji et al. (2018)	Developing a Decision-Making Framework to Select Safety Technologies for Highway Construction	• This paper develops a DMF for safety technologies selection in highway projects • It uses the Choosing by Advantages (CbA) decision-making method • The framework consists of five steps: identify objective, identify technology category, assess technology for performance data, evaluate technology alternatives, and technology selection and implementation
Goh, Goh, and Chong (2019)	Integration Model of Fuzzy AHP and Life-Cycle Cost Analysis for Evaluating Highway Infrastructure Investments	• This paper aims to develop an integration model to leverage the fuzzy AHP and LCCA in evaluating highway infrastructure investments • The decision-making model evaluates both qualitative and quantitative factors of cost components • The model has been evaluated through case study implementation and sensitivity analysis
Austroads (2020)	Procurement Decision Tool: A Case Study of the Toowoomba Second Range Crossing	• This report describes the development of the Procurement Decision Tool which focuses on the aspect of Value-for-Money in the delivery of infrastructure projects • The tool is designed to replace the four-step procurement development process. It offers objectivity in decision making • The five-step in the tool are activity analysis, project specific or network analysis, risk analysis, contract packaging analysis and exchange relationship analysis • The strength of this report lies in its validation through empirical testing and successful trial in the delivery of two major transport projects

2.11 Gaps in Knowledge and Practice

The reviews and discussions above have revealed some important issues related to the demand for a simple and effective decision-making framework in Indonesia. The following section provides a gap analysis that resulted from the literature review and expert interviews to highlight the importance of this research. This research aims to develop a model for a DMF during the FEP phase for infrastructure project selection that integrates multiple decision criteria. Thus, there are three main research gaps, related to the FEP phase, DMF for infrastructure project selection in Indonesia and integration of NSFDSS-II as an MCDM technique. All of these issues are analysed in the Indonesian context, which has not been studied previously.

2.11.1 Decision-Making Process during the Front End Planning Phase

Previous research has shown the relationship between the FEP phase and project success. In Indonesia, poor project planning and inconsistencies between the planned and actual conditions are considered to be some of the main causes of project failure. The FEP phase starts with a project initiation and ends with a decision of final investment by decision makers. Several previous studies have researched the FEP stages, especially in relation to the project definition. The result is the development of various tools such as project alignment and PDRI tools that can be applied to infrastructure projects, building projects and industrial projects. However, little research has focused on the decision-making phase of the FEP even though the impact of this phase is crucial. The complex and unpredictable nature of the decision-making process makes it even more important to be understood in terms of infrastructure project selection. Thus, this study seeks to develop a DMF that incorporates FEP elements such as considerations of project definitions, goals, risks, innovation and political environment to evaluate project alternatives through a systematic decision-making process.

2.11.2 Indonesia's Infrastructure Decision-Making Framework

The Indonesian government realises that they have limited investment resources for infrastructure development so they must ensure that investments are provided for the most appropriate infrastructure projects. This is attempted through a project selection and prioritisation process, as discussed in the previous section. However, the existing practice does not provide a clear project selection and prioritisation process. The current guideline (NDEG) provides no explanation regarding the quantitative assessment and selection of the project portfolios. Meanwhile, the framework developed by KPPIP does not explain how the weighting for each of project selection criteria was obtained. The weighting of each criteria should be done through a systematic analysis process to ensure its validity and reliability. Therefore, MCDM techniques should be applied to determine the significance of each criterion.

On the other hand, there is a need for a DMF that can be used to select and prioritise infrastructure project proposals across different project types. Most currently available DMFs are project specific. Thus, the DMF development in this study was carried out according to this consideration. In addition, this research also contributes to developing a DMF through three important stages: conceptualisation, contextualisation, and implementation. Contextualisation becomes crucial to provide accurate representation of the decision-making process, i.e. infrastructure project selection and prioritisation in the Indonesian context. The methods used in this research are directed at contextualisation efforts including expert interviews and questionnaire surveys to achieve this goal so that this research can provide a clear, systematic and informative assessment of infrastructure project proposals for Indonesian decision makers.

2.11.3 Integration of NSFDSS-II in Determining Priority Scale of Decision Criteria

Since infrastructure project selection is characterised by impreciseness, incompleteness and uncertainty of data, it requires a fuzzy MCDM technique to select and prioritise the project alternatives. While the project selection process is usually done with only one constraint or one dimension, NSFDSS-II can be used to develop a DMF that can assess the relative importance of various elements in a system where they co-exist under the same situation. Thus, it allows more than one constraint as assessment parameters or dimensions, i.e. time effectiveness, cost effectiveness and project complexity. This is useful considering that the selection and prioritisation of infrastructure projects is a very complex process and influenced by more than one dimension. Although it is superior in evaluating the relative importance of various decision criteria compared to NSFDSS-I and other MCDM techniques, the application of NSFDSS-II in infrastructure project selection and prioritisation has never been studied previously. Therefore, this research seeks to integrate NSFDSS-II into the development of a Decision-Making Tool (DMT) which will be incorporated into the proposed DMF for infrastructure project selection in order to provide a better and more solid ground for decision makers to allocate suitable investment resources.

To sum up, Table 2.11 presents the gap analysis for DMF advancement in this study.

Table 2.11 Gap analysis for Decision-Making Framework advancement

Concepts	Characteristics and Gaps	Novelties and Areas for DMF Advancement
Decision-making process during Front End Planning (FEP) phase	While FEP is widely recognised, it is still understated in the literature (Samset & Volden 2016). In general, the FEP phase is not well understood. Clarity is required to understand what FEP is conceptually, where it stops and starts, and the relationship of FEP with the project (Williams et al. 2019)	This research provides an extensive and systematic literature review on the FEP phase in the construction industry. The review has established certain aspects of the FEP phase including the scope and definition of the FEP phase, the differentiation between FEP and project planning, the position of FEP within a project life cycle, the FEP stages based on FEP characteristics and the importance of FEP for strategic decision-making

	The impact of the FEP phase particularly its last stage i.e. decision making which results in a final investment decision and project approval has not yet been studied (Hansen, Too & Le 2018a)	This research aims to develop a Decision-Making Framework for infrastructure project selection and prioritisation that can assist decision makers in making judgments related to final investment decision and project approval. Thus, the developed DMF serves a managerial and technical tool that is appropriate for use during the FEP phase and deals mainly with the last stage of FEP
	Innovation potential during the project planning phase in megaprojects still needs to be explored (Williams et al. 2019)	Several previous studies on this matter have focused on providing methods for assessing project innovation potential at the FEP phase (Tawiah & Russell 2008); practical innovation considerations, qualities and complexities (van Binsbergen et al. 2013); and a case study of innovation potential in a megaproject (Worsnop, Miraglia & Davies 2016). In this research, innovation is recognised as one of the key selection criteria during the FEP phase for infrastructure projects
	FEP adoption in developing countries has not been widely studied (Hansen, Too & Le 2018a)	This research explores FEP adoption in terms of developing a DMF for infrastructure investment decisions in the Indonesian context
	More research is needed on how a project originates from the relevant political environment during the FEP phase and the effect of megaproject complexity during the FEP phase (Williams et al. 2019)	This research understands that infrastructure project selection in Indonesia is still strongly influenced by political agendas which may add to decision biases during the FEP phase. Therefore, this study directly observes the current planning and selection processes of the relevant political entities, namely the related ministries in Indonesia. Furthermore, project complexity is recognised as one of three constraints in the selection process in Indonesia.
Indonesia's infrastructure Decision-Making Framework (DMF)	There is no research that holistically and comprehensively develops a DMF for infrastructure project selection and prioritisation in the Indonesian context. The absence of a clear and structured DMF is one of the most important challenges in infrastructure planning and development (Hansen, Too & Le 2020a).	This research aims to develop a holistic and comprehensive integrated framework for robust decision making. It proposes a systematic procedure for DMF development that includes three stages of development, i.e. conceptualisation, contextualisation and implementation of DMF. The conceptualisation helps to direct the DMF development. Contextualisation situates the DMF development in a specific context or situation by identifying actual challenges and issues in infrastructure project planning and selection processes in Indonesia as well as DMF key features so that the DMF development is applicable to Indonesian context. The DMF consists of two parts, i.e. the framework process and DMT. The framework process advances the project evaluation process by compartmentalising it into four sequential stages which makes it easy for decision makers to understand the procedure for selecting

		infrastructure project proposals. The DMT can automatically analyse input judgments so as to facilitate the assessment of project proposals. This will result in a project priority list. In addition, the DMF has established a hierarchical structure of problems consisting of goals, assessment parameters, selection criteria and project alternatives. Thus, this research contributes by providing a clear, systematic and informative assessment of infrastructure project proposals for decision makers. It can assist decision makers in accurately selecting and prioritising infrastructure project proposals.
	Infrastructure projects as megaprojects are influenced by many variables that have not been widely considered such as sustainability, regulatory, politics and risks (Eid & El-adaway 2018; Goh, Goh & Chong 2019; Yazdani et al. 2019; Rasoulkhani et al. 2020)	Ways to identify these variables as criteria in selecting and prioritising infrastructure project proposals have been provided in this research.
	Decision making as a cognitive process may be influenced by factors that influence decision makers in making their decisions. These influencing factors are still underexamined in previous studies (Hansen, Too & Le 2020b)	This research extends the coverage of the DMF development by dealing with multiple factors influencing the decision-making process during infrastructure project selection. Through expert interviews, this research explores these factors qualitatively.
	There is a need for project prioritisation across different project types (NCHRP 2005)	This research adapts to the needs in Indonesia (namely MPWH) to be able to select and prioritise infrastructure project proposals regardless of the project types. For this reason, this research has limited its study by establishing selection criteria based on this consideration so that it is capable of prioritising across project types.
	Infrastructure projects are highly interdependent with each other. These interdependencies can be motivated by use of the same competencies, resources, stakeholders, etc. (Moersidik et al. 2015).	This research is an attempt to encompass the national scale of infrastructure project planning conducted by relevant ministries. The DMF is developed by considering the interdependencies between various project aspects in selecting and determining project priority.
	There is a need for a DMT that supports not only a single set of geographic categories, but also a single set of network categories (NCHRP 2005).	The developed DMF and DMT can be utilised by various levels of decision makers since the performance indicators are key indicators established in the Indonesian context (without geographic restrictions).
	In order to develop a DMF that better mimics the decision actions,	To be applicable, the DMF development requires multi-sequence techniques including various expert

	various techniques are required to provide accurate representation of the decision-making contexts (Eid & El-adaway 2018).	interviews, questionnaire surveys, pairwise comparisons through the Delphi method and several evaluation strategies. It is also developed specifically to the Indonesian context though it can be modified for use in other countries.
	In the project selection problem, efforts should be made to obtain an extension of the sample to increase the generalisability of the results and to confirm their application to specific contexts only (Costantino, Gravio & Nonino 2015).	This research adopts a mixed method in which multi-sequence techniques were employed to gather both quantitative and qualitative data. The qualitative data were mainly obtained from three relevant ministries as well as academics and professionals in the industry. The quantitative data were obtained from a larger group of respondents from the survey distribution. All data are in the Indonesian context.
	The developed DMF needs to be validated in real cases to improve the usability of the DMF. It also needs to be compared with other simulations to determine the accuracy and practicality of the results (Marcelo et al. 2016; Shafahi & Haghani 2018; Guerra & Abebe 2019). Thus, there is a need to extend the operationality of a proposed DMF through real case study implementations and sensitivity analysis.	The developed DMF is validated through several strategies including real case study implementations, parallel-form reliability tests and sensitivity analysis. Doing so improves the usability and operationality of the developed DMF (proof-based DMF). The methodologies adopted to develop this DMF can also be applied to other decision-making problems.
NSFDSS-II as an MCDM technique in infrastructure project selection and prioritisation	Identifying criteria is the most crucial step in developing the DMF. Infrastructure project selection and prioritisation problems require multiple criteria based on the MCDM technique (Hansen, Too & Le 2019)	This research contributes by identifying the underlying selection criteria as variables that influence the investment decisions through multi-sequence techniques in the Indonesian context, which has never been explored before.
	The project selection process is usually done with only one constraint, cost effectiveness (Gabriel, Ordóñez & Faria 2006; Dutra, Ribeiro & de Carvalho 2014; Kedir, Raoufi & Fayek 2020) to calculate the weight contributions of each indicator.	The use of NSFDSS-II allows the application of three constraints as assessment parameters, i.e. time effectiveness, cost effectiveness and project complexity. It is effective in determining the priorities and weights of selection criteria. Thus, its results can be effective in establishing an infrastructure project priority list.
	Fuzzy problems require the fuzzy MCDM technique (Al-Khafaji, Mesheb & Abrahim 2019). Since infrastructure project selection is characterised by impreciseness, incompleteness and uncertainty of data, this technique is needed to select and prioritise the project	This research proposes a methodology to integrate the NSFDSS-II – a fuzzy MCDM technique in the DMF development to improve decision-making processes in infrastructure project selection and prioritisation. The integration of this technique in solving infrastructure project selection problems has never been done before. Variances in the decision-making process can be assessed through

	alternatives. Thus, there is a need to address variances and uncertainties in decision-making problems (Shafahi & Haghani 2018; Goh, Goh & Chong 2019)	sensitivity analysis. Thus, this research develops an innovative and structured project evaluation that addresses the variances and uncertainties through integration of the MCDM technique and sensitivity analysis.
	In MCDM, pairwise comparison is used to elicit knowledge from experts and assign weights for each criterion (Guerra & Abebe 2019). A large pairwise comparison is needed involving more decision makers in the development process (Yazdani et al. 2019)	The usage of the Delphi method in ranking and weighting project selection criteria during pairwise comparisons is promoted in this research. This will ensure more accurate judgment in pairwise comparisons provided by experts involved in the Delphi method.
	In MCDM, sensitivity analysis should be conducted to analyse which alternatives have the most influence on the decision-making process (Shafahi & Haghani 2018; Kedir, Raoufi & Fayek 2020)	In this research, sensitivity analysis was done to obtain a comprehensive understanding of the infrastructure project selection and prioritisation processes. It is used to assess the reliability of the proposed DMF under different scenarios.

2.12 Chapter Summary

This chapter presented an extensive literature review of infrastructure project development, particularly in Indonesia. It also investigated the significance of the FEP phase and FEP processes. It further reviewed the fundamental concepts of the decision-making process and analysis. Here, a theoretical framework and major components of decision making to be utilised for developing a framework in this study were also provided. In addition, this chapter also investigated several MCDM techniques and existing DMFs for infrastructure project selection. The review of the literature contributed by highlighting several key issues and gaps in the knowledge. The following chapter will describe the methodology adopted in this study.

CHAPTER 3. METHODOLOGY

3.1 Introduction

The purpose of this study is to develop a model of a Decision-Making Framework (DMF) for infrastructure project selection and prioritisation. A DMF is an effective tool for decision makers to make correct and accountable decisions. There is a need to develop this DMF as the construction industry lacks the mechanisms to support the decision-making process (Chen et al. 2008; Li, Irani & Love 2000). Developing a practical and efficient DMF will significantly help the government, particularly the Ministry of Public Works & Housing (MPWH) in selecting and prioritising infrastructure projects. In seeking to understand this challenge, this research addressed four research questions:

RQ 1. What are the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection?

RQ 2. What are the key features of a good DMF for infrastructure project selection?

RQ 3. What are the appropriate decision criteria in selecting infrastructure projects?

RQ 4. How can a DMF for infrastructure project selection be developed and to what extent can it be implemented?

To answer the above research questions, this chapter provides this research's methodology. It includes discussion around the following areas: the selection of research methodology elements, i.e. research philosophy, research paradigm, research approach, and research method; the development of research design; and the description of research operations in detail.

3.2 Research Philosophy

Research philosophy refers to people's philosophies and assumptions about the world and the nature of knowledge (Collis & Hussey 2014) all of which may help or influence researchers in creating and clarifying their research designs (Easterby-Smith, Thorpe & Jackson 2008). There are two philosophical assumptions, i.e. ontological and epistemological; and two basic beliefs in research philosophy, i.e. axiology and methodology (Wahyuni 2012). According to Saunders, Lewis, and Thornhill (2009), these assumptions and beliefs assist researchers in positioning their research within the philosophical continuum.

Ontology is related to the study of the nature of reality (Collis & Hussey 2014; Saunders, Lewis & Thornhill 2009) and thus, concerns the assumptions in conceptual reality (Fellows & Liu 2015). It is the science of being and existence (Easterby-Smith, Thorpe & Jackson 2008). Scientific research traditionally adopts a *being* ontology, which is concerned with investigating 'how things are' (Fellows & Liu 2015). However, Winter, Smith, Morris and Cicmil (2006) suggest a *becoming* ontology for research in project management area to understand meanings in the dynamic context of human existence. According to Creswell (2014), reality is created by the individual involved in the research situation. In social science, an ontological assumption can observe reality as objective or subjective. Objectivism or realism holds the view that things exist independently. It signifies the position where social entities exist in a reality that is external to social actors (Neuman 2013). Meanwhile, subjectivism or nominalism holds that things are constructed from the perceptions and actions of those social actors (Saunders, Lewis & Thornhill 2009).

Epistemology is concerned with the origins, nature, methods and limits of human knowledge (Fellows & Liu 2015). It is the study of the criteria needed to identify what does and does not constitute scientific knowledge (Johnson & Duberley 2000). Guba and Lincoln (1994) state that it shows the connection between the would-be knower and what can be known. It focuses on the nature and forms of knowledge, how it can be obtained and how it can be transferred to others (Cohen, Manion & Morrison 2000).

Axiology refers to judgments about the research values (Collis & Hussey 2014; Saunders, Lewis & Thornhill 2009) and whether the researcher values particular approaches over others (Rahmani 2016). *Methodology* denotes the overall approach to answer a scientific problem that could be set into practice. It includes the theoretical background to the data collection and analysis (Collis & Hussey 2014). Generally, it can be further divided into qualitative, quantitative and mixed method approaches.

Polarities of research philosophy as adapted from several previous studies are presented in Table 3.1 (Fellows & Liu 2015; Morgan & Smircich 1980; Remenyi et al. 1998; Wahyuni, 2012).

Table 3.1 Polarities adopted by researchers

Philosophy	Continuum	Assumptions
Ontology	Objectivism – Subjectivism	Whether the object of investigation exists independently (objectivism) or whether it is the product of consciousness (subjectivism)
Epistemology	Empiricism – Rationalism	What our grounds of knowledge are
Axiology	Pragmatic – Positivist	What we value in our research
Methodology	Quantitative – Qualitative	What approach we take in our research

3.2.1 Justification of the Research Philosophy

This research justifies its research philosophy within the philosophical continuum through ontological and epistemological assumptions and axiological and methodological beliefs. ***Ontologically***, this research holds ***subjectivism***. This research aims to develop a DMF model for infrastructure project selection during the FEP phase within the construction industry, particularly for professionals working at the relevant ministries in Indonesia. In developing such a framework, this study considers the reality as a projection of individual imagination or experience. This projection supports a consideration for understanding the process through which social actors concretise their relationships to the world (Morgan & Smircich 1980).

Epistemologically, this research holds ***empiricism***, which admits personal experiences related to observation as a valid source of knowledge. This research tends to use expert interview as its primary technique in developing the DMF for infrastructure project selection in Indonesia, which has never been studied previously. The researcher asked for the opinions of and extracted knowledge as well as experiences from the participants as insights for developing the framework. Meanwhile, other sources of knowledge gained through valid and reliable findings (rationalism) might be used as secondary sources (Hallebone & Priest 2009).

Axiologically, values play a large role in understanding results in this research. The researcher had to gather information through personal interaction and a targeted sample. Here, the researcher is not an objective and authoritative observer standing outside the situation; rather, he is historically positioned and situated as an observer of the phenomena (Denzin & Lincoln 2008). In terms of viewpoints obtained, this research tends to be 'etic' (from outside) rather than 'emic' (from within). The emic viewpoint investigates how a group of people think regarding a study phenomenon, while the etic viewpoint is a scientist-oriented approach that interpret the phenomenon impartially by linking the phenomenon to factors of interest to the researcher (Kottak 2006). The validity of the experts in this study was also reliable because they were involved in the reality of the infrastructure projects in the relevant ministries. They are key actors with extensive industry experience and were the best people able to gauge what was needed in developing a DMF for infrastructure project selection. Thus, a ***pragmatic*** axiological approach was pursued (Biedenbach 2015) in this research.

Methodologically, this research employs a ***mixed method*** approach. Further justification of this is discussed in section 3.4.3.

3.3 Research Paradigm

A paradigm is "… a characteristic set of beliefs and perceptions held by a discipline…" (Mir & Watson 2000). It is a theoretical framework used by people to investigate research phenomena. The significance of paradigms is they determine what views are accepted as well as the approach to questioning and discovery (Fellows & Liu 2015). The impacts of research paradigms are crucial, thus "… They need to be declared … to facilitate understanding of the findings" (Williamson 2002). Sarantakos (1998) contends that every research paradigm has an influence on the selection of research methodology and methods.

There are four types of research paradigms as summarised by Creswell and Clark (2011), namely: post-positivism, constructivism, participatory and pragmatism. These four paradigms "have common elements but take different stances on these elements, which take a different stance on the assumed nature of reality (ontology), how we gain knowledge of what we know (epistemology), the role values play in research (axiology), and the process of research (methodology)" (Creswell & Clark 2011). Table 3.2 summarises the main characteristics of these paradigms (Creswell 2014).

Table 3.2 Main research paradigms and their major elements

Post-positivism	Constructivism	Participatory	Pragmatism
Determination	Understanding	Political	Consequences of action
Reductionism	Multiple participants meaning	Empowerment and issue oriented	Problem-centred
Empirical observation and measurement	Social and historical construction	Collaborative	Pluralistic
Theory verification	Theory generation	Change oriented	Real-world practice oriented

3.3.1 Positivism & Post-Positivism

Positivism has its roots in the thoughts of Auguste Comte (1798-1857). It states that there are observable facts that can be measured, which remain uninfluenced by the observation and measurement (Fellows & Liu 2015). Positivists believe that the social world is objective, measurable and rests on order. For positivist researchers, science is based on strict rules and procedures, making it "deductive" in nature with research questions expressed as hypotheses and subjected to empirical testing (Too 2009). On the other hand, post-positivism acknowledges social conditioning and believes that reality needs to be observed in a certain context of relevant dynamic social structures or law that has created the phenomena within the social world (Wahyuni 2012).

3.3.2 Constructivism (Interpretivism)

Constructivism contends that reality is relative and there are many different and valid realities. The task of constructivists is to interpret those realities rather than to determine the cause-effect relationship for general purposes (Fellows & Liu 2015). Constructivists believe that reality is in the minds of people, experienced internally, and is shaped through interaction and social interpretation. Patterns of behaviour arise through the allocation of meanings to objects and the adoption of social conventions established through social interaction. Constructivists naturally follow an inductive research path. They believe that science is value-free. They also believe that scientific basis for explaining social life is through understanding people and how they make sense of their life (Too 2009).

3.3.3 Participatory

The participatory paradigm is based on the critical social science theories and participatory worldview that views the primary purpose of human inquiry as practical (Heron & Reason 1997). Bergold and Thomas (2012) stated that participatory research focuses on planning and executing the research process with people whose life-world and actions are under study. Thus, it has a strong correlation with action research. In the participatory paradigm, the researcher actively involves their participants as research collaborators. Here, participatory consent is needed before the researcher involve participants in all stages of the research. The research findings are then negotiated with participants (Creswell & Clark 2011; Cunliffe 2011).

3.3.4 Pragmatism

Under pragmatism, a mixture of ontology, epistemology and axiology is an acceptable approach to understand social phenomena (Tashakkori & Teddlie 2003). Pragmatists are concerned with action and change and the interplay between action and knowledge; hence, it interferes the world rather than merely observing it (Goldkuhl 2017). Pragmatists believe that values play a large role in interpreting the research results, thus the researchers may adopt both subjective and objective points of view. In terms of methodology, pragmatists adopt a mixed method approach.

Table 3.3 presents the fundamental beliefs of research paradigms and their implications for practice as compiled from Creswell and Clark (2011), Cunliffe (2011) and Kolar (2017).

Table 3.3 Fundamental of research paradigms and implications for practice

Fundamental Beliefs/ Philosophies	Paradigms			
	Post-positivism	**Constructivism (Interpretivism)**	**Participatory**	**Pragmatism**
Ontology (What is the nature of reality?)	Singular reality, objective (e.g., researchers reject or fail to reject hypothesis; reality as concrete structures and behavioural patterns, reality as process: interrelated actions)	Multiple realities, socially constructed, subjective (e.g., researchers provide quotes to illustrate different perspectives; social reality relative to interactions between people in moments of time and space, socially constructed, emerging; context is human action and interpretation)	Political reality (e.g., findings are negotiated with participants)	Singular and multiple realities, multiple views chosen to best achieve an answer to the research question (e.g., researchers provide multiple perspectives)
Epistemology (What is the relationship between the researcher and that being researched?)	Distance and impartiality (e.g., researchers objectively collect data on instruments)	Closeness (e.g., researchers visit participants at their sites to collect data)	Collaboration (e.g., researchers actively involve participants as collaborators)	Practicality (e.g., researchers collect data by “what works” to address research questions)
Axiology (What is the role of values?)	Formal style (e.g., researchers use agreed-on definitions of variables)	Informal style (e.g., researchers write in a literary, informal style)	Advocacy and change (e.g., researchers use language that will help bring about change and advocate participants)	Formal or informal (e.g., researchers may employ both formal and informal styles of writing)
Methodology (What is the process of research?)	Deductive (e.g., researchers test a priory theory; surveys, observation, structured/coded interviews)	Inductive (e.g., researchers start with participants’ views and build “up” patterns, theories, and generalisations; grounded theory, discourse analysis, content analysis)	Participatory (e.g., researchers involve participants in all stages of the research and engage in cyclical reviews of results)	Combining (e.g., researchers collect both quantitative and qualitative data and mix them)

3.3.5 Justification of the Research Paradigm: Pragmatism

The goal of this study is to develop an effective DMF model to assist decision makers in selecting and prioritising infrastructure projects with adequate consideration for decision makers' inputs at the FEP phase of infrastructure projects, thereby facilitating better project selection and prioritisation. To develop such a framework, it is necessary to understand the experiences of decision makers in making decisions related to infrastructure project selection and prioritisation. It is critical to obtain insights from the participants on problems related to the actual decision-making process. Relevant data needs to be gathered so that it can be interpreted. Here, decision makers' experiences become the central focus of this research, which is the basis for the development of a DMF model. This study mainly follows an inductive research path where emphasis is first given to observation before conclusions are drawn based on the observations made. It is a research that goes from specific to the general. Inductive research, generally focuses only on a small part of the phenomenon relevant to the issue observed; in this case, this is the development of a DMF for infrastructure project selection. In addition, this research also employs a mixed method approach to develop a DMF model. Values play an important role in interpreting findings from the observations, making it value-laden and etic (from outside where the researcher acts as an observer). All of this means this research tends to be **pragmatist**.

To locate this study's approach within the philosophical continuum as adapted from Morgan and Smircich (1980), refer to the red dots in Figure 3.1.

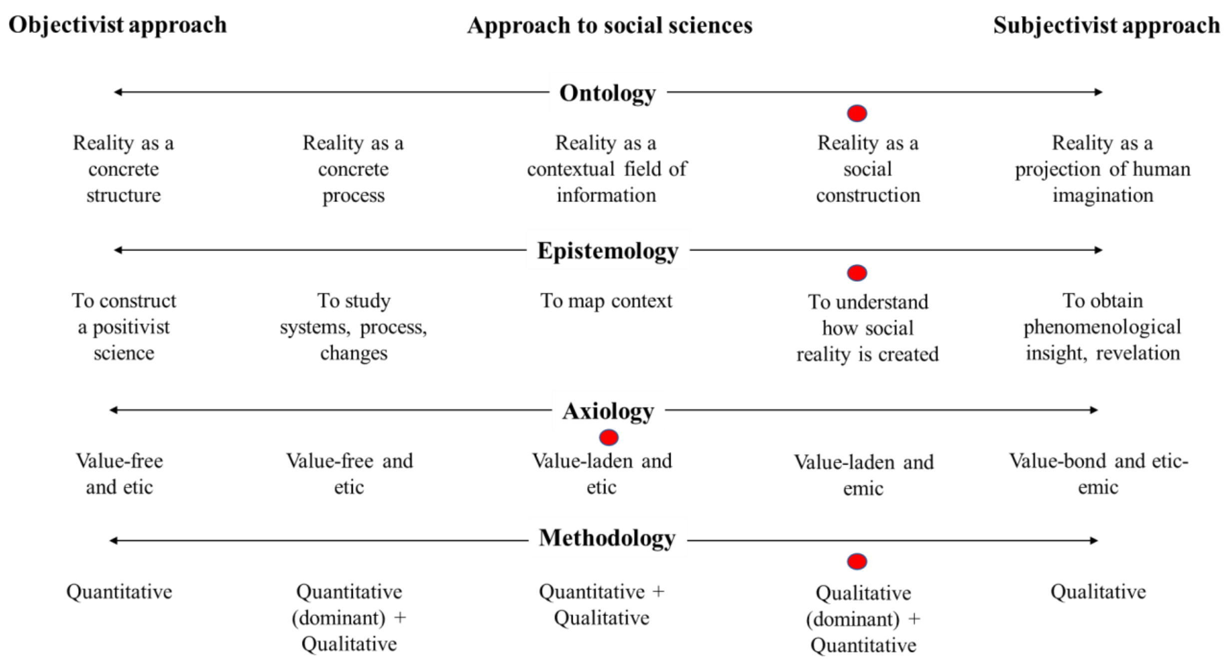


Figure 3.1 Positioning this research within the philosophical continuum

3.4 Research Approach

A research approach or research strategy is the way of thinking adopted by the researcher regarding how their research design is devised and how research will be conducted. Generally, there are two types of research approaches, namely: qualitative (interpretive) and quantitative (verification) (Creswell 2007; Fellows & Liu 2015; Neuman 2013). In addition, Denscombe (2010) mentioned three types of research approaches, i.e. qualitative research, quantitative research and triangulated research (mixed method research).

3.4.1 Qualitative and Quantitative Approach

A qualitative approach involves the researcher's perspective by adopting a qualitative design in conducting research. Several characteristics of a qualitative research design include investigative, subjective, descriptive, explorative and flexible. It is usually used to investigate the causes of a phenomenon (Tracy 2012). It is done by gathering the opinions, suggestions and experiences of people who are related to the phenomenon. A qualitative approach is subjective in nature, with emphasis given to meanings, descriptions, experience etc. (Naoum 2007). There are no statistical procedures or other means of quantification (Strauss & Corbin 1998); this means it tends to be more difficult and time-consuming to analyse than quantitative data (Fellows & Liu 2015).

On the other hand, a quantitative approach is based on figures and data from a representative sample (Marlow 2010). It intends to be objective in nature (Naoum 2007). In doing so, it employs scientific techniques and statistical methods to find relationships and to express these relationships with numbers (Rudestam & Newton 2007). The analysis will produce quantified results so that the conclusion can be obtained. In the quantitative approach, the objective is to test or verify a theory rather than to develop it (Naoum 2007). Table 3.4 shows the differences between the qualitative and quantitative research approaches.

Table 3.4 Differences between qualitative and quantitative research approach

Features	Qualitative research	Quantitative research
Purpose	Focus	Generalisation
Sample size	Small	Large
Data collection methods	Interviews, FGDs, reviews of documents, observations, etc.	Questionnaires, structured observations, experiments, etc.
Data characteristic	Text-based	Number-based
Data analysis characteristic	Descriptive	More statistical
Result characteristic	In-depth discussion	More generalisable

3.4.2 Mixed Method Approach

In addition to the two main approaches described above, there is also an approach referred to as a mixed method. A mixed method research employs more than one type of research method. It may be a mix of qualitative and quantitative, a mix of qualitative methods or a mix of quantitative methods (Brannen 2005). It is also known as triangulation or multi method approach.

In the research design phase of a mixed method research, there are two considerations, namely: the ordering and the dominance of methods. According to Ritchie & Ormston (2013), the order of methods may be sequential or simultaneous. Following this, researchers must consider how dominant a particular method is going to be (Brannen 2005). Morse (2003) presents several possible permutations of a mixed method research as shown in Table 3.5. The arrows (→) indicate sequencing of methods while the plus signs (+) indicate simultaneity. The capital letters indicate the dominance of one method towards the other.

Table 3.5 Possible permutations of a mixed method approach

Simultaneous designs		
1. QUAL + quan	2. QUAL + QUAN	
3. QUAN + quan	4. QUAN + QUAN	
5. QUAL + qual	6. QUAL + QUAL	
Sequential designs		
1. QUAL → qual	2. qual → QUAL	3. QUAL → QUAL
4. QUAN → quan	5. quan → QUAN	6. QUAN → QUAN
7. QUAL → quan	8. qual → QUAN	9. QUAL → QUAN
10. QUAN → qual	11. quan → QUAL	12. QUAN → QUAL

3.4.3 Justification of the Research Approach: Mixed Method

According to Fellows and Liu (2015), the fundamental issues in the selection of a research approach relate to research questions, what is to be measured, and the requirement of validity and reliability. In conducting this research, a mixed method approach that combines both qualitative and quantitative research techniques was employed. This was intended to reduce the disadvantages of each individual approach while gaining the advantages of the others (Fellows & Liu 2015).

This study raises the main research question: how can an effective DMF model be developed for infrastructure project selection and prioritisation during the FEP phase in Indonesia. To answer this main question, four sub questions must be addressed: (1) what are the current practices of FEP, particularly those related to the decision-making process for infrastructure projects selection? (2) what are the key features of a good DMF for infrastructure project selection? (3) what are the appropriate decision criteria in selecting infrastructure projects? and (4) how can a DMF for infrastructure project selection be developed and to what extent can it be implemented?

These four questions as a whole series answer the main question. These questions can be answered through a series of research approaches. RQ 1 and RQ 2 were answered mainly based on a qualitative research approach in which the available data were qualitative data that place emphasis on meanings and experiences. Meanwhile, RQ 3 was mainly based on a quantitative approach in which the measurements of quantitative data were tangible, countable and sensate features of the world (Bouma & Atkinson 1995). Finally, RQ 4 was answered through the development of a DMF that incorporates an MCDM technique, i.e. NSFDSS-II. Case study implementations were then employed to evaluate the efficacy of this framework.

3.4.4 Which Type of Mixed Method Approach?

In a mixed method approach, it is important to determine the ordering and the dominance of methods employed. This research used a multi-sequenced design that combined both qualitative and quantitative approaches. Explicitly, this research can be described in the following sequence:

qual → qual → quan → QUAL + QUAN

In this research, qualitative becomes the dominant approach. This research aims to develop a DMF for infrastructure project selection. In its development, it takes a series of data analysis in the form of interpretation of theories and experiences of decision makers related to the decision-making process in selecting infrastructure project proposals. Interpretations of the theory were completed through a typology analysis used as the basis for developing the conceptual DMF model. Furthermore, interpretation of the decision makers' experience was obtained through interview analysis. Finally, the proposed DMF should be validated through actual case study implementations. Thus, the qualitative approach is emphasised more strongly. This is also confirmed by Harrison et al. (2007), who stated that the qualitative approach works best for developing new theoretical ideas and interpretating a theory or a phenomenon's significance.

Similarly, Sarantakos (1998) recommends the use of a qualitative approach in a research where information on the study area is limited and discovery is an important aim of the research. Hence, it is important to consider that there have been no previous studies discussing Indonesian infrastructure project selection practices. The aim of qualitative research is to understand the process. This characteristic is consistent with the aim of this research. In developing a Decision-Making Framework, an understanding of the process becomes critical. This is also supported by de Ruyter and Scholl (1998) who stated that qualitative research is widely employed as it provides answers to questions about the management of decision-making processes.

On the other hand, quantitative approach is needed to answer RQ 3. This involved making measurements of data on suitable scales through a questionnaire survey. RQ 3 has the similar characteristics as the quantitative approach, i.e. fact-finding based on evidence or records, requires testing/verification and has countable data. Table 3.6 summarises the multi-sequenced design adopted in this research.

Table 3.6 Multi-sequenced design with QUAL and quan adopted in this research

Sequence	Method	Purpose	Answering
First: qualitative	Integrative literature review	• To assess the current FEP practices and extent of FEP significance in construction projects • To identify the criteria in selecting infrastructure project proposals	RQ1, RQ3
	Typology review	• To investigate the key features of a good DMF for infrastructure project selection	RQ2
		• To develop the conceptual DMF model	RQ4
Second: qualitative	Semi-structured expert interviews	• To investigate the current practice, issues and challenges of infrastructure project selection in Indonesia	RQ1, RQ2, RQ3
Third: quantitative	Questionnaire survey	• To examine the appropriate decision criteria in selecting infrastructure project proposals	RQ3
	MCDM technique: NSFDSS-II	• To calculate the contribution of each criterion • To develop a decision-making tool to be incorporated into the proposed DMF	RQ3, RQ4
Fourth: QUAL + QUAN	Case study implementations	• To develop and implement the proposed DMF for infrastructure project selection	RQ4
	Expert interviews	• To investigate the effectiveness of the proposed DMF during its implementation	
	Parallel-forms reliability tests	• To conduct method comparison tests as a means to establish the consistency of DMF decision outputs	
	Sensitivity analysis	• To evaluate the reliability of the proposed DMF under different scenarios	

3.5 Research Methods

After identifying the research paradigm and research approach, the next step is to determine the most appropriate research methods to be adopted. Research methods are a set of skills, assumptions and practices employed by researchers as they move from their paradigm to the empirical world (Denzin & Lincoln 2005).

In this study, the research method is derived from a combination of two or more research methods. The qualitative research techniques include the use of an integrative literature review, typology review, expert interviews and case study; while the quantitative research technique includes a questionnaire survey and the MCDM technique. The explanation below follows the sequence of mixed method outline in Table 3.6.

3.5.1 Integrative and Typology Review

Through a literature review, a piece of research may establish an appropriate theoretical framework (Creswell 2014). In developing a conceptual DMF model, it is crucial to know the current practices of decision-making process in infrastructure projects especially during the FEP phase. In addition, a good framework should also have essential features in its model.

To answer RQ1 and RQ3, this research employed the qualitative approach of the Integrative Literature Review. This is a technique to review, critique and synthesise the related literature in an integrated way so that new insights can be obtained (Torraco 2005). A systematic process used by Chan and Owusu (2017), Le et al. (2014), and Osei-Kyei and Chan (2015) has been applied in this study. Here, the researcher developed five stages, i.e. (1) searching for target sources, (2) searching for target literature, (3) selecting relevant literature, (4) analysing the content and (5) reporting the findings. Further explanation of these stages can be found in Table 3.7.

Table 3.7 Integrative Literature Review adopted in this study

No	Stage	Description
1	Searching the sources	Considering the literature sources. These include journal libraries and trusted online sources
2	Searching the literature	Searching related literature using keywords to narrow down the search
3	Selecting the literature	Selecting relevant literature using visual examination by reading the abstracts or summaries, and skimming the content
4	Analysing the content	Content analysis was used to extract the key ideas and insights from the literature. This involves reading and re-reading the documents, data coding, data synthesis (theme elaboration, patterns development, etc.) and review of findings
5	Reporting the findings	Reporting the findings, providing sufficient evidence/supports/arguments

Meanwhile, the researcher used a Typology Analysis to answer RQ2 and RQ4. This is a qualitative classification that can be conducted without statistical analysis. According to Bailey (2011), a typology review is practical for highlighting the relevant theoretical dimensions of concepts. In this research, a typology review was employed to identify the key features of a good DMF and to develop a conceptual DMF model of infrastructure project selection and prioritisation. Further explanation is provided in Chapter 4.

3.5.2 Semi-structured Expert Interview

An expert interview is a type of interviews carried out between the interviewer and a respondent who is a specialist in the subject area (Libakova & Sertakova 2015). It can be used to explore complex problems by gaining insights into the participant's behaviours in detail and depth (Denscombe 2010). There are three types of interview, i.e. structured, un-structured and semi-structured interview (Fellows & Liu 2015). In a structured interview, a detailed list of interview questions is provided so that the interviewer has fewer opportunities to ask additional questions. In an un-structured interview, there is no interview question and the interviewer just briefly provides the study topic to the participants who will answer across a wide scope (Fellows & Liu 2015). On the other hand, a semi-structured interview is a form of non-standardised interview that is often used in qualitative research when the interviewers do not intend to test a specific hypothesis (Sutton & David 2004). It is typically based on a simple list of questions, and then more detailed questions may be asked during the interview (Fellows & Liu 2015).

Since it is critical to design the right interview questions, the researcher developed a list of interview questions that are expected to answer the related research questions. To ensure that these interview questions were directly tied to the research questions, a matrix was created that lists the research questions and interview questions (Table 3.8). A preliminary test (pilot interview) was then performed with one participant. The participant in this preliminary test does not have to be an expert since the goal is just to ensure that the interview questions are clear, concise and satisfy the kind of responses. In addition, the pilot interview is also helpful to get a picture of the actual interview situation and to develop the skill in reframing the questions during interview sessions. Once the preliminary tests were completed, the expert interviews were conducted to a minimum of five experts who meet the following criteria:

(1) Professionals working at a relevant ministry, such as MPWH, MT or infrastructure consultant agencies
(2) Have a minimum of five years of working experience
(3) Have an educational background in construction-related disciplines with a minimum of Master degree level
(4) Have experience in decision making of infrastructure project planning and/or selection process

Table 3.8 Interview questions development matrix

No	Interview Question	Addressing Research Question	Description/Purpose	Literature References
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**			
1	How does FEP occur and how is it carried out in your organisation?	What are the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection?	Investigating the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection from the interviewee's perspective	George, Bell, and Back (2008); Hansen, Too, and Le (2018a); Samset and Volden (2016); Yussef et al. (2017)
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?			Hansen, Too and Le (2018a); Omar, Trigunarsyah, and Johnny (2009); Priemus (2010); Williams and Samset (2010)
3	Is there any procedure, technique, tool etc available to help you make decisions / select the project proposals?			Bakht and El-Diraby (2015); Hansen, Too and Le (2018a); Priemus (2007); Schaaf (2008)
4	Is the decision-making process more judgmental or rational?			Cabanac and Bonniot-Cabanac (2007); Kolar (2017); Mintzberg and Westley (2001); Priemus (2010b)
5	How effective is the current decision-making process?			Samset and Volden (2016); Williams and Samset (2010)
6	What are the weaknesses of government decision making?			Buijs, Eshuis, and Byrne (2009); Samset, Berg, and Klakegg (2006)
B	**Criteria in infrastructure project selection and prioritisation**			
7	What are the criteria for selecting and prioritising infrastructure projects?	What are the appropriate decision criteria in selecting infrastructure projects?	Investigating the decision criteria in infrastructure project selection from the interviewee's perspective	CDIA (2010); Infrastructure Australia (2018); Infrastructure NSW (2016); Hansen, Too, and Le (2019); Queensland Treasury (2015)

8	Is there a methodical approach to using these criteria? / How do you assess these criteria?		Exploring the interviewee's approach in assessing these criteria	Al-Ali and Filion (2015); Deschaine (2014); Mouter, Annema, and Wee (2013); Tam, Tong, and Zhang (2007)
C	**Factors influencing infrastructure project selection decision-making process**			
9	What are the factors influencing the decision-making process for infrastructure project selection?	-	Identifying the factors influencing the decision-making process	Dietrich (2010); Nooraie (2012)
D	**Challenges in infrastructure project planning and selection**			
10	What are the challenges in the decision-making process of infrastructure project selection?	What are the challenges of infrastructure project selection and prioritisation process?	Identifying the decision-making challenges	Arif (2013); Deschaine (2014); Gerrish (2013); Liu and Ding (2016); Omar, Trigunarsyah and Johnny (2009); Williams and Samset (2010)
11	How do these challenges affect the decision-making process? / Can you provide cases?		Exploring the effects and consequences of the perceived challenges	Arif (2013); Deschaine (2014); Omar, Trigunarsyah and Johnny (2009); Williams and Samset (2010)
12	What are the solutions? / How do you deal with the challenges?		Exploring the solutions to the perceived challenges	Deschaine (2014); Markou (2015); Williams and Samset (2010)
13	How does politics influence the selection process? / What is the best way to measure political criteria?		Investigating the political influence on the selection process	Annema, Mouter, and Razaei (2015); Lee (2012); Priemus (2010b)
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?		Exploring cross sector coordination and integration in the selection process	Hampl (2012); Hurwitz, Heaslip, and Moore (2015); Schweikert (2013)
E	**Considerations of expected Decision-Making Framework (DMF)**			
15	How should the decision-making process ideally be carried out and	What DMF for infrastructure project selection can be	Investigating the most effective strategy to develop a DMF for	Berechman and Paaswell (2005), Jin-Lin, Ali, and Alias (2015), Marcelo et al. (2016), Mawdesley,

	improved? / How should the DMF be developed?	developed and to what extent can it be implemented?	infrastructure project selection and prioritisation	Hernandez, and Al-Jibouri (2005), Nnaji et al. (2018), Pangsri (2015); Piyatrapoomi, Kumar, and Setunge (2004); Wang et al. (2017)
16	Is it important to have a DMF for infrastructure project selection in Indonesia?		Examining the importance of DMF for infrastructure project selection	Arif (2013); Bakht and El-Diraby (2015); Hansen, Too, and Le (2018c)
17	What are the features that must be available in the DMF?	What are the key features of a good DMF for infrastructure project selection?	Investigating the key features of a good DMF for infrastructure project selection from the interviewee's perspective	Arif, Bayraktar, and Chowdhury (2016); CDIA (2010); Hansen, Too and Le (2018c); Infrastructure Australia (2018); Infrastructure NSW (2016); Queensland Treasury (2015)
18	Is an audit process required? / Transparent process?	What DMF for infrastructure project selection can be developed and to what extent can it be implemented?	Considering the requirement of a transparent process during decision-making	Hassim (2012); Liu (2015)
19	What are the consequences of having no DMF?		Examining the consequences of having no DMF in infrastructure project selection	Bakht and El-Diraby (2015); Hansen, Too and Le (2018c); Liu (2015)
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?		Exploring the interviewee's suggestions that may improve the DMF	Davies, Atkins, and Slade (2018); Hansen, Too and Le (2018c); Mathur (1995)

3.5.3 Questionnaire Survey and MCDM Technique

A questionnaire survey is used to derive the dominant decision criteria in the infrastructure decision-making process. This is a type of descriptive and quantitative research. In the questionnaire survey, there is a list of questions to be answered by the participants. Generally, there are two types of questions, i.e. open and closed questions. Open questions provide participants the freedom to answer the questions. They are easy to ask, but hard to answer and analyse (Ma 2011). On the other hand, closed questions may limit the responses by providing potential answers (Fellows & Liu 2015). In this research, for the purpose of uniformity the questionnaire employed closed questions.

All questionnaires should be piloted to ensure that all questions have been clearly stated (Denscombe 2010). Piloting a questionnaire aims to test whether the questions given are intelligible, easy to answer, unambiguous, etc. by obtaining some feedback from a small sample of participants. Thus, the questionnaire can be improved (Fellows & Liu 2015). In this research, pilot questionnaires were given to five pilot participants before being distributed to the practitioners working at the relevant ministries. The final questionnaires were distributed to professionals working at the relevant ministries who meet the following criteria:

(1) Professionals working at the relevant ministries such as MPWH and MT, or infrastructure consultant agencies
(2) Have a minimum of five years of working experience
(3) Have an educational background in construction-related disciplines

The questionnaires were then analysed to identify appropriate decision criteria in the infrastructure project selection. An MCDM technique, namely Non-Structural Fuzzy Decision Support System II (NSFDSS-II), was then employed to calculate the importance of each decision parameters. To obtain agreement for the data input matrix in NSFDSS-II, pairwise comparisons were conducted through a two-rounds Delphi method. The result was criteria weighting, which could then be incorporated into the proposed DMF for infrastructure project selection.

3.5.4 Case Study Implementations

In this research, a case study was used as the main research method. According to Yin (2013), case studies are rich, empirical descriptions of particular instances of a phenomenon based on a variety of data sources. It is also useful for research in which the researcher has little or no control. These characteristics are consistent with the current study.

Due to limited knowledge in the concept of DMF for infrastructure project selection and prioritisation during the FEP phase, particularly in Indonesian, this study aims to develop an effective DMF for infrastructure project selection and prioritisation in the Indonesian context. DMF is still a developing area and its development and implementation vary widely. Thus, a case study is appropriate because in conducting the research, it does not rely on previous literature or prior empirical evidence. The significance of a case study is that it may create a novel theory, which is desirable and provides freshness in perspective to an already researched topic (Eisenhardt 1989).

In conducting the case study implementations, the researcher developed five stages, namely: (1) designing case study, (2) preparing for presentation, (3) DMF implementation, (4) analysing the data and (5) reporting the results. The first stage, case study design, is a phase in which the research objective is defined and the case study is planned. This is followed by the second stage, i.e. presentation preparation in which data, procedures and protocols for DMF implementation are established (Appendix 6). The third stage is DMF implementation. In this research, the implementations of DMF for infrastructure project selection were conducted through a technical workshop and an online implementation. In the next step, all evidence from DMF implementations were then recorded and analysed to establish the effectiveness of the proposed DMF. Finally, the researcher reported the findings.

During the implementation stage, experts was invited to test and evaluate the effectiveness of the proposed DMF. To be able to participate, they should meet the following criteria:

(1) Professionals working at the relevant ministries such as MPWH and MT, or infrastructure consultant agencies
(2) Have a minimum of 15 years of working experience
(3) Have an educational background in construction-related disciplines at Master degree level
(4) Have a professional certification
(5) Have been involved in the infrastructure project selection and investment process
(6) Have been involved in a construction-related training/activity
(7) A member of a construction-related professional organisation

(8) Have awareness of infrastructure project development in Indonesia
(9) Have a manager/above position
(10) Have access to and are willing to share their opinions/knowledge about the topic

Furthermore, the reliability of DMF decision outputs have been tested through parallel-forms reliability tests and sensitivity analysis. Both tests are used to establish the consistency and stability of the DMF in providing sound decision outputs. Further explanation is given in Chapter 9.

3.6 Research Sample

The purpose of sampling is to provide a practical means of enabling data collection that presents a good representation of the population (Fellows & Liu 2015). Since this research tends to be more qualitative, typically the selection of the research sample is purposeful (Patton 2002). This type of sampling focuses on selecting information-rich cases to obtain insights and understanding of the phenomenon. In this study, the researcher has a reason for choosing specific participants. These participants are practitioners in the construction fields, particularly those working in the infrastructure sector. The main participants were the planning officers working at the relevant ministries, such as MPWH and MT in Indonesia. They are responsible for the selection of infrastructure project proposals at the ministerial level.

As for RQ3 with regard to the quantitative approach, questionnaires were distributed to obtain a wider sample. In this case, random sampling was employed. It is based on statistical probability theory and is generally used in quantitative research. It can control selection bias and seek generalisation of the sample, which are the characteristics of quantitative research (Bloomberg & Volpe 2012).

3.6.1 Interview Sample Size

Since sample size is a crucial issue in qualitative research, this study has tried to provide some arguments from previous research. Literature studies provide different findings as to how many interviews are enough in qualitative methods. In essence, the data sought in qualitative techniques such as interviews do not rely on any formal statistical analysis because they focus on the meaning and interpretation of the collected data (Galvin 2015; Mason 2010). While Denzin and Lincoln (2008) suggest to conduct 30 to 50 interviews, others believe that there is no strict guideline in determining sample size for the interview technique (Patton 2002). This is reflected in many published papers (both theses and journals) that include only small and medium-sized interviews. This can be seen in papers published by some reputable construction project-related journals such as: Journal of Construction Engineering and Management (e.g. Oviedo-Haito et al. 2014 conducted 12 interviews, Smith and Bohn 1999 conducted 12 interviews); Journal of Management in Engineering (e.g. Berteaux and Javernick-Will 2015 conducted nine interviews, Larsen et al. 2016 conducted eight interviews); Engineering Project Organisation Journal (e.g. Edkins et al. 2013 conducted 16 interviews); Australasian Journal of Construction Economics and Building (e.g. Fugar and Agyakwah-Baah 2010 conducted 15 interviews); and Built Environment Project and Asset Management (e.g. Nguyen and Chileshe 2015 conducted ten interviews). Similarly, some Masters and PhD theses have been published using a medium-sized number of interviews (e.g. Baba 2013 conducted ten interviews, Bosfield 2012 conducted 15 interviews, Mast 2012 conducted ten interviews, and Rahmani 2016 conducted 14 interviews).

Saturation is the central concern in determining interview sample size. It simply means the state at which no more absorption, addition or combination can be derived from further interviews. In an attempt to justify sample size for interview research, Guest, Bunce and Johnson (2016) developed an empirical study and concluded that data saturation is reached within 12 interviews. Others claimed that saturation is achieved after 12 interviews and definitely after 30 interviews (Galvin 2015). Meanwhile, Hagaman and Wutich (2016) suggest that saturation is reached at larger sample sizes ranging from 20 to 40 interviews.

On the other hand, Galvin (2015) has tried to present a statistical approach to determining the size of interviews in building and energy research. He provided an equation (Equation 1) to determine the number of interviews required based on two indicators, namely: the stated level of confidence (P) and the proportion (R) of the population.

Equation 1: Number of Interviews

$$n = \frac{\ln(1 - P)}{\ln(1 - R)}$$

In this study, for example, the researcher needs to be at least 95% confident that all the issues have emerged that are represented in 15% of population; using Equation 1 indicates that 19 interviews are required.

Based on the above explanation, this study has reached data saturation with a large sample size of 20 collected interviews. This is shown in the emergence of commonalities during the data analysis process. It has also been justified through a statistical approach based on the above equation.

3.6.2 Questionnaire Sample Size

In each study especially with a quantitative approach through a survey questionnaire, it is important to determine the minimum sample size needed. This is because without the appropriate sample size, the data obtained may not be reliable and thus, conclusions would be obtained from inadequate data. In general, the greater the sample size the better because more data will increase the validity and reliability of the findings. However, often research is limited by a lack of time and costs. Hence, it is important for the sample size to be determined to produce valid and reliable results, in addition to being efficient and realistic in terms of performing the research.

In this study, the sample size determination was largely influenced by the goals of the questionnaire survey. In addition, sample size is also influenced by the tests to be conducted because different sample sizes are influenced by different types of statistical procedures. Here, the quantitative approach that will be used is Exploratory Factor Analysis (EFA).

Based on the literature, there are several different recommendations related to the required minimum sample size for factor analysis. Kang (2013) cited in Park et al. (2017) believes that no universal criteria exist regarding sample size determination. One common approach that is often applied is by considering the *N:p* ratio, where *N* refers to the minimum required sample size and *p* refers to the number of variables. According to Cattell (1978), this ratio may range between 3 to 6. Other researchers have a suggested a ratio of 5:1 between subjects to variables (Gorsuch 1983, Tabachnick & Fidell 2013). A recommendation of a 10:1 ratio between subjects to variables was suggested by Everitt (1975). On the other hand, others recommend that samples in the range of 100-200 are acceptable (with factor loadings> 0.80) (MacCallum et al. 1999). Finally, Hair et al. (2010) simplify this by suggesting that a sample size must be more than 100.

In this study, the maximum number of variables contained in the questionnaire is 23 items. Following Gorsuch's (1983) and Hair et al.'s (2010) recommendations, the minimum sample amount recommended for this research is 115. It should be highlighted that this amount is the number of valid responses, so efforts had to be taken to acquire more than these numbers to account for potential invalid responses.

3.7 Type of Information Needed

There are four types of information in most qualitative research, namely: contextual, perceptual, demographic and theoretical information. Contextual information refers to the context in which participants work (Bloomberg & Volpe 2012). This information includes the environment and culture of participants, such as the organisations. In a case study conducted on a particular site, this information becomes crucial since as suggested by Lewin (1935) in Bloomberg and Volpe (2012), the environment or culture may influence behaviour. In this study, contextual information is related to the overview of the Indonesian ministries.

Demographic information relates to the participants' profile information and explains who they are. This information covers participants history and background such as education, age, experience, gender, position, etc. It is needed to explain what may be underlying a participant's perceptions. It is also useful in explaining the similarities and differences in perceptions among participants (Bloomberg & Volpe 2012). In this study, this type of information is provided in each relevant chapter.

A participant's perception on the subject of a study is perceptual information. This is the most important type of information when interviews are used as the main method of data collection. This type of information comes from the descriptions given by the participants in answering the interview questions (Bloomberg & Volpe 2012). In this research, perceptual information from expert interviews includes many aspects of the participants' experiences in the decision-making process of planning and selecting infrastructure projects.

Finally, theoretical information refers to the information obtained through a literature review. It is employed to assess what is already known regarding the research topic (Bloomberg & Volpe 2012). In this research, theoretical information was employed primarily to support the answers to RQ1, RQ2 and RQ3. This includes evidence, theories and support for interpretations, analyses and conclusions.

3.8 Types of Data Gathered

Since data are important in research, it is useful to consider what types of data are needed in the study. The data acquired in this research consist of two types, namely:

(a) Primary data

Data directly taken from the object of research. The primary data of this research includes interviews, questionnaires surveys and case study simulations obtained from the practitioners working at the relevant ministries.

(b) Secondary data

Data obtained from the results of literature review or other secondary sources such as journals, books, theses and other relevant and reliable documents.

Furthermore, these data were analysed through the triangulation of qualitative and quantitative data. This is a preferred approach to strengthen construct validity in case study research, as it encourages the collection of multiple sources of information (Yin 2013). Figure 3.2 illustrates the triangulation process described by Fellows and Liu (2015) as employed in this research.

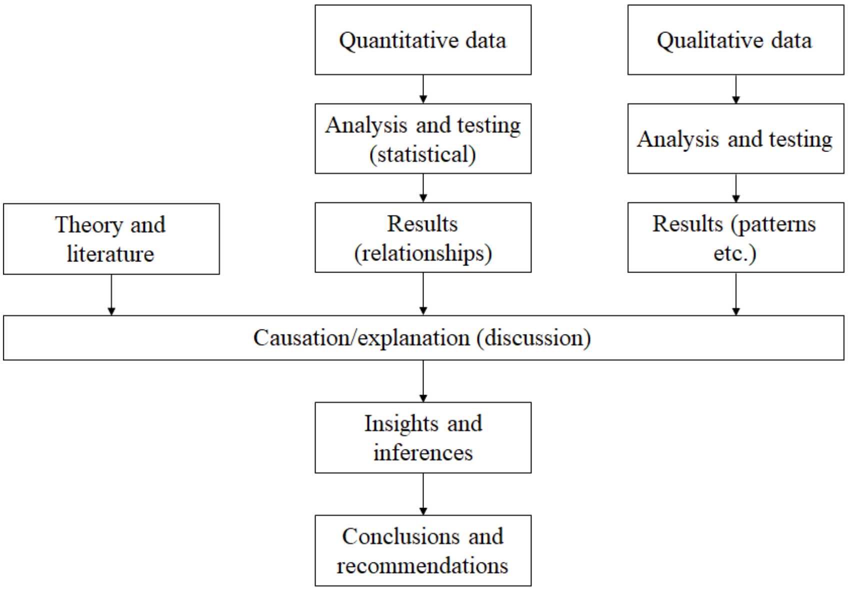


Figure 3.2 Triangulation of qualitative and quantitative data adopted in this research

3.9 Research Process

This research was carried out in four phases as shown in Figure 3.3.

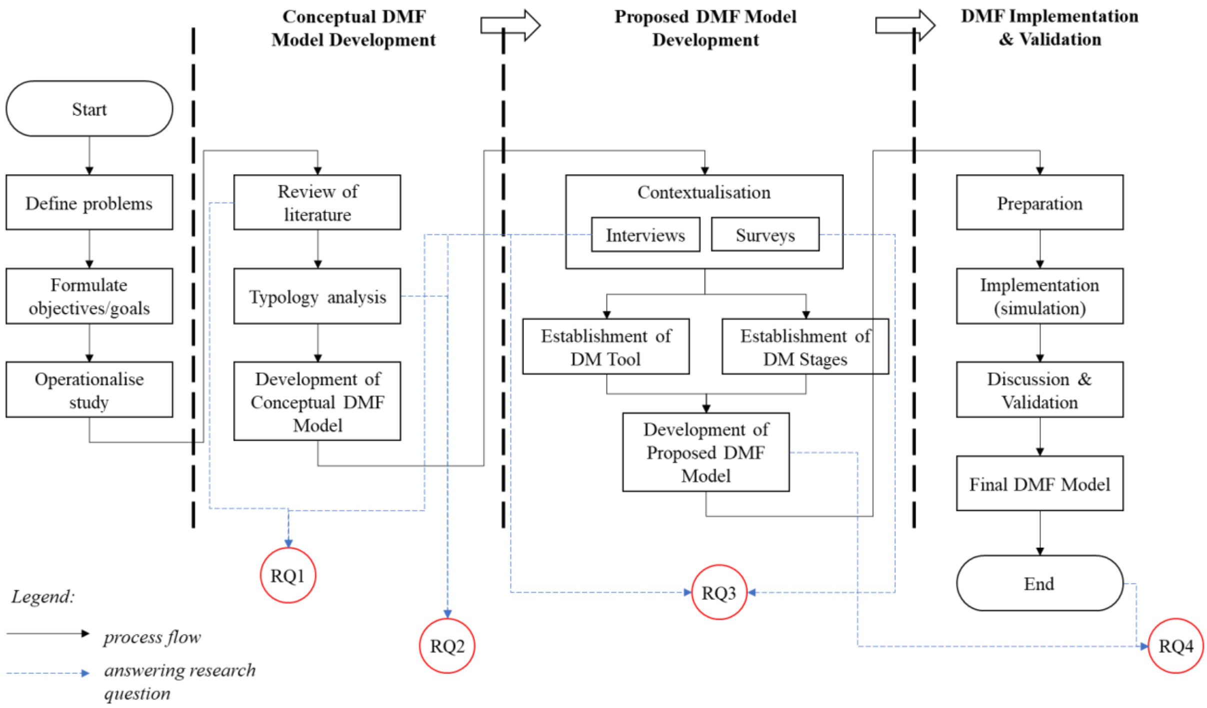


Figure 3.3 Research phases conducted in this study

1. Capturing the research gap

   This phase was conducted to establish the knowledge base of infrastructure project selection and decision making during the FEP phase. A comprehensive literature review of journal and related publications was completed to identify gaps in practice.

2. Conceptual DMF model development

   This phase was conducted to develop a conceptual DMF model to serve as a foundation for DMF model development. Here, typology analysis was performed to identify key concepts and variables in a good DMF for infrastructure project selection and prioritisation.

3. Proposed DMF model development

   This phase was conducted to develop a proposed DMF model for infrastructure project selection and prioritisation. Here, contextualisation through investigation of the current decision-making practices in the Indonesian context was done to establish selection stages and a DM tool for infrastructure project selection and prioritisation. Thus, development of the proposed DMF model was designed on the basis of the established findings from the previous phases.

4. DMF implementation and evaluation

   Finally, the proposed DMF model was implemented and evaluated through case study implementations. Any feedback from the implementation was discussed to investigate the effectiveness of the proposed DMF for infrastructure project selection and prioritisation.

To better understand the above phases, Table 3.9 presents several strategies adopted in this study.

Table 3.9 Strategies adopted in this research

Step	Strategy	Actual Activity
1	Identify the research context, the decision makers, stakeholders and constraints	Context: Front End Planning → decision making → infrastructure project selection & prioritisation in Indonesia. Decision makers: planning officers at the Ministry of Public Works & Housing (MPWH). Stakeholders: MPWH, MT (ministry of transportation), MNDP (ministry of national development planning). Constraints: problems (issues, key features, planning considerations) faced in infrastructure project selection & prioritisation process in MPWH, for all types of infrastructure project.
2	Identify the selection criteria and assessment parameters	The most important aspect in developing the DMF and DMT. Multi-sequenced techniques used to identify these selection criteria: integrative literature review, expert interviews and questionnaire survey. Assessment parameters were identified using the integrative literature review.
3	Obtain the criteria weights	A long and comprehensive process that employed pairwise comparisons using the Delphi method, followed by NSFDSS-II (non-structural fuzzy decision support system II) analysis.
4	Develop the DMF & DMT	Synthesise all findings to develop the DMF and DMT.
5	Evaluate the DMF & DMT	Generate a set of project proposals to be used in a case study simulation to validate the DMF and DMT. The final result is a list of project priorities. Expert opinions were sought to identify the effectiveness and efficiency of the DMF and DMT.

3.10 Data Collection Techniques

In the process of collecting data, there are several restrictions such as cost, time and confidentiality. The key principle in selecting the most appropriate data collection technique is to ensure that the collected data can achieve the study objectives (Fellows & Liu 2015). Data collection techniques can be categorised into two groups, namely: one-way communication and two-way communication.

In a one-way communication, the information may be accepted or rejected by participants. It means that the researcher has fewer opportunities to ask additional questions. Instances of one-way communication include postal questionnaires, completely structured interviews, diaries and scrutiny of archives. Meanwhile, a two-way communication allows feedback and collection of further data through asking additional questions. Thus, there is an interaction during the data collection process. The typical two-way methods include semi-structured interviews (Fellows & Liu 2015).

In this study, the techniques use to collect data from the participants consist of a literature review, interviews, questionnaire surveys, pairwise comparisons and case study implementations. The data collection from the literature was mainly based on journal articles related to the topic of the study. These articles were searched using the available journal virtual libraries (VLs) such as Elsevier, Emerald, Taylor and Francis, ASCE Library, etc. The search was done using several keywords to narrow down the search. Additionally, other types of publications that had similar content to the keywords were also identified, including institution web sources, conference papers, theses and published books.

The data collection from interviews was done by interviewing the participants at the agreed locations, i.e. the MPWH office and Podomoro University in Jakarta, Indonesia. The interviews were conducted in accordance to the developed interview protocol (Appendix 1) and script (Appendix 2). Besides face-to-face interviews, there were also several telephone interviews due to limitations from the respondents and the COVID-19 outbreak. The duration provided for each interview was approximately 40-80 minutes where interaction was done intensively yet comfortably to ensure that the participants were not disturbed. Table 3.10 shows an overview of the actual interview schedule as part of the data collection process.

Table 3.10 Expert interview schedule

Participants	Dec'18		Jan'19				Feb'19				Mar'19			
	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
Expert 1	V													
Expert 2				V										
Expert 3				V										
Expert 4					V									
Expert 5					V									

Expert 6	V									
Expert 7	V									
Expert 8		V								
Expert 9				V						
Expert 10				V						
Expert 11					V					
Expert 12						V				
Expert 13							V			
Expert 14								V		
Expert 15									V	
Expert 16									V	
Expert 17									V	
Expert 18									V	
Expert 19										V
Expert 20										V

The data collection for the questionnaire was achieved by both online and offline means. In this study, the identity of the participants is kept confidential. The approximate time duration needed to complete the questionnaire was about 30-45 minutes. For the offline distribution, the survey was disseminated to groups of practitioners working in the MPWH and other sectors in the construction industry. The return of completed questionnaire was done within one week after the distribution.

Meanwhile, pairwise comparisons for NSFDSS-II input data were conducted through a two-rounds Delphi method. The Delphi method was employed to ensure accurate judgments from the experts when conducting the pairwise comparisons. Each round lasted for two weeks and the pairwise comparisons were distributed online using RMIT University's Qualtrics Survey Software.

Finally, the proposed framework was tested through several evaluation strategies including case study implementations, parallel-forms reliability tests and sensitivity analysis. Case study implementations were carried out in two phases with a total of three experts involved in the implementation process. It took approximately two hours to complete each case study implementation. Parallel-forms reliability tests and sensitivity analysis followed to further evaluate the effectiveness of the proposed DMF.

3.11 Data Analysis and Synthesis

Since this research uses a mixed method approach, the data analysis was completed using both quantitative and qualitative techniques. In general, qualitative data analysis can be difficult and laborious compared with quantitative data analysis. Its emphasis is on determining the meaning of the data (Fellows & Liu 2015). For the qualitative data gathered from the integrative literature review, typology review and expert interviews, the thematic coding technique is employed, in which the researcher read all reports, documents and interview records, and then coded interesting expressions of issues, phenomena, etc. in the text. The researcher then categorised based on the common themes (the nodes) and examined the relationships between each node. NVivo software was used to help analyse these qualitative data.

NVivo is a software tool that helps researcher organise, present, browse, code, annotate and analyse data records. It can improve the process of qualitative research and expand analytical approaches (Auld et al. 2007) as well as to synthesise ideas (Azeem & Salfi 2012). It assists the researcher to manage, explore and establish patterns in research data. Using the thematic coding technique, the researcher read all reports and documents, then coded interesting expressions of issues, opinions, phenomena, etc. in the text. As it was coded, the text was evaluated and grouped into categories ("nodes" in NVivo) based on common themes. When some of these categories were found to be similar, they were grouped into a more general category. Finally, the researcher used NVivo to establish connections between categories ("parent node" in NVivo) and their subcategories ("child nodes" in NVivo). A detailed explanation of this qualitative analysis is provided in Chapter 5.

Meanwhile, the quantitative data analysis was carried out based on statistical calculations using SPSS software. In this study, the quantitative data were obtained from questionnaire surveys. Exploratory Factor Analysis (EFA) was used to identify underlying variables that explain correlation patterns in a set of observed variables (Pham 2016). This type of analysis is often used to reduce a large number of variables to a smaller set of underlying factors that summarise essential information in the variables (Field 2017). In this study, EFA was used to explore success factors—in this context, the critical criteria of infrastructure project selection—from a large number of variables. The standard EFA procedure includes three steps: (1) assessment of data suitability, (2) determination of factor extraction method and (3) justification of factor rotation and interpretation. The result of this analysis is a valid and reliable selection criteria list. Further explanation of this is offered in Chapter 6.

In order to develop the Decision-Making Framework model—in this case, the determination of weighting of each criterion—the researcher employed Non-Structural Fuzzy Decision Support System II (NSFDSS-II). NSFDSS-II was developed based on Chen's NSFDSS model. NSFDSS-II was chosen in this research due to the following strengths:

(1) It is a systematic and scientific method for decision making in a complex problem
(2) It is able to decompose a complex problem into a hierarchy of subproblems
(3) The pair-wise comparison can be more straightforward
(4) It can generate more precise ordering of the decision criteria
(5) It can measure the decision makers' preference towards each decision criterion

Accordingly, NSFDSS-II was chosen for this research to analyse professional judgments and to determine the relative importance of various decision criteria; in this case, the decision parameters for infrastructure project selection. The working flow of NSFDSS-II (Tam, Tong & Zhang 2007) is illustrated in Figure 3.4. A detailed explanation is included in Chapter 7.

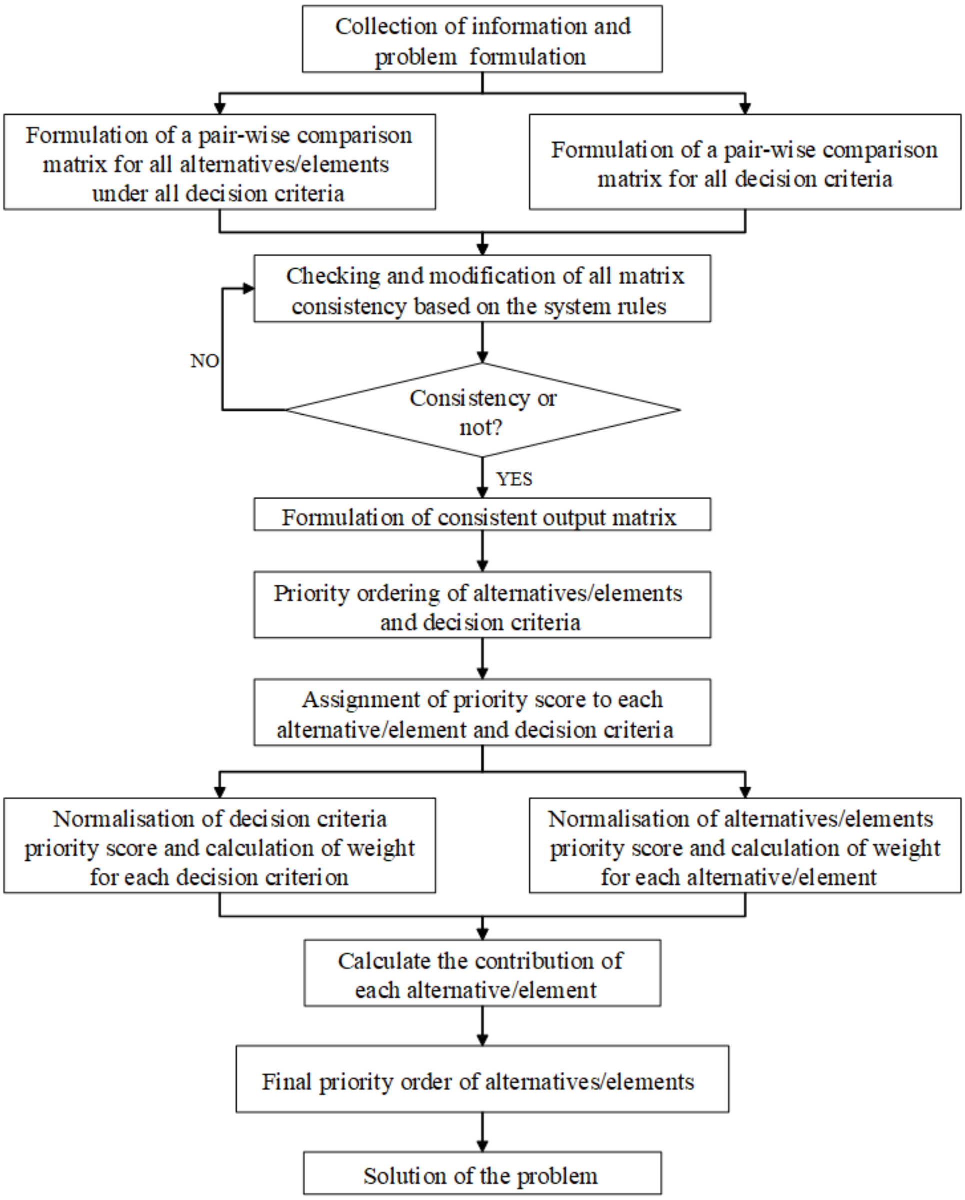


Figure 3.4 NSFDSS-II working flow

Finally, all the findings need to be synthesised. This is the process of pulling together the research findings to ensure that they have answered research questions. This process is not linear and occurs throughout the discussion (Bloomberg & Volpe 2012). It is discussed in Chapter 8.

3.12 Research Matrix

To facilitate better understanding, Table 3.11 presents the relationship between the research questions, research objectives, approaches adopted and deliverables for each question.

Table 3.11 Research design matrix

No.	Research Question	Research Objective	Approach	Deliverable
1	What are the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection?	To assess the current FEP practices and extent of FEP significance in infrastructure projects	Integrative literature review, Expert interview	The significance of FEP, the current practices of decision-making process for infrastructure project selection
2	What are the key features of a good DMF for infrastructure project selection?	To investigate the key features of a good DMF for infrastructure project selection	Typology analysis, Expert interview	The key features of DMF, proposed conceptual DMF
3	What are the appropriate decision parameters in selecting infrastructure projects?	To examine the appropriate decision parameters in selecting infrastructure project proposals	Integrative literature review, Expert interview, Questionnaire	Result of literature review, Analysis of qualitative data, Analysis of quantitative data
4	What DMF for infrastructure project selection can be developed and to what extent can it be implemented?	To propose a DMF that enhances the decision-making efficacy for infrastructure project selection and to investigate the effectiveness of the proposed framework	MCDM technique (using NSFDSS-II) and case study implementation (through FGD/technical workshop)	Proposed DMF and its validation to establish a final DMF

3.13 Research Validity and Reliability

According to Rahmani (2016), research reliability is "the extent to which results are consistent over time and how they represent the total population under study accurately". Meanwhile, research validity is "concerned with the meaningfulness of research components" (Drost 2011). Since this research uses a mixed method approach, the research validity and reliability are evaluated from two different perspectives.

3.13.1 Validity and Reliability in Quantitative Research

In this research, validity and reliability tests were carried out mainly to interpret the questionnaire responses. According to Lucko and Rojas (2010), validity tests are concerned with 'doing the right things'. It is necessary to ensure that the research instrument used and the results obtained are valid. There are various types of validity in quantitative research (Lucko & Rojas 2010; Trochim 2006):

(1) ***internal validity*** which is 'related to the concept of causality and is preoccupied with the derivability of relations within data'
(2) ***external validity*** which is 'related to the concept of induction and focuses on the generalizability of results for prediction purposes'
(3) ***face validity*** which is 'subjective judgment of nonstatistical nature that seeks the opinion of non-researchers regarding the validity of a particular study'
(4) ***content validity*** which is a 'nonstatistical approach that focuses on determining if the content of a study fairly represents reality'
(5) ***criterion validity*** which refers to 'the extent to which the results of an assessment instrument correlate with another, presumably related measure/criterion'
(6) ***construct validity*** which refers to whether operationalisations of the theoretical constructs are appropriate

Meanwhile, the reliability test is used to ensure the stability and consistency of the instrument. Thus, it assists in assessing the goodness of a measure (Sekaran and Bougie (2010) as cited in Kalutara 2013), meaning that the instruments and procedures used in a study should produce the same results when applied to other similar studies (Sommer & Sommer 2001). There are several types of reliability (Lucko & Rojas 2010; Peterson & Kim 2013):

(1) ***interrater reliability*** which refers to 'the consistency between different measured subjects'
(2) ***internal reliability*** which refers to 'the consistency within a measuring instrument'
(3) ***parallel-forms reliability*** which refers to 'the consistency of different, but related, measurement tools when applied to the same sample'

Besides validity and reliability, another parameter that can be used to determine the quality of a quantitative study is research objectivity. This refers to the ability of researchers to examine evidence dispassionately (Nahrin 2015). There are several strategies employed in this study to ensure research objectivity, i.e. using a mixed method approach to provide stronger evidence through triangulation, performing critical literature analysis to identify the criteria in the infrastructure project selection and prioritisation process, using random sampling for the questionnaire survey, performing statistical analysis to ensure data are value-free, controlling possible biases and providing evidence of data collection. Table 3.12 presents a summary of the quantitative research quality strategies adopted in this study.

Table 3.12 Quantitative research quality strategies

Parameters	Type	Strategies adopted in this research
Validity (related to doing the right things)	**Internal validity**	• Using input from the literature review • Performing pilot tests to allow experts to clarify the research problems • Randomisation of respondents
	External validity	• Ensuring heterogenous data by random sampling for questionnaire survey
	Face validity	• Involvement of subject matter experts in data collection processes • Performing pilot tests
	Content validity	• Collecting data from practitioners in the Indonesian construction industry • Triangulations • Using Average Index to validate the set of selection criteria from questionnaire responses
	Criterion validity	• Performing pilot tests • Comparing predictions with those obtained from a different method
	Construct validity	• Performing pilot tests • Using Factor Analysis to confirm the factors that represent key selection criteria
Reliability (related to consistency and repeatability)	**Interrater reliability**	• Performing Cronbach's alpha test • Performing Composite Reliability test
	Internal reliability	• Performing sensitivity analysis • Performing Pearson's R correlation coefficient
	Parallel-forms reliability	• Performing comparison with other methods: NSFDSS-II vs AHP OS, SAW and NSFDSS-I
Objectivity (related to value free, neutrality and credibility)	**Research objectivity**	• Keeping evidence of data collection (survey responses) • Triangulations • Performing critical literature analysis • Using random sampling • Performing statistical analysis • Controlling possible biases by ensuring confidentiality and anonymity of the respondents, randomising the order of questions, etc.

3.13.2 Trustworthiness in Qualitative Research

On the other hand, some qualitative researchers argue that validity and reliability should be viewed differently in qualitative research and the results should be evaluated in a different way from the quantitative research (Hoepfl 1997; Winter 2000). Amongst qualitative researchers, issues of *trustworthiness* are the criteria in evaluating the research quality, i.e. credibility, transferability, dependability and conformability (Healy & Perry 2000; Thomas & Magilvy 2011).

Credibility refers to whether the participants' perceptions match with the researcher's portrayal of them. It is similar to the validity in quantitative research (Bloomberg & Volpe 2012). In this research, credibility was assured with employment of a number of strategies:

- *Data Triangulation*: using multiple data sources to ensure diversity in time, space and respondents involved (Korstjens & Moser 2018)
- *Method Triangulation*: using multiple methods corroborates the evidence which have been obtained through different means (Bloomberg & Volpe 2012).
- *Peer debriefing*: the examination of field notes, asking questions that help in examining research assumptions and providing considerations of alternative ways of looking at the data. The findings of this study were consistently checked and examined by experienced researchers who were the researcher's supervisors.
- *Prolonged engagement*: involving several respondents in long-term engagement to obtain rich data.
- *Statement of researcher biases*: in this research, all efforts have been made to describe all processes needed to conduct this study. This includes the researcher's experience, assumptions and biases that might happen during data collection, and the interpretation and analysis process.

Transferability is about how easily the study is transferable by other researchers. It refers to the fit between the research context and other contexts as judged by the reader (Bloomberg & Volpe 2012). The strategies adopted to ensure the transferability of this research are:

- *Thick description*: a way for communicating to the reader a holistic and realistic picture (Bloomberg & Volpe 2012). Description of the research process throughout all phases was provided in detail to allow readers to determine how closely this study matches their situation and if the research findings are transferable (Merriam 1995).

- *Shared experience*: allows the results to be applied in a wide range of other similar situations (Glaser & Strauss 2006). This study used experts from both professional and academics world within different organisations in Indonesia.

Although it is not assessed through statistical procedures, ***dependability*** parallels with reliability in quantitative research. It refers to "whether one can track the processes and procedures used to collect and interpret the data" (Bloomberg & Volpe 2012). Some strategies employed to ensure the reliability of a qualitative research are triangulation and peer debriefing (Merriam 1995). In addition, there is the *audit trail process* where detailed steps taken in this research were described transparently and data records were kept throughout the study (Korstjens & Moser 2018). Other strategies adopted in this study include providing a clear protocol for interviews and conducting multiple rounds of coding during the analysis process.

Lastly, ***conformability*** parallels to objectivity in quantitative research. It ensures that findings and interpretations are derived from the data (Korstjens & Moser 2018). Statement of researcher biases, evidences of data and control of possible biases can be used to ensure conformability. Meanwhile, according to Thomas and Magilvy (2011), it is achieved when credibility, transferability and dependability have been fulfilled. Based on the above explanation, it is clear that conformability of this research has been achieved. Table 3.13 summarises the qualitative research quality strategies adopted in this study.

Table 3.13 Qualitative research quality strategies

Parameters	Strategies adopted	Description
Credibility (related to confidence)	Data triangulation	Using multiple data sources to ensure diversity in time, space and respondents involved (stratification of respondents, use multiple cases)
	Method triangulation	Using multiple methods corroborates the evidence that has been obtained through different means
	Expert involvement	Ensuring high level of expertise participation
	Peer debriefing	Findings of this study were consistently checked and examined by experienced researchers who were the researcher's supervisors
	Prolonged engagement	Involving several respondents in the long-term engagement to obtain rich data
	Statement of researcher biases	Explaining all researcher's experience, assumptions and biases that might happen during data collection, interpretation and analysis process
Transferability (related to the	Thick description	Describing the research process throughout all phases in details

degree to which the results can be transferred)	Shared experience	Involving experts from both professional and academic world within different organisations
Dependability (related to the stability of the findings)	Audit trail process	Describing transparently the detail steps taken in this research and data records are kept throughout the study
	Data triangulation	*as above*
	Method triangulation	*as above*
	Peer debriefing	*as above*
	Clear protocol	Providing a systematic and clear protocol
	Deep analysis	Conducting multiple rounds of coding during the analysis process
Conformability (related to the degree to which the results can be confirmed)	Evidences of data	Keeping evidences of data collection (interview records and transcripts, PISC forms, etc.)
	Statement of researcher biases	*as above*
	Control possible biases	Controlling possible biases by ensuring confidentiality and anonymity of the respondents, randomise the order of questions, etc.

3.14 Research Ethics

Considerations related to ethical issues should be integrated in research. Ethical issues are considered to ensure that no harm occurs to the respondents as a result of the research activities (Cooper & Schindler 2006). For this research, the researcher met RMIT University's ethical code of practice in research. Since this study involves humans as the participants, it is also subject to human research ethics policies.

In order to align this research with RMIT's human research ethic policies, the researcher obtained formal ethics approval before starting the data collection phase. The formal ethics application included an explanation of the scope of this research, research methods and related information of participants involved in this study. Regarding qualitative data collection, before conducting any interviews, participants were requested to accept their participation voluntarily through the approved Participant Information Sheet/Consent Form (PISCF). Templates of the approved PISCF are attached in Appendix 7.

In all of the research processes, the ethical standards of doing research were strictly followed, including providing assurance to all participants that their privacy was kept intact at all times during and after the research, that their involvement was voluntary and thus, that they were free to withdraw from the study at any time.

This research was classified as low risk and received ethics approval from the RMIT Human Research Ethics Committee Project Number: CHEAN B 21600-07/18 for the period of 8 August 2018 to 18 June 2021.

3.15 Chapter Summary

This chapter presented the research methodology conducted for this doctoral study. It started with an explanation of the research philosophy, paradigms, approaches and methods. It then provided an explanation of the choices made with regards to research approaches and methods. The research phases, data collection and analysis were presented as well. Due to the compound nature of this research, a mixed method was adopted in this study. It involves both qualitative and quantitative techniques, i.e. typology analysis, semi-structured expert interviews, questionnaire survey and case study simulation. The next chapter will present the first key step of this research process, i.e. development of conceptual DMF model through typology analysis.

CHAPTER 4. DEVELOPMENT OF A CONCEPTUAL DECISION-MAKING FRAMEWORK MODEL FOR INFRASTRUCTURE PROJECT SELECTION

4.1 Introduction

The infrastructure project selection process employs decision-making practices to assess and select infrastructure project proposals which eventually leads to a list of priority projects. Thus, this research aims to develop a model of Decision-Making Framework (DMF) for infrastructure project selection that integrates multiple decision criteria that will assist decision makers in defining and determining investment plan for appropriate projects. The first step in developing this DMF is to establish a conceptual DMF model for infrastructure project selection. As shown in Figure 4.1, it is followed by DMF development and implementation which will be discussed in the subsequent chapters.

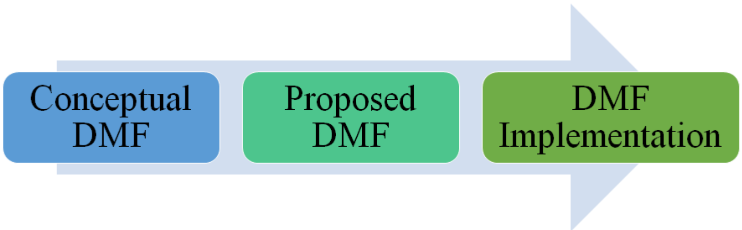


Figure 4.1 Three major steps of DMF model development adopted in this study

In Chapter 2, the significance of the Front End Planning (FEP) phase, particularly related to the investment decision-making process was described. The importance of Multi-Criteria Decision-Making (MCDM) in infrastructure project portfolios appraisal was also established. Furthermore, some DMF models for infrastructure project appraisal from several countries were provided. Information obtained from this literature review can be used as a basis to develop a conceptual DMF model. This chapter focuses on the development of a conceptual DMF model for infrastructure project selection. It starts with a brief explanation of the conceptual framework, the steps needed to develop a conceptual DMF model and identification of the required dimensions in a DMF using typology analysis. Finally, a conceptual DMF model for infrastructure project selection is established and discussed.

4.2 What is a Conceptual Decision-Making Framework Model?

The reviews and critiques of literature that have been carried out in the previous chapter have contributed to the development of conceptual framework. The term ‘conceptual framework’ has a broad definition. Jabareen (2009) describes it as a network of interlinked concepts for constructing a comprehensive understanding of a phenomenon. Grant and Osanloo (2014) define it as an understanding of how the research problem will best be investigated, the specific direction that has to be taken and the relationship between different variables in the study. It is different from a theoretical framework. While a theoretical framework provides a general and broader set of ideas within which a study belongs, a conceptual framework denotes specific ideas a researcher utilises (Adom, Hussein, & Agyem 2018). Thus, a conceptual framework may serve as a basis for understanding specific relationship patterns from various concepts, ideas, observations and other experiences so that a logical structure of connected patterns can be established.

In relation to DMF development, a conceptual DMF model can be defined as a means to categorise and describe various concepts relevant to the study of decision making for infrastructure project selection, and to map relationship patterns among them. The conceptual DMF model serves as a foundation for DMF development in which concepts and variables of good DMFs are generated, traced and mapped. Thus, it can provide a reference point for:

(1) The direction of DMF development (what are the concepts, variables, etc. to look for?)
(2) The steps to develop DMF (what are the steps that should be conducted?)
(3) Interpretation of the findings (do the findings obtained answer the research questions and objectives of the DMF?)

The existence of this conceptual DMF model will make it easier for researchers to identify concepts and variables that need to be discussed in a study related to decision-making for infrastructure project selection. The conceptual DMF model has several positive characteristics, namely:

(1) Straightforward: it is developed with focus on being practical and easy to understand
(2) Flexibility: it is developed based on flexible concepts and variables so that it is adaptable for further development in the future
(3) Modifiable: it can be easily reconceptualised and modified in accordance with the development of future information updates

As with any framework, this conceptual DMF model must also be stated in writing for it to be understood (Fisher & Buglear 2007). Thus, this study not only presents a diagrammatic representation of the conceptual DMF model, but it also explains the relations among the main variables and how they help to answer the defined research problem.

4.3 Developing a Conceptual Decision-Making Framework Model

In order to develop a conceptual DMF model, a systematic analysis procedure must be established (the PISCAF procedure). A detailed explanation of this procedure and its application in this study are provided as follows:

1. **P**roblem identification

   The first step is to define and identify problems. This is done by finding out the actual problems and the desired conditions to overcome these problems. In relation to this research, the problem is:

   the absence of a Decision-Making Framework makes it difficult for decision makers to assess and select infrastructure project proposals in Indonesia.

   Thus, the development of a DMF for infrastructure project selection has become the main objective in this study.

2. **I**nformation gathering

   This includes extensive information gathering from various data sources that have been selected. This is done by locating relevant literature sources. In this research, there were two type of literature sources used, i.e. journal databases and online sources. Both were trusted sources, meaning only peer-reviewed journal databases and credible online sources (those managed by government agencies and credible institutions) have been used and selected. Next, several keywords were used to narrow down the search and to retrieve related literature. These keywords include decision-making framework, decision support system, infrastructure project selection, infrastructure project assessment and infrastructure project appraisal.

3. **S**creening

   Screening is done through visual examination by extensive reading of all literature collected from the previous step. The techniques applied in this study is to read the abstracts and document summaries related to DMFs for infrastructure project selection, and then to skim the contents to identify relevant literature for further analysis.

4. **C**oncepts identification and classification

   This step includes the process of identifying concepts, ideas or variables found in the literature and coding them. Next, these concepts, ideas or variables are grouped based on their main attributes and similarities. In relation to this study, further explanations are provided in the next section.

5. **A**nalysis, synthesis and design of conceptual DMF

   This step includes integrating process of identified concepts, ideas or variables; establishing relationship patterns; synthesising concepts, ideas or variables into a unified framework; and designing a conceptual DMF model so that it is reasonable and easy to understand. In relation to this study, further explanations are provided in the next section.

6. **F**ramework validation and modification

   This step includes conceptual DMF model presentation and validation to obtain expert's feedbacks and opinions. After validation is done, a conceptual DMF model may be revisited and modified based on new insights obtained as the results of validation process. Thus, this step ensures that the conceptual DMF model is sensible, well-established and useful for the further development of DMF.

To develop the conceptual DMF model, this study adopted the classification technique called typology analysis. This is a qualitative classification technique that can be either verbal or conceptual in form. According to Bailey (2011), a typology is more conceptual while a taxonomy is more empirical. A typology is derived in a deductive manner, while a taxonomy is usually derived in an inductive manner using statistical methods (Paré et al. 2015). Here, a typology is used to highlight the relevant theoretical dimensions of concepts – or in this study, the DMFs. Bailey (2011) conveyed that this is the premier technique for defining and comparing multi-dimensional type of concepts. Since the development of this conceptual DMF model is related to knowledge synthesis and the literature review process is inclined to deductive analysis, it is thus clear that a typology is more appropriate for this research.

This study adopted a typology analysis as a means to review various DMFs for infrastructure project selection and hence to simplify complex concepts using several important classification dimensions. While there have been no previous studies on typology analysis review for DMFs in the context of infrastructure project selection, there are a few examples of research projects studying the typology of decision-making processes in general such as those conducted by

Malakooti (2010) and Whitney, McGuire and McCullough (2003). In both studies, the findings of typology analysis were used as a tool to develop a DMF. Similarly, in this study, a typology is used as a tool for mapping all concepts and considerations in the development of a DMF model.

After undergoing the information gathering and screening stages, five relevant DMFs for infrastructure project selection were selected, namely: Infrastructure Australia's Assessment Framework (IAAF), the Infrastructure Investor Assurance Framework (IIAF), the Project Assessment Framework (PAF), Cities Development Initiative for Asia's Framework (CDIA), and Indonesia's KPPIP Framework (KPPIP). They were selected based on three main reasons, namely:

(1) Representativeness
These DMFs represent infrastructure project selection guidance used in both developed and developing countries.
(2) Implementation
These DMFs have been used to guide the process of infrastructure project selection and prioritisation.
(3) Accessibility
These DMFs are completely available and accessible from trusted online sources. The use and dissemination of these DMFs have also been encouraged.

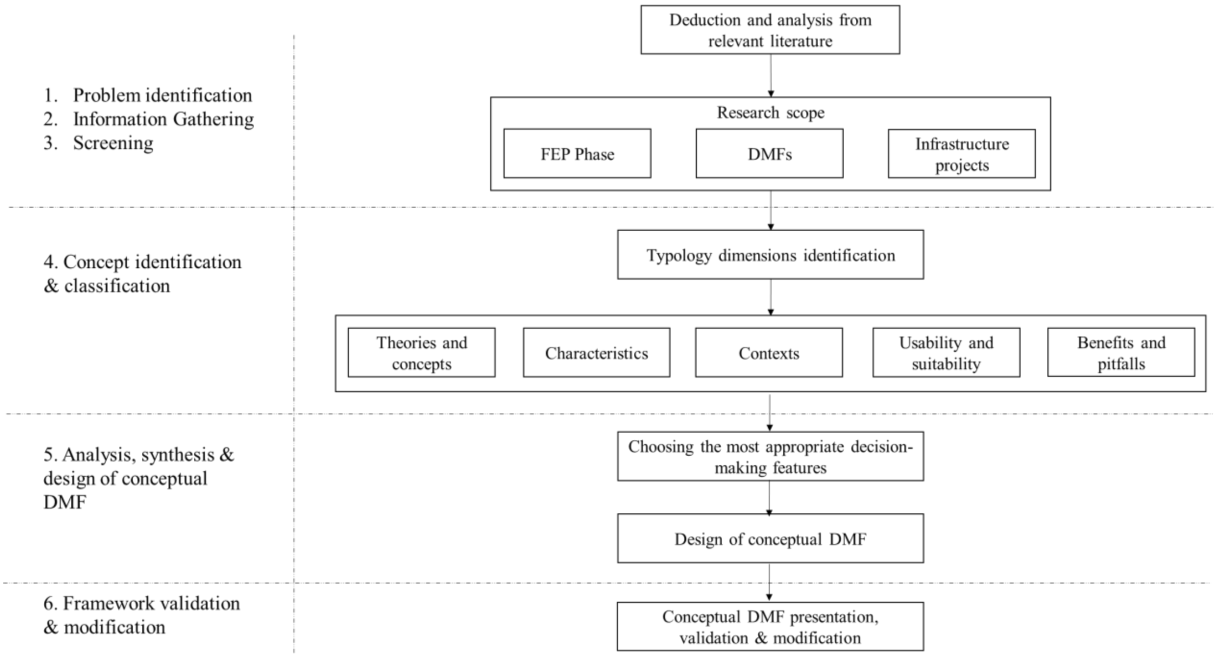


Figure 4.2 Typology analysis adopted in this research

The underlying concepts of these DMFs were analysed using a typology technique (as shown in Figure 4.2) by which the existing knowledge and practices was consolidated. At the concept identification and classification stage, five typology dimensions were established to facilitate understanding and evaluation. These dimensions were grouped by common attributes and similarities. Explanations regarding these typology dimensions can be seen in Table 4.1.

Table 4.1 Typology dimensions used in this study

Dimensions	Description
Theories and concepts	The main concepts and theories relating to the creation of DMFs, the conceptual and statistical approaches of the DMFs
Characteristics	The main characteristics of the DMFs
Contexts	The decision-making contexts contained in the DMFs
Usability and suitability	The capability and relevance of the DMFs in selecting infrastructure projects
Benefits and pitfalls	Potential merits and pitfalls from applying the DMFs

Next, these five selected DMFs were evaluated and analysed based on the established typology dimensions. These dimensions have several sub-dimensions. The results of typology analysis from these five selected DMFs can be seen in Table 4.2.

Table 4.2 Results of the typology analysis

Dimensions	Sub-dimensions	IAAF	IIAF	PAF	CDIA	KPPIP
Theories and concepts	**Approach**	• Systematic evidence-based and economic assessment approach • Well-structured and objective	• Systematic risk-based approach	• Systematic approach • Assessment throughout project lifecycle	• Systematic approach • Objective	• Systematic approach
	Methods and tools	• Mixed (qualitative and quantitative) • Cost-benefit analysis	• Qualitative • Weighted scoring of risk profile	• Mixed but tends to quantitative • Involves many analyses	• Mixed (qualitative and quantitative) • Scoring method	• Qualitative • Elimination • Scoring method
	Selection techniques	• Rational	• Judgmental	• Rational	• Rational	• Rational
Charac-teristics	**Decision makers**	• Network	• Network	• Network	• Network	• Network
	Stages of development	• Two stages: initiatives and projects	• -	• -	• Two stages: proposals and priority packages	• Three stages: proposals, strategic projects and priority projects
	Time scale	• Three types of time scale: near-term, medium-term, and longer-term	• -	• -	• Five-year plan	• -
	Stages of assessment/ selection	• Five stages: problem identification and prioritisation; initiative	• Two stages: preliminary process;	• Three main stages: the pre-project stage, the project stage	• Three stages: financial capacity analysis; project prioritisation;	• Two stages: elimination stage; scoring stage

		identification and options development; business case development; business case assessment; post completion review	guarantee process	(consists of six generic stages) and the post-project stage	investment programming	
	Selection criteria	• Three criteria: strategic fit; economic, social and environmental value; deliverability	• Five criteria: level of government priority; interface complexity; procurement complexity; agency capability; essential service	• Many criteria but not limited to: target dates, major functions, appearance, performance levels, capacity, accuracy, availability, reliability, development costs, running costs, security and ease of use	• Five criteria: project purpose; public response; environmental impact; socio-economic impact; feasibility of implementation	• Three criteria: basic criteria; strategic criteria; operational criteria
Contexts	**Political**	• Identified	• Identified	Identified	• Identified	• Identified
	Economical	• Identified	• Identified	Identified	• Identified	• Identified
	Stakeholders	• Identified	• Identified	Identified	• Identified	• Identified
	Decision-making process	• Identified	• Identified	Identified	• Identified	• Identified
	Socio-environmental	• Identified	• Identified	Identified	• Identified	• Identified

	Technological	• Identified	• Identified	Identified	• Identified	• Identified
Usability and suitability	**Usability**	• Early engagement • Provides templates, checklists, notes	• Prioritisation and monitoring tool • Gateway review process	• Early engagement • Provides templates, checklists, notes	• Provides a rational and pre-determined set of indicators	• Provides selection criteria
	Suitability	• Priority infrastructure projects	• All capital projects	• General projects	• General infrastructure projects	• Priority infrastructure projects
Benefits and pitfalls	**Benefits**	• Clear national perspective • Improve coordination • Encourage private involvement • Evidence-based • Detailed assessment stages and checklists	• Early warning of risks • Fir-for-purpose reporting tool • Encourage private sector involvement	• Early warning of risks • Assess throughout project lifecycle • Encourage private sector involvement	• Simple (scoring model) • Attractive and easily understandable	• Clear national perspective • Improve coordination • Encourage private involvement • Simple (elimination and scoring model)
	Pitfalls	• Need time and trainings	• Lack of accuracy and detailed assessment	• Need time and trainings	• Lack of detailed financial feasibility study	• Lack of practical tools such as templates and checklists

4.3.1 Theories and Concepts

a. Approach

This refers to the underlying DMF approach in selecting and prioritising infrastructure project proposals. In general, the five DMFs apply a systematic approach to selecting project proposals, indicating an effort to provide a well-structured and objective approach in making selection decisions.

b. Methods and Tools

This refers to methods and tools used to select and prioritise infrastructure project proposals that existed in the DMFs. Here, three DMFs namely: IAAF, PAF and CDIA use a mixed method, while IIAF and KPPIP tend to use a qualitative method.

c. Selection Techniques

This refers to the types of selection techniques used to select and prioritise infrastructure project proposals. There are three types of selection techniques in decision-making process, namely: judgmental, rational, and emergent-based selection techniques (Bakht & El-Diraby 2015). Based on the typology analysis, four DMFs employ a rational selection technique characterised by a formal objective approach in their selection process. On the other hand, IIAF tends to be more judgmental due to the fact that it relies more on the judgment (subjectivity) of decision makers in determining the risk profile of the proposed projects.

4.3.2 Characteristics

a. Decision Makers

This refers to the types of decision makers in the reviewed DMFs. There are three types of decision makers, namely: single type, hierarchy type and network type (Bakht & El-Diraby 2015). Based on the typology analysis, these five selected frameworks employ a network type of decision makers characterised by the multi-stakeholder interactions during the decision-making process for infrastructure project selection and prioritisation.

b. Stages of Development

This refers to the stages of development of a project. In general, there are two stages of development, namely: the stage of making a proposal or initiative and the stage of prioritisation. KPPIP has an additional stage—i.e. strategic projects—because KPPIP is related to the selection and prioritisation of strategic projects. On the other hand, IIAF and PAF do not classify infrastructure project proposals into their development stages.

c. Time Scale

This refers to the time scale of the planning designation. In general, project infrastructure planning can be divided into three scales, i.e. short-term, medium-term and long-term planning. Here, two frameworks provide time scale while three frameworks do not provide any explanation on the project time scale.

d. Stages of Assessment

This refers to the stages of assessment for selecting and prioritising infrastructure project proposals. Determining the stages of assessment (or selection stages) is critical to assist decision makers or the FEP team to make appropriate selection decisions. The five frameworks show a variety of selection stages in accordance with their needs and conditions. However, all of their stages for the assessment process in infrastructure project selection and prioritisation are sequential.

e. Selection Criteria

This refers to criteria that become the benchmarks for measuring assessment and selection of infrastructure project proposals. In practice, there are many selection criteria that can be grouped into several large groups. The five frameworks show a variety of selection criteria groups, depending on how they are grouped.

4.3.3 Contexts

a. Political Context

This refers to the political influences during infrastructure project selection and prioritisation process. All selected frameworks show the influence of politics during the decision-making process for infrastructure project selection.

b. Economical Context

This refers to the economic considerations during infrastructure project selection and prioritisation process. All selected frameworks take into account the economic impacts of the proposed projects.

c. Stakeholders Context

This refers to the stakeholder influences during infrastructure project selection and prioritisation process. All selected frameworks identify key stakeholders and their respective roles in the decision-making process of infrastructure project selection and prioritisation.

d. Decision-Making Process Context

This refers to the approach adopted during infrastructure project selection and prioritisation process. All selected frameworks present a scientific and systematic decision-making process, either qualitative, quantitative or mixed methods.

e. Socio-Environmental Context

This refers to the socio-environmental aspects during infrastructure project selection and prioritisation process. All selected frameworks take into account the socio-environmental benefits of infrastructure project proposals.

f. Technological Context

This refers to the technological considerations during infrastructure project selection and prioritisation process. All selected frameworks present a technological context that encompasses many aspects, including but not limited to deliverability, operational technology, project safety and future technology.

4.3.4 Usability and Suitability

a. Usability

This refers to the ease of use and capability of the framework as a tool in facilitating the decision-making process for infrastructure project selection and prioritisation. All selected frameworks provide a variety of tools and techniques to improve the usefulness of the frameworks.

b. Suitability

This refers to the degree of relevancy to which the framework is suitable for a particular type of project. All selected frameworks relate to infrastructure projects.

4.3.5 Benefits and Pitfalls

a. Benefits

This refers to the advantages of using the framework. All selected frameworks provide numerous advantages in the context of infrastructure project selection and prioritisation.

b. Pitfalls

This refers to the limitations of the framework. All selected frameworks have several limitations that have been identified.

Finally, the results of the typology analysis were used to design and develop a preliminary conceptual DMF infrastructure project selection.

4.4 Conceptual Decision-Making Framework Model

In developing a conceptual DMF model, it is necessary to consider the key dimensions which later become part of the DMF. Therefore, a typology analysis has been conducted to obtain these key dimensions from the selected DMFs. Based on the typology analysis, a preliminary conceptual DMF model was developed as shown in Figure 4.3.

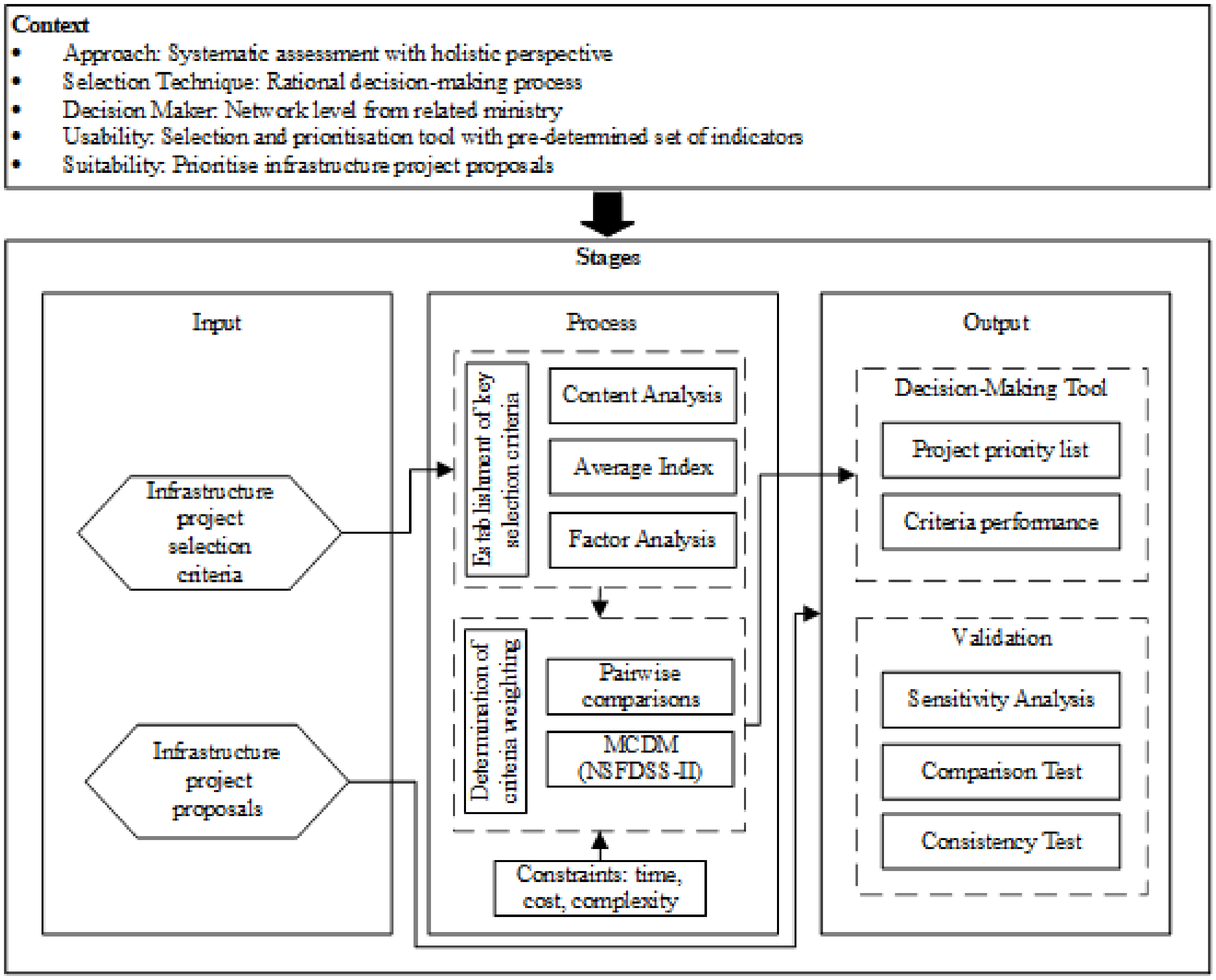


Figure 4.3 The conceptual DMF model for infrastructure project selection

As a preliminary conceptual DMF model, Figure 4.3 presents a logical grouping of activities for infrastructure project selection and prioritisation. It is a context-based DMF generated from the previous typology analysis. The context in the conceptual DMF includes five elements, namely approach, selection technique, decision maker, usability and suitability. The overall approach of this conceptual DMF model is systematic. The project proposals will be reviewed and assessed through a step-by-step procedure so that they can be gradually selected and prioritised. Both quantitative and qualitative methods can be employed as techniques to identify the required criteria for selecting and prioritising infrastructure project proposals.

Regarding selection technique, this conceptual DMF model suggests a rational type of selection technique. Since infrastructure projects are complex and mainly use public funds, the decision-making process of infrastructure project selection must be justified through an objective rational selection technique. In fact, there have been many previous studies on adopting a rational selection technique in their decision-making processes (Ashley, Uehara & Robinson 1983; Darwish & Cadorin 2014; El Chanati et al. 2016; Ioannou 1989; Kang et al. 2011; Masoumi 2015; Thunberg 2016).

A network type of decision makers is proposed in this DMF. Since infrastructure project planning and implementation are mainly done by relevant ministries such as MPWH, MT and MNDP, the multi-stakeholder interactions during the decision-making process are inevitable (as seen in the planning development forums and other multi-stakeholder meetings in the ministries). Meanwhile, the usability and suitability of this DMF are focused on the effectiveness of the decision-making process in the selection and prioritisation of infrastructure projects based on pre-determined set of selection criteria and assessment parameters.

The conceptual DMF has three stages of development, i.e. input, process and output. It starts with identification of DMF inputs which consists of two main inputs, namely: the selection criteria and the infrastructure project proposals. Next, the process stage refers to the formulation and establishment of key criteria to be used in solving the infrastructure project selection and prioritisation problem. It consists of two main activities, i.e. establishment of key selection criteria and determination of criteria weighting. The first activity involves both qualitative (through content analysis) and quantitative approaches (through average index and factor analysis), while the latter involves pairwise comparisons and NSFDSS-II analysis. These activities are crucial as a means to select and prioritise infrastructure project proposals in an objective and systematic manner where multiple criteria involved are identified and sorted based on the scale of importance. In determining the criteria weighting, three constraints—time effectiveness, cost effectiveness and project complexity—are used as assessment parameters.

The output of these activities is a Decision-Making Tool as part of the developed DMF. It is used to assist decision makers in evaluating the project proposals. Here, the prospective infrastructure project proposals are assessed, filtered and ranked based on their calculated performance scores. There are two types of decision outputs, i.e. project priority list and criteria performance graphics which will be reviewed for approval by top management. Furthermore, to validate the effectiveness of these decision outputs, several tests are proposed which include sensitivity analysis, comparison test and consistency test.

Next, in order to develop a more comprehensive model, the development of the DMF model is not only based on feedbacks on the conceptual DMF model, but it also based on the investigation of the real practices and establishment of the DMT that will be part of the DMF model (as shown in Figure 4.4). In other words, the modification of the conceptual DMF model will be carried out by considering the findings of the investigation results and the DMT. Both of these will be discussed in subsequent chapters.

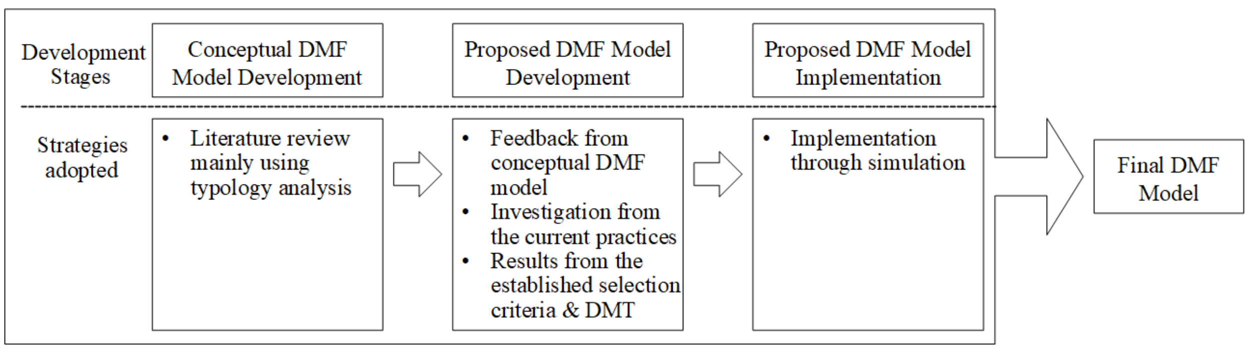


Figure 4.4 DMF model development stages and strategies

4.5 Chapter Summary

This chapter discussed the development of the conceptual DMF model. It should be highlighted that this conceptual DMF model serves as an initial step to develop a DMF model for infrastructure project selection and prioritisation. In doing so, it attempts to map all of the main decision-making activities in the process of infrastructure project selection. The purpose of developing a conceptual DMF model is to establish the backbone structure for the development of the proposed DMF model. A conceptual DMF model has thus been established using a typology analysis. It is useful in organising the complex nature of the decision-making process and identifying relationships between the main activities. The next chapter will present the investigation results on the current practices, plus the issues and challenges of infrastructure project selection and prioritisation in Indonesia. Together with the results of this investigation, the conceptual DMF model will be modified and developed into a proposed DMF model.

CHAPTER 5. INVESTIGATION OF THE CURRENT PRACTICES, ISSUES AND CHALLENGES OF INFRASTRUCTURE PROJECT SELECTION AND PRIORITISATION IN INDONESIA

5.1 Introduction

This chapter presents the qualitative data analysis and findings according to the responses from the semi-structured expert interviews that have been conducted. It focuses on investigating the current practices, issues and challenges of infrastructure project selection and prioritisation in Indonesia. The analysis used the thematic coding technique, which is one of the most common qualitative data analysis techniques. The findings contributed to the development of a Decision-Making Framework (DMF) by identifying the current practices, issues and challenges of infrastructure project selection and prioritisation in Indonesia that have never been explored before. In other words, it is contextualising the DMF development. By doing so, it is expected that advancements in developing a good and appropriate DMF for infrastructure project selection and prioritisation in the Indonesian context could be obtained.

5.2 Interview Data Collection

A total of 20 interviews (not including pilot interviews) were performed from December 2018 to March 2019. Table 5.1 shows the interview schedule and duration for each respondent. The average interview duration was 48.45 minutes. Meanwhile, the respondents' profile is shown in Table 5.2. It consists of five identification groups, namely: affiliation, educational background, work experience, job position and gender. As indicated, the average working experience of the respondents is 13.63 years.

Table 5.1 Interviews schedule

No	Respondent	Interview Date	Interview Duration	No	Respondent	Interview Date	Interview Duration
1	**R-1**	19 Dec 2018	60	11	**R-11**	18 Feb 2019	40
2	**R-2**	9 Jan 2019	45	12	**R-12**	25 Feb 2019	45
3	**R-3**	9 Jan 2019	45	13	**R-13**	1 Mar 2019	32
4	**R-4**	15 Jan 2019	55	14	**R-14**	14 Mar 2019	45
5	**R-5**	16 Jan 2019	70	15	**R-15**	15 Mar 2019	40
6	**R-6**	17 Jan 2019	55	16	**R-16**	15 Mar 2019	40
7	**R-7**	18 Jan 2019	45	17	**R-17**	20 Mar 2019	45
8	**R-8**	23 Jan 2019	47	18	**R-18**	20 Mar 2019	40
9	**R-9**	11 Feb 2019	80	19	**R-19**	26 Mar 2019	45
10	**R-10**	16 Feb 2019	60	20	**R-20**	28 Mar 2019	35
Average interview duration = 48.45’							

Table 5.2 Respondents’ profile

	A : ID	B : Affiliation	C : Educational Backgr...	D : Work Experience (y...	E : Job Position	F : Gender
1 : ...	R-12	Bappenas	Master	15	Planning Officer	Male
2 : ...	R-9	Cipta Karya	Master	11	PPK	Male
3 : ...	R-2	BPIW	Master	>20	Head of Department	Male
4 : ...	R-10	MT	Master	11	Head of Department	Male
5 : ...	R-14	Bina Marga	Master	12	PPK	Male
6 : ...	R-1	Podomoro Univ, Trisakti U	Doctoral	>20	Senior Lecturer	Female
7 : ...	R-3	BPIW	Master	11	Head of Department	Male
8 : ...	R-7	Podomoro Univ	Master	4	Lecturer	Male
9 : ...	R-18	Cipta Karya	Master	8	Functional Officer	Female
10 ...	R-17	Bina Marga	Master	13	Head of Department	Male
11 ...	R-13	Bappenas	Master	31	Planning Officer	Male
12 ...	R-11	MT	Master	14	Head of Department	Male
13 ...	R-15	MT	Master	9	Functional Officer	Female
14 ...	R-4	BPIW	Master	10	Head of Department	Male
15 ...	R-16	MT	Master	9	Head of Department	Female
16 ...	R-5	BPIW	Doctoral	17	Head of Department	Male
17 ...	R-20	MT	Master	10	Budget Impl. Evaluator	Male
18 ...	R-6	BPIW	Doctoral	24	Head of Department	Female
19 ...	R-19	MT	Master	10	Programming	Female
20 ...	R-8	BPIW	Doctoral	21	Head of Department	Male

The respondent’s profiles are:

- Respondent 1 (R-1) is a senior lecturer and professional with more than 20 years of experience. She teaches both undergraduate and master degree students in two different campuses in Jakarta, Indonesia. She is also an expert in PPP projects and heavy equipment for construction.

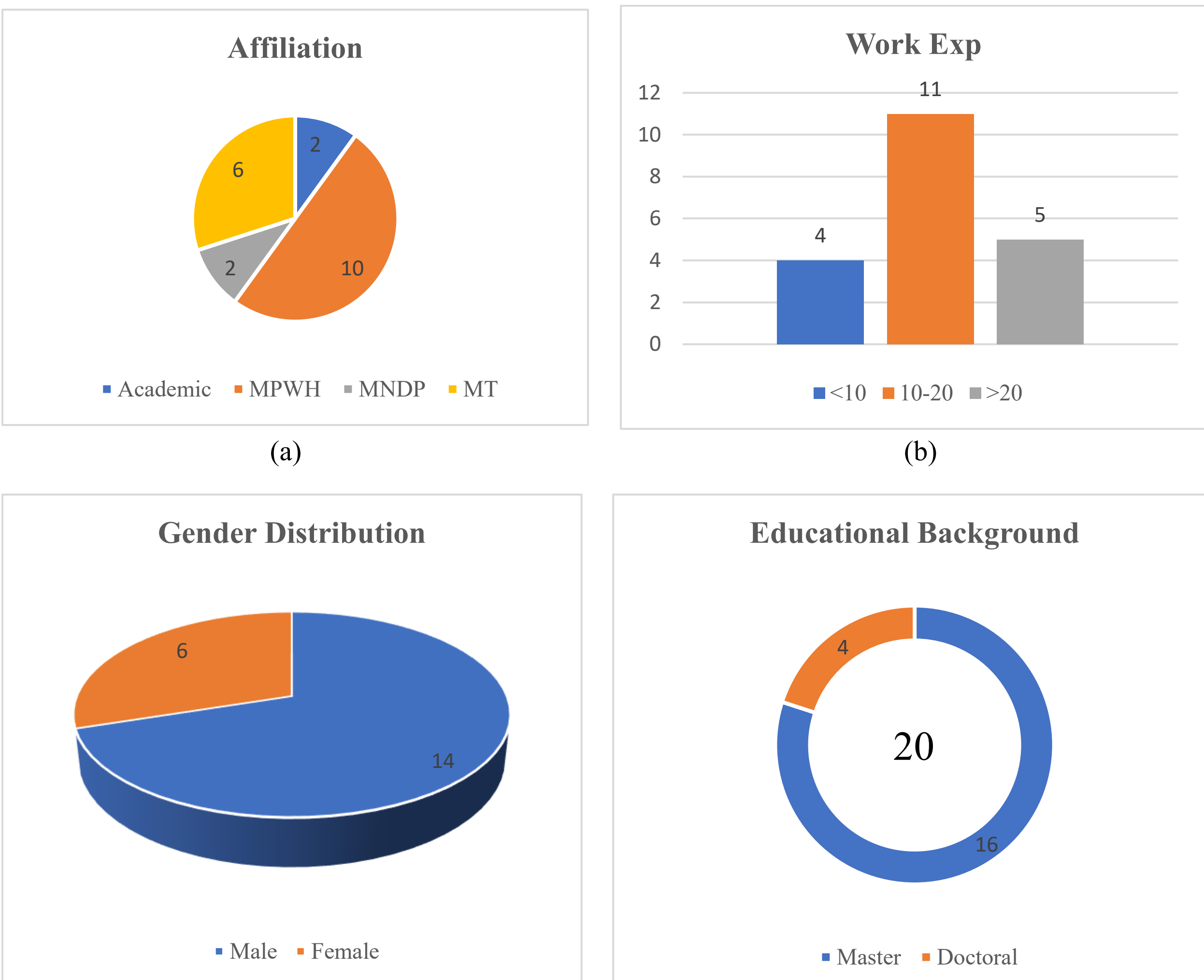
- Respondent 2 (R-2) is the head of infrastructure planning centre at the Indonesian MPWH. He is a senior professional with more than 20 years of working experience.
- Respondent 3 (R-3) is a professional who has been working at the Indonesian MPWH for more than 11 years. Currently he is the head of strategic plans preparation.
- Respondent 4 (R-4) is a professional who has been working at the Indonesian MPWH for more than ten years. He is the head of the programming and budgeting sub-division.
- Respondent 5 (R-5) is the head of the programming division at the Indonesian MPWH. He has a vast knowledge of infrastructure programming at the MPWH with 17 years of experience.
- Respondent 6 (R-6) is a senior professional at the Indonesian MPWH. She has more than 24 years of experience and currently she is the head of infrastructure integration in the strategic regions division. She has a vast knowledge of the current practices for infrastructure project selection in Indonesia.
- Respondent 7 (R-7) was a practicing constructor and is now in academia. He is a young and enthusiastic lecturer with strong ideas on construction innovation. He has four years of experience.
- Respondent 8 (R-8) is the head of the programme and funding synchronisation division at the MPWH. He is an expert in infrastructure project selection. He has 21 years of experience.
- Respondent 9 (R-9) has more than 11 years of working experience at the MPWH. Currently he is the commitment officer of strategic buildings 3, directorate general of human settlement.
- Respondent 10 (R-10) is a professional who has been working at the Indonesia MT for more than 11 years. He is the section chief of traffic and road transport at the regional management transportation centre XIX.
- Respondent 11 (R-11) is the head of government-SOEs investment and cooperation facilitation sub-division of MT. He has 14 years of working experience.
- Respondent 12 (R-12) is a professional with more than 15 years of experience. Currently he is the junior planning officer of the deputy for facility and infrastructure at MNDP.
- Respondent 13 (R-13) has 31 years of working experience at MNDP. Currently he serves as the senior planning officer at the transportation department.

- Respondent 14 (R-14) is a commitment officer of the directorate general of highway, MPWH. He is young and dynamic with more than 12 years working experience.
- Respondent 15 (R-15) is a professional and researcher at the road and railway transportation R&D of MT. She has more than nine years of working experience.
- Respondent 16 (R-16) is the head of polytechnic affairs sub-division of road transportation safety, MT. She is an enthusiastic professional with more than nine years of working experience.
- Respondent 17 (R-17) is a professional with thirteen years of experience at MPWH. Currently he is the head of sub-directorate of data analysis and system development of Bina Marga.
- Respondent 18 (R-18) is a functional officer of health environment engineering at MPWH. Even though she is young, with eight years of working experience, she had many experiences with urban sanitation projects.
- Respondent 19 (R-19) is a programming officer at air transport of MT. She has more than ten years of working experience.
- Respondent 20 (R-20) is a professional of ten years' experience. Currently he serves as the budget implementation evaluator at the planning department of MT.

From Table 5.2, some distributions of the respondents' profiles could be further developed, as shown in Figure 5.1. Figure 5.1(a) shows that half of the respondents (50%) are working at the Indonesian Ministry of Public Works & Housing (MPWH) and six respondents (30%) are working at the Indonesian Ministry of Transportation (MT). Meanwhile, respondents affiliated with the Indonesian Ministry of National Development Planning (MNDP) and academic roles are two (10), respectively.

Figure 5.1(b) shows the respondents' working experience. Here, three groups of working experience are distinguished to simplify the profile grouping. Group 1 is for those who have less than 10 years of working experience. There are four respondents (20%) belonging to this group. Group 2 is for those who have working experiences between 10 to 20 years. Eleven respondents (55%) belong to group 2, making it the majority group. Lastly, group 3 is for those who have more than 20 years of working experience. There are five respondents (25%) in this group.

In Figure 5.1(c), the distribution of gender shows that the majority of the respondents are male with 14 (70%) while the remaining six (30%) people are female. Finally, Figure 5.1(d) conveys the distribution of the respondents' latest educational background. It shows that majority of the respondents (80%) have a Master's degree while 20% of the respondents have a Doctoral degree qualification.



(c) (d)

Figure 5.1 Distribution of respondents' profile

A visualisation of the respondents' job position is illustrated in Figure 5.2. Through this NVivo 12 Pro tree map diagram, this visualisation illustrates that half of the respondents (50%) have a qualification as the head of a department. The remaining half distributes quite evenly. Planning officers, PPK (commitment maker officers) and functional officers account for 10% distribution, respectively, while a senior lecturer, a programmer, a budget implementor, and a lecturer comprise 5% distribution, respectively.

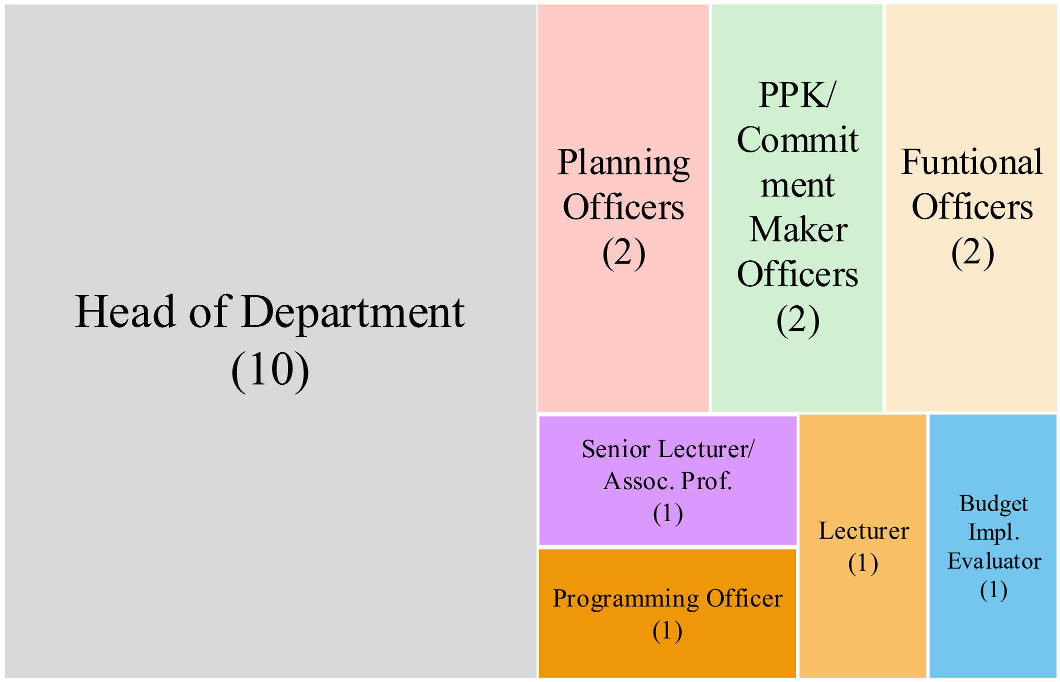


Figure 5.2 Respondents' job position visualisation

5.3 Interview Data Analysis

Semi-structured expert interviews were conducted that consisted of eight steps, as shown in Figure 5.3. This commenced with a preparation phase that consisted of drafting the interview questions, followed by a pilot interview and the selection of interview respondents. Next, interviews were conducted in Bahasa Indonesia. Transcriptions were done for each interview transcript followed by translations to English. This was followed by qualitative data analysis using the thematic coding technique.

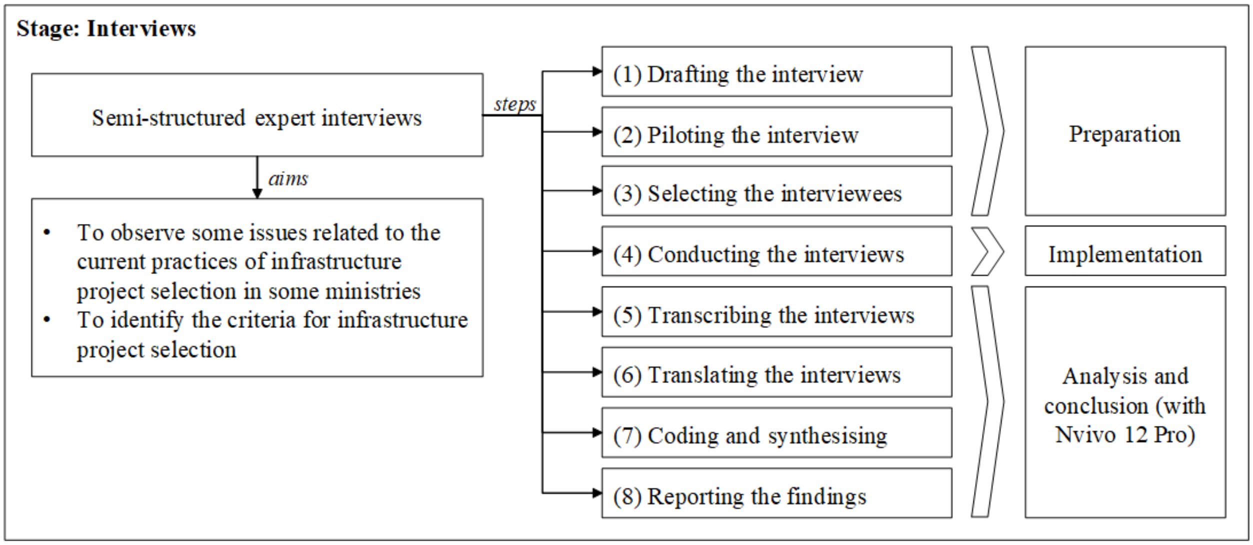


Figure 5.3 Interview process conducted in this study

Thematic coding analysis was done to capture important ideas and responses from the respondents. The process involves coding, examining and recording patterns within data (Braun & Clarke 2006). There are six phases of thematic analysis as suggested by Braun and Clarke (2006). Table 5.3 shows these six phases and the strategies adopted in this study.

Table 5.3 Phases of thematic coding analysis

No	Phase	Strategies adopted in this research
1	Familiarisation	Transcribing data; translating data; reading and re-reading data; noting down initial ideas
2	Generating initial codes	Coding interesting ideas/responses; finding the most frequent terms; data reduction and complication
3	Searching for themes	Grouping codes based on their similarity or commonness
4	Reviewing themes	Checking the relationship of the codes within the themes and the entire data set
5	Defining and naming themes	Refining the themes; creating clear definitions and names for each theme
6	Producing the report	Reporting the findings; providing sufficient evidence, supports and arguments

From these six phases, coding is perhaps the most important step in thematic analysis. It is used to generate a list of items that have implications for the research questions. Codes refer to “the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon” (Boyatzis 1998). It is usually a word, short phrase or metaphor with a common meaning or relationship derived from the respondents (Carpenter & Suto 2008). Rather than being a linear process, coding is a recursive process, where the movement goes back and forth between phases as needed (Braun & Clarke 2006).

In this study, NVivo 12 Pro was used to help the researcher to organise, code and develop patterns. Here, interesting ideas and responses were observed and grouped into categories as "codes" (or "nodes" in NVivo). Similar categories were then grouped into more general categories, known as "themes" (or "parent nodes" in NVivo). This is a process that identifies important things from data related to the research questions (Braun & Clarke 2006). Finally, the researcher established connections between categories and their subcategories, and provided narratives to capture the full meaning of the findings. Figure 5.4 presents a coding process example performed in this study.

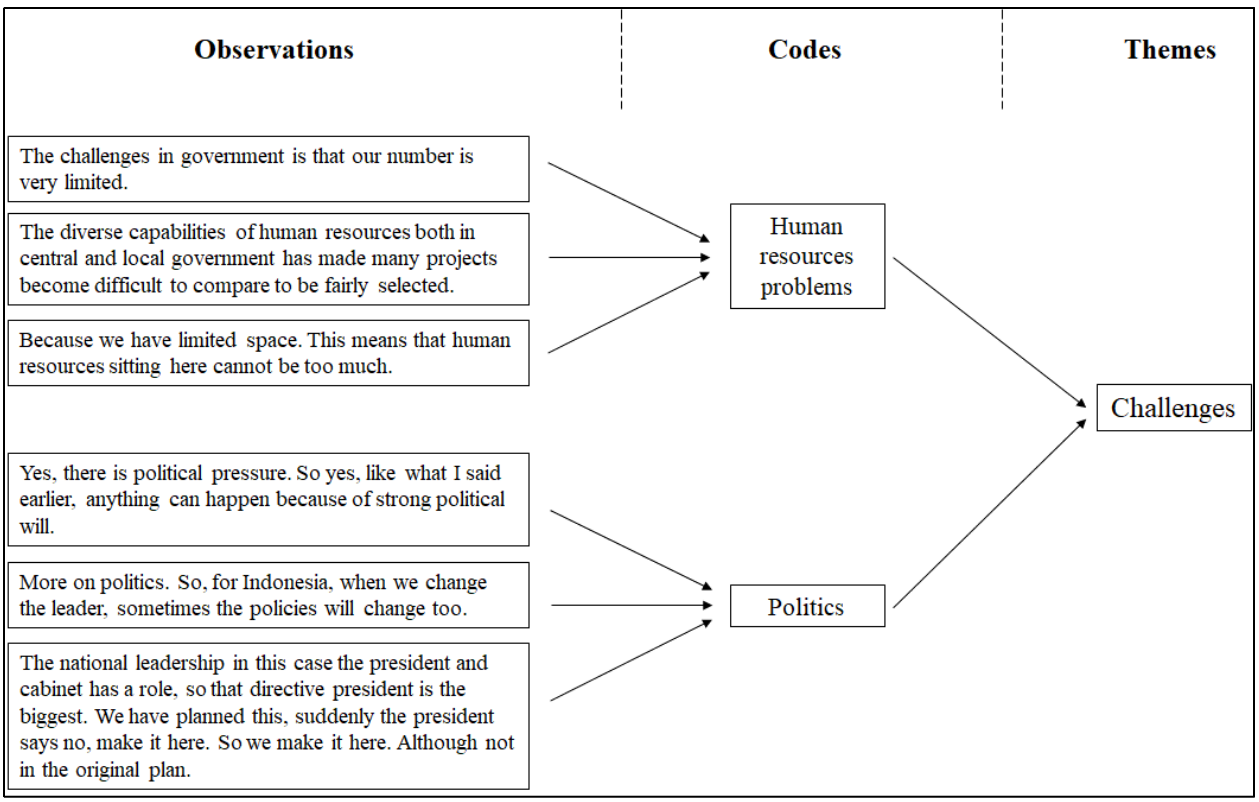


Figure 5.4 Example of the coding process conducted in this study

To present the report, matrices were used. A matrix is a tool, normally in form of a rectangular grid, used to display data or findings in a structured format. Table 5.4 shows the matrix of respondent's responses to each key question given during the interviews. There is a total of 20 interview questions that might have been asked to the respondents (shown as 'V') or inferred from the respondent's answers (shown as '*'). These questions are grouped into five categories, namely: (a) current practices of decision-making process for infrastructure project selection and prioritisation, (b) criteria in infrastructure project selection and prioritisation, (c) factors influencing infrastructure project selection process, (d) challenges in infrastructure project planning and selection, and (e) considerations of Decision-Making Framework (DMF) development. Other probe interview questions are not included in this matrix due to the small number of responses.

The key responses of each respondent for each interview question were provided in Appendix 3. These key responses are either taken directly from the respondent's answers or inferred from the respondent's overall response towards specific questions. Interview transcriptions and coding technique were important in gathering these key responses.

Table 5.4 Interview Questions – Respondents Matrix

No	Questions	Respondent																			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**																				
1	How does FEP occur and how is it carried out in your organisation?	V	*	*	*	V	*	V	*	*	*	V	*	*	*	*	*	*	*	*	*
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
3	Is there any procedure, technique, tool etc. available to help you make decisions / select the project proposals?	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
4	Is the decision-making process more judgmental or rational?	*	*	*	*	*	*	*	*	V	*	*	*	*	*	*	*	*	*	*	*
5	How effective is the current decision-making process?	V			V	V	V		V												
6	What are the weaknesses of government decision making?		V					V	V	V	V				V		V	*		V	
B	**Criteria in infrastructure project selection and prioritisation**																				
7	What are the criteria for selecting and prioritising infrastructure projects?	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
8	Is there a methodical approach to using these criteria? / How do you assess these criteria?	V	V	V	V	V	V	V	V	V	V	V	V		V	V		V	V	V	V
C	**Factors influencing infrastructure project selection decision-making process**																				
9	What are the factors influencing the decision-making process for infrastructure project selection?	V	V		V			V		V					V	V	V		V		V

D	**Challenges in infrastructure project planning and selection**																				
10	What are the challenges in the decision-making process of infrastructure project selection?	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**
11	How do these challenges affect the decision-making process? / Can you provide cases?	**V**	**V**	**V**	**V**	**V**	**V**		**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**
12	What are the solutions? / How do you deal with the challenges?	**V**	**V**	**V**	**V**	**V**	**V**		**V**	**V**	**V**	**V**	**V**		**V**	**V**	**V**	**V**	**V**	**V**	*
13	How does the politics influence the selection process? / What is the best way to measure political criteria?	**V**	**V**	**V**		**V**		**V**	**V**	**V**	**V**		**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?		**V**		**V**	**V**	**V**		**V**		**V**	**V**			**V**	**V**			**V**	**V**	**V**
E	**Considerations of expected Decision-Making Framework (DMF)**																				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	**V**	**V**		**V**			**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**			*	**V**	**V**	**V**
16	Is it important to have a DMF for infrastructure project selection in Indonesia?	**V**	*					**V**		**V**	*	*	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**
17	What are the features that must be available in the DMF?	**V**			**V**			**V**		**V**		**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**
18	Is an audit process required? / Transparent process?	**V**			**V**	**V**		**V**		**V**			**V**		**V**	**V**		**V**		*	*
19	What are the consequences of having no DMF?									**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**		**V**

20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	**V**				**V**	**V**	*	*	*	**V**	**V**	**V**	**V**	**V**	**V**	*	**V**	**V**	**V**

Note: (*) inferred from the respondent's response

5.4 Findings

In this study, interviews were used to investigate the current practices, issues and challenges faced by decision makers during the selection and prioritisation process of infrastructure projects. The analysis of the interview data is qualitative (Galvin 2015) so it really depends on the researcher's ability to analyse the available data. In this study, the interview data analysis used thematic coding analysis which emphasised the coding aspect of the available data to identify patterns or relationships explicitly or implicitly (Hansen 2020). By utilising NVivo 12 Pro as a software for coding analysis, this study has identified six findings which highlight the responses of the expert interviewees. The grouping of these findings may differ from the grouping of interview questions that were developed during the interview design stage. In general, the grouping of interview questions is based on literature review, while the grouping of interview findings is the result of the analysis that has been carried out, which involves the process of familiarising and reviewing the data.

Based on the above analysis, the findings are grouped into six sections for discussion:

(1) current decision-making practices of infrastructure project selection and prioritisation process
(2) challenges in the infrastructure project selection and prioritisation process
(3) effects and solutions of the perceived challenges to infrastructure project selection and prioritisation process
(4) criteria in selecting and prioritising infrastructure projects
(5) factors influencing the decision-making process of infrastructure project selection and prioritisation
(6) issues related to the decision-making framework development for infrastructure project selection and prioritisation

Figure 5.5 was generated using NVivo 12 Pro. It shows the distribution of these six findings based on the number of coding references. The issues of ‘challenges’ (grey) has the largest scope followed by the ‘criteria’ (yellow) and ‘current practices’ (green).

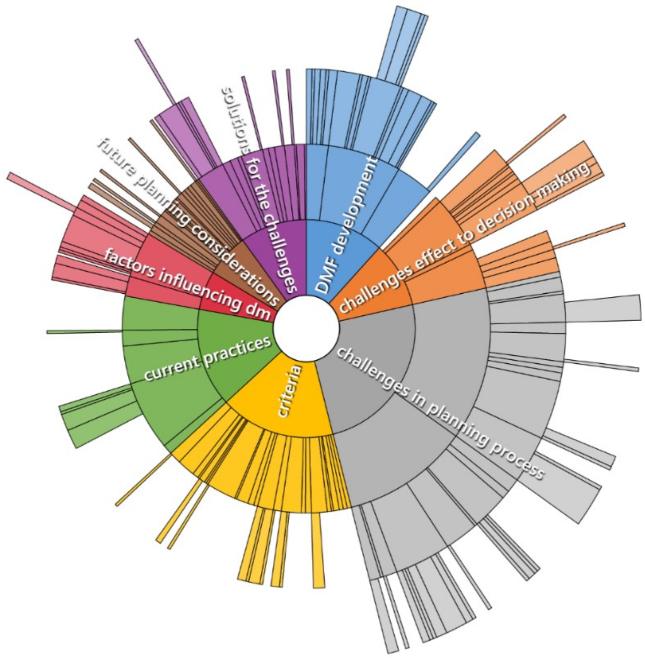


Figure 5.5 Distribution chart by number of coding references

5.4.1 Finding 1: Current Decision-Making Practices of Infrastructure Project Selection and Prioritisation Process

An investigation into the current practices of infrastructure project FEP and selection process in Indonesia is necessary because there are no previous studies on the subject matter. By understanding the current practices on infrastructure project FEP and selection process, insights on the decision-making practices and selection procedures can be obtained. Therefore, the future development of the Decision-Making Framework (DMF) may address these issues and challenges arising from the current practices as well.

Finding 1 focuses on how decision-making practices related to infrastructure project selection are conducted in the Indonesian context. These findings were obtained from case studies involving three different ministries in Indonesia, namely: the Ministry of National Development Planning (MNDP), the Ministry of Public Works & Housing (MPWH) and the Ministry of Transportation (MT). These three ministries are mainly responsible with infrastructure planning and development.

Infrastructure project selection is part of the development planning conducted across ministries and institutions. It starts with the national level planning conducted by MNDP, one of the government organisations that serves as a planning agency at the national level. It has four roles, namely: (1) to formulate policies and decision making, (2) to function as a think-tank institution, (3) to function as a coordinator agency and (4) to function as an administrator for national development planning (as stipulated in the MNDP Regulation Number 2 of 2017 concerning Strategic Plan of the MNDP of 2015-2019).

As a think-tank institution, MNDP is in charge of developing short-term, medium-term and long-term development plans. To do this, it has employed many experts from various disciplines and sectors including the economic and social development, healthcare and education, and construction and infrastructure sectors. In doing so, MNDP refers to the National Development Planning System (*Sistem Perencanaan Pembangunan Nasional*) as invoked by the Indonesian Law No. 25 of 2004 concerning National Development Planning System. According to article 1(3) of the law, it is a unit of development planning procedures that produces long-term, medium-term and annual development plans to be carried out by state and community administrators at the central and regional levels. In this instance, long-term planning refers to planning for a period of 20 years, while medium-term planning is for a period of five years and annual development planning denotes short-term planning. Figure 5.6 illustrates the Indonesian development planning hierarchy at the national, ministerial and regional levels.

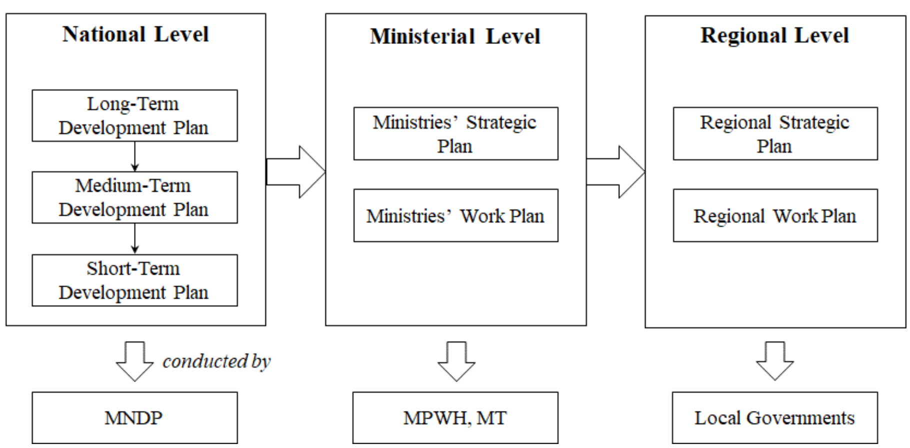


Figure 5.6 Development infrastructure planning hierarchy in Indonesia

Here, it needs to be highlighted that the focus of MNDP planning is strategic projects that will become national priorities. As described by R-12, there is a procedure for selecting priority infrastructure projects as stipulated in the MNDP regulations:

> *Overall the management of priority projects is regulated in the MNDP Regulation Number 13 of 2018 concerning procedure for managing priority projects. In this regulation there are a number of things related to the scope, criteria for priority projects, priority output, preparation of priority projects, elaboration, proposal, preparation, delivery, assessment, determination and so on.*

Meanwhile at the ministerial level, many infrastructure development plans are carried out by relevant ministries, namely: MPWH and MT. According to the Presidential Decree of the Republic of Indonesia No. 15 of 2015 concerning the Ministry of Public Works and Housing article 2, MPWH has the task of organising government affairs in the field of public works and housing. The main function of this ministry is to formulate, stipulate and implement policies in the field of water resources management, road management, housing provision and development of residential areas, housing finance, building arrangement, drinking water supply systems, waste water management and environmental drainage and solid waste systems, and construction services development (article 3(a)). Thus, it is clear that the main responsibility for infrastructure development in Indonesia is held by MPWH. It is one of the strategic ministries that received a substantial national budget allocation of 112.07 trillion rupiah for 2018.

Regarding MPWH's current practice in selecting and prioritising infrastructure project proposals, interviews with officials at the *Badan Perencanaan Infrastruktur Wilayah* (BPIW or Regional Infrastructure Planning Agency) have been conducted. BPIW was established in 2015 as an innovation in the area of regional development-based planning and programming. Before the establishment of BPIW, the planning and programming functions of MPWH were carried out through coordination between work units in each organisational unit of MPWH. The birth of BPIW is actually a response intended to integrate infrastructure and regional development. One of the respondents, R-5 confessed:

> *This is an experimental institution actually. So, it is an institution based on needs.*

Although it is a newly-established institution, it has an important role in selecting and prioritising infrastructure projects that will be carried out by MPWH. In doing this, BPIW has established four centres as explained by R-4:

So, we have 4 centres and 1 secretariat to manage the administration, staffs etc. We have 4 centres.

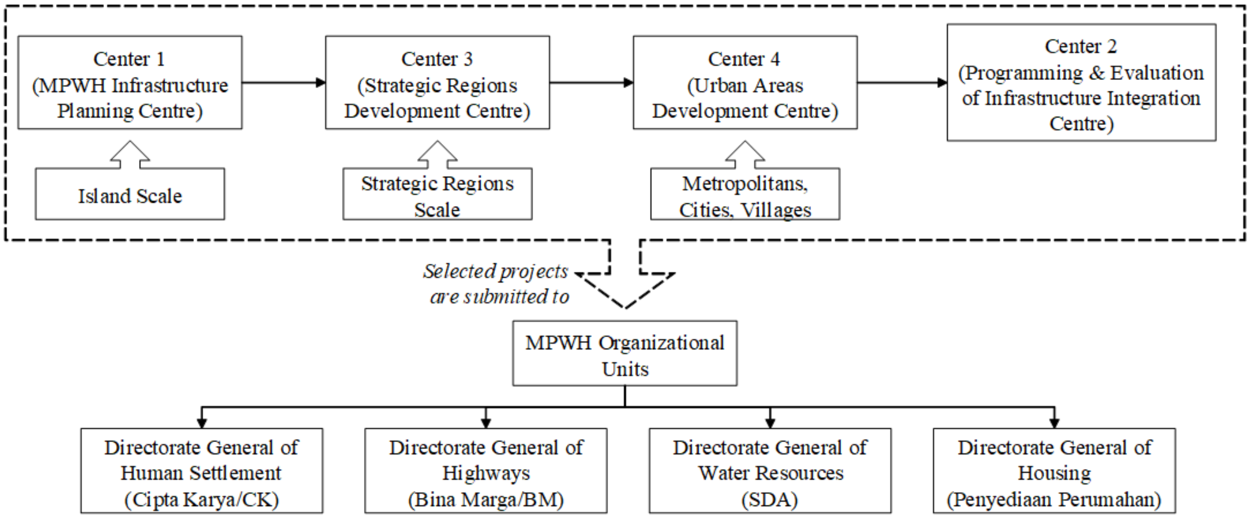


Figure 5.7 BPIW's planning process

To facilitate understanding of BPIW's process, Figure 5.7 was developed based on the information provided by the respondents. By implementing the process described above, MPWH seeks to carry out its planning role by selecting and prioritising infrastructure project proposals based on regions. Regional-based integration is carried out as an effort to ensure programming efficiency and integration of infrastructure in order to improve the national quality of life, food and energy security. Thus, it is expected that through this process, an appropriate and valid decision on infrastructure project selection can be obtained. R-8 mentioned:

This may be the most valid (process) given or made into a collective agreement and on the basis of real considerations. In the past it wasn't like this. So, it was more (based on) sense and feeling, which one is the priority and which one is not.

In addition to MPWH, there is another ministry related to infrastructure development that specifically handles transportation affairs in Indonesia. The Ministry of Transportation's (MT) main function is to develop, establish and execute transportation-related policies. It focuses on all transportation infrastructure (excluding what are managed by MPWH), including land, sea, air and rail transportation. Thus, it has four directorate generals: directorate general of land transportation, directorate general of sea transportation, directorate general of civil aviation and directorate general of railways.

According to the respondents, the process of selecting and prioritising infrastructure projects in MT is based on the strategic plans set by the ministry. R-20 explained the process:

> *Actually, all planning comes from the strategic plans, 'renstra'. From there it will be derived, becomes plans at the directorate level.*

In practice, the transportation development planning in MT is very closely related to other supporting infrastructure development undertaken by MPWH. Therefore, coordination between these two ministries is very important to ensure the integration of development that brings maximum benefits to the development of the region. This is also reflected in the Presidential Decree No. 40 of 2015 concerning Ministry of Transportation, article 37 which states:

> *Every element in the Ministry of Transportation in carrying out its duties must apply the principle of coordination, integration and synchronisation both within the Ministry of Transportation and relations between the government agencies in central and regions.*

While MPWH deals with various infrastructure development in Indonesia, MT focuses on transportation programs. In practice, both ministries often carry out *musrenbang* (*musyawarah perencanaan pembangunan* or planning development forums) to gather input for national, ministerial and regional infrastructure development plans. These forums are held at various levels from the central, provincial and district to sub-district. The idea is to get input related to the development of infrastructure from the bottom and to synchronise development plans across stakeholders.

From the above case studies, six approaches to the decision-making process related to infrastructure project selection and prioritisation in Indonesia could be extracted, i.e. political, technocratic, participatory, deliberative, top-down and bottom-up (Figure 5.8).

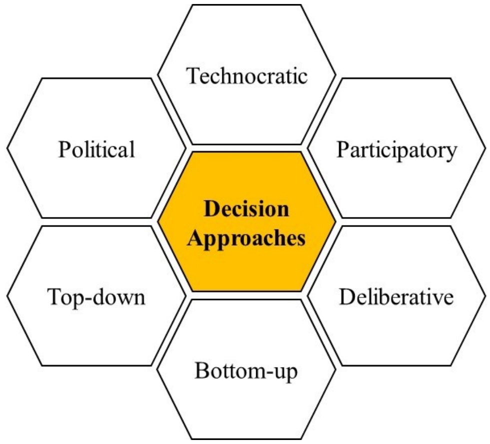


Figure 5.8 Decision approaches for infrastructure development plans

The political approach refers to decision-making related to infrastructure development planning that is based on political agendas. These agendas are sourced from the president and other political elites who have authority in the development policy in Indonesia. For example, *Nawa Cita* is the current president's vision and mission. The technocratic approach refers to decision making related to infrastructure planning based on technical data generated from scientific methods. In contrast to the political approach, it is more rigid due to the fact that it is based on many technical considerations.

The participatory approach refers to infrastructure planning decision making that empowers groups or stakeholders to make decisions. It may involve people from the executive, legislature, judiciary, society and private sectors. On the other hand, the deliberative approach refers to a decision-making process through joint assessment between participants. It emphasises the assessment and argumentation processes (possibly in terms of pros and cons) between participants on a number of alternatives.

The top-down and bottom-up approaches refer to the direction of the hierarchical approach in decision making related to infrastructure development planning. The top-down approach occurs when the top decision makers make decisions to disseminate to the lower level within their authority. In contrast, the bottom-up approach emphasises the importance of the grassroot level workers in making joint decisions. This is due to the fact that they are the ones who know exactly what is being faced and what is needed.

These six decision approaches are seen in the responses of the respondents. Although each can stand alone, in reality, decision makers in the relevant ministries often make an effort to combine the implementation of these approaches. For instance, the *musrenbang* is a discussion forum that forms part of the process of selecting and prioritising infrastructure projects in Indonesia. It involves various stakeholders (participatory), by assessing various considerations (deliberative) and is delivered mainly by grassroot level workers (bottom-up).

Table 5.5 provides a comparison of these six decision-making approaches. It is divided into six comparison items, i.e. focus, adaptability, basis, relationship, politicisation and inclusiveness. Focus refers to the approach's main point or essence that becomes the central quality. Adaptability refers to the decision's ability to be changed. Basis refers to the main focus or consideration in decision making. Relationship refers to the type of relationship that occurs during the decision-making process. Politicisation refers to the level of politicisation of the approach, while inclusiveness refers to the level of inclusion that involves people who might otherwise be excluded from the decision-making process.

Table 5.5 Comparison of six decision approaches

Topic	Political	Technocratic	Participatory	Deliberative	Top-down	Bottom-up
Focus	Politics	Technical	Participation	Deliberation	Hierarchy	Hierarchy
Adaptability	Flexible	Rigid	Flexible	Flexible	Rigid	Mid
Basis	Interest	Data	Collective agreement	Thoughtful agreement	Autocratic	Democratic
Relationship	Competitive	Competitive	Cooperative	Cooperative	Directive	Inclusive
Politicisation	High	Low	Mid	Mid	High	Low
Inclusiveness	Weak	Weak	Strong	Mid	Weak	Strong

In relation to the overall decision-making process, the respondents agreed that they implemented a rational decision-making process rather than a judgmental or intuitive one. This means that in the decision-making process, they tend to rely on logic, objectivity and formal techniques in analysing data and consideration of various alternatives. They also gave some examples of formal techniques that they had done, including alternative comparison, prioritisation based on a readiness criteria checklist and cost-benefit analysis. In addition to these techniques, the respondents also shared that they always refer to official documents, procedures and regulations when making decisions to select infrastructure project proposals. These documents, procedures and regulations can be in the form of masterplans, development plans, ministry regulations, etc.

According to the respondents, there are several important points that become the basis of good decision-making practice, namely:

(1) in the decision-making process, goals and objectives must be clearly identified
(2) decision making must consider risks and uncertainties
(3) decision making must be based on appropriate data and technical considerations

In the decision-making process, it is important to know why someone makes decisions; that is what the goals and objectives are. In the context of selecting infrastructure project proposals, decision making is not just about selection, but also about producing a list of priority projects to be implemented. Here, selection is related to the sorting process while prioritisation is related to the goals and objectives to be achieved. Prioritisation must be carried out by considering the budget constraints and urgency factors in implementing infrastructure projects in Indonesia. This notion was echoed by R-9 who said:

> *First, decision is basically about prioritisation of activities or interests. ... This means that in every decision-making, there are many parties involved. ...*

Besides knowing the goals and objectives of decision making, the second aspect that needs to be considered for good decision-making practice is to consider any risks and consequences that may exist. According to R-15:

> *In general, we consider what are the possible risks when we make a decision. Then we look at the urgency.*

Similarly, R-9 said that:

> *Every decision we make will certainly have risks, consequences.*

These risks can be identified by conducting a risk analysis. This is a process of managing any risks that can hinder the achievement of strategic goals. In the context of selecting and prioritising infrastructure project proposals, there are at least two reasons for conducting a risk analysis, namely:

(1) to identify and anticipate possible problems
(2) to decide whether or not to move forward with the projects

Finally, according to the respondents, good decision-making practice must be based on data. Data are sets of facts obtained from observations or measurements. Data that have been analysed becomes information that is useful in making decisions. Therefore, the adequacy of data is important for decision makers so that they can justify their considerations when making decisions. Data insufficiency can result in difficulties in the decision-making process, which ultimately makes the decisions invalid and unsound. R-14 illustrated the importance of having sufficient data as a basis for technical considerations when making decisions:

> *If I want to make decisions, it will be based on technical considerations, based on data. … At the planning stage, for the decision making, first we will look at the data completely.*

The analysis also found several flaws that have occurred within current decision-making practices. Some respondents admitted that there are indeed flaws that could clearly be found in the process of selecting and prioritising infrastructure projects in Indonesia. These flaws include: (1) open cycle planning system, (2) no good selection tool/system, (3) lack of support and (4) lack of integration. By identifying these flaws, it is expected that improvements can be made in the future.

R-2 said that the existing current system still has an open cycle:

> *At BPIW, no. I say it bravely. We are still learning. Here at the planning, I have .. I regret that there is an open cycle here. … Just planning but never being executed. When will it be executed? … And there is no feedback. The cycle is not closed. There has never been a monitoring & evaluation. When it's failed, when it's wrong, no. Right now, our cycle is open. … The cycle is not closed. It should be closed.*

The occurrence of this flaw is understandable since the selection and prioritisation process is still under development in Indonesia. R-2 and R-4 acknowledged that they are still in the stage of developing a good selection system. R-4 said:

> *We are still developing it. What is it actually we called as integrated indicators? How can it be said as integrated regions? … Now, we are still exercising these indicators.*

On the other hand, BPIW as the main planning institution for MPWH infrastructure project is a recently-established institution formed in 2015. As a fairly new institution, BPIW faces some obstacles especially from the internal MPWH organisation itself. R-2 said:

> *They look at BPIW as a troublesome division, no result. Just complementary, not as a reference.*

This reflects the prejudice that BPIW is not really needed since each MPWH organisational unit has its own planning bureau. For this reason, BPIW must ensure that they can provide maximum planning outputs and show the other organisational units that results based on integrated planning will provide maximum impacts on development in Indonesia.

Another identified flaw is related to the integration of all key stakeholders in the selection and prioritisation process. In Indonesia, the process of selecting and prioritising infrastructure projects is not only carried out at the inter-ministerial level (in its role as an executive body), but also involves the People's Representative Council/DPR (as a legislative body). Here, DPR can submit a list of projects. This has resulted in increasingly limited budgets that should have been intended for projects that have actually been selected at the ministerial level. R-5 complained:

> *Well, we are rather miss there. We already have technocratic. Actually, the selection results, not the BPIW selection anymore. It has become a Ministry selection. The regional consultations have already been done there. The list appears. That is brought to the People's Representatives. And the Representatives can have a list of programs too, right? That's what we usually have troubled controlling there.*

Due to this kind of intervention, the project selection and prioritisation process is not optimal. Selected projects that have met the criteria and should have been well integrated with each other, can fail to provide their optimal impacts because several selected projects were excluded from the list.

To sum up, knowledge of current decision-making practices will be useful as insights that help in developing appropriate and contextual DMF. Here, an overview of decision-making practices from three different ministries as case studies have been provided. Gaining insights from these cases is important to demonstrate what is needed to make this process work correctly, including knowing the flaws that exist in the current practices. Thus, it is expected that in future DMF planning, developments can be made to improve the effectiveness of the DMF for infrastructure project selection and prioritisation.

5.4.2 Finding 2: Challenges in the Infrastructure Project Selection and Prioritisation Process

In practice, there are several challenges that hinder the decision-making process for infrastructure project selection and prioritisation in Indonesia. These challenges occur due to several factors, including Indonesia's growing population, which means growing demands, limited financial resources and the need for improvement of the current decision-making practice. These challenges make Front End Planning (FEP) more important as the right strategy is needed to determine what we invest in and how we invest.

Finding 2 focuses on identifying 19 challenges in the FEP process, particularly during the selection and prioritisation process of infrastructure projects (Figure 5.9). Identifying challenges is important for defining the current problems that occur during the selection and prioritisation process. Doing so will lead to breakthroughs and appropriate solutions. In the context of developing a better DMF for infrastructure project selection and prioritisation, identifying challenges will increase the success of the DMF to provide appropriate and useful decisions.

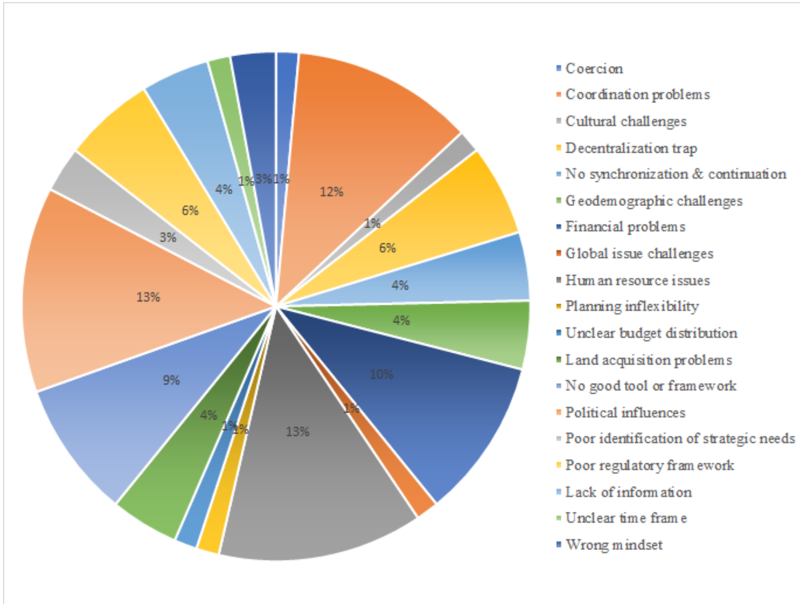


Figure 5.9 Response frequency of challenges in the infrastructure project selection process

Based on the findings revealed in Figure 5.9, issues around ‘political influences’, ‘human resource issues’ and ‘coordination problems’ are the most frequent challenges identified by respondents, followed by ‘financial problems’ and ‘the absence of standard framework or tool’. These challenges that have been obtained from the interview analysis can be grouped into six categories based on their similarities, namely: (1) planning related challenges, (2) programming related challenges, (3) resources related challenges, (4) policy and political related challenges, (5) behaviour and coordination related challenges, and (6) regulatory related challenges.

To facilitate better understanding, Figure 5.10 illustrates the six categories of challenges in infrastructure project selection and prioritisation process in Indonesia. These challenges can further be grouped into two larger classifications, namely: internal and external challenges. Internal challenges are challenges within the FEP team or organisation. When looking internally, these challenges may hinder the achievement of project goals. Meanwhile, external challenges refer to challenges that are outside the control of the FEP team or organisation. They are more difficult to predict and manage rather than internal challenges. Nevertheless, both internal and external challenges have a huge effect on project success. Therefore, identification of these challenges is an important initial step to develop a DMF.

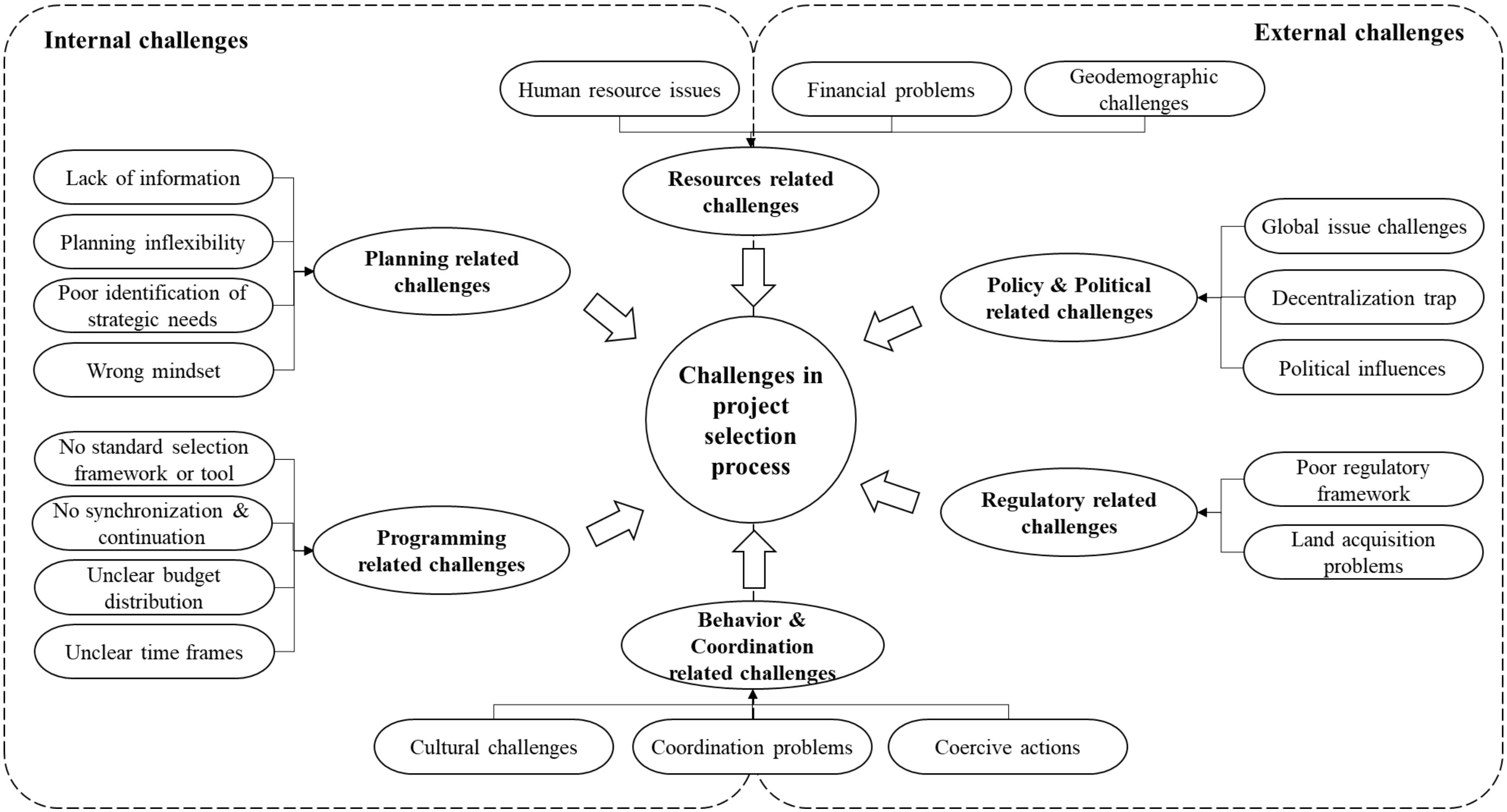


Figure 5.10 Classification of identified challenges in infrastructure project selection and prioritisation process

Planning related challenges refer to challenges that arise due to poor planning practice in the process of selecting and prioritising infrastructure projects in Indonesia. These include planning inflexibility, poor identification of strategic needs, lack of information and wrong mindset. Planning inflexibility refers to the inability to change or adapt during the planning process. This inability occurs internally within the organisation. R-14 stated:

> *Those things sometimes take a long time. Sometimes, we cannot be flexible, internally.*

With the increasing number of project proposals and the demand to work fast, there is a need for a certain level of flexibility so that the existing procedure can be performed without being limited by rigidity.

Another challenge relates to poor identification of strategic needs which leads to inappropriate budget allocation. In other words, the government is working on a project that is actually less strategically necessary or required. This was illustrated by R-4 who provided an actual project case:

> *So, for example in West Java, at Cimahi, there is a flat build for ASN (civil servants). The mechanism was it is built by the government, then will be transferred to the local government to become their assets. Later it will be managed by the local government. But it is stalled. No body want to stay there.*
>
> *It's finished already. That becomes a problem as well. So, we have spent a lot of expense but no…. So that's because miss the target actually. …. Then actually at the beginning whether they had already calculated appropriately that the community need that. Perhaps the demand is not that. So, at the end it becomes neglected.*

This can occur due to several things. One of them is a lack of sufficient information during the project selection and prioritisation process. If the data or information available are incorrect or insufficient, this can lead to an incorrect analysis of the project requirements. R-12 confirmed this:

> *The first one is lack of information. In determining problem on a national scale, very or quite comprehensive data or information is needed to determine which problems are prioritised to be resolved immediately. These include data about the deficiency / things that*

> *caused the problem to arise. .... If the data or information is wrong or lacking, the achievement of national priorities will not be achieved or deviated from the target.*

This lack of actual information can happen due to the fact that the planning team whose task it is to select and prioritise infrastructure project proposals, does not really know the actual conditions on the site. This was conveyed by R-3 who works at BPIW. He explained:

> *The problem is that in BPIW, we don't know the field.*

A crucial challenge presented by two respondents is related to the wrong mindset problem. Typically, the approach adopted by the Indonesian ministries focuses on funding and spending the budget. Whereas according to R-10, focus should be given to effective planning. He said:

> *Whereas for us, we are very difficult with continuity. That's why in my opinion, our milestones are not based on the plans, just based on how this project can run and the budget is available for the following year. The milestone is focused on financing, and not on the planning.*

This results in inappropriate planning and budget allocation, which ultimately leads to waste of public funds. Generally, a ministry's performance is measured by how much budget absorption has been carried out by the ministry. This causes the ministry to compete in spending their budget for projects, even though these projects often later need to be re-reviewed. Thus, R-2 emphasised the importance of focusing on value for money rather than just spending the available budget.

The second category is programming related challenges. Here, programming is defined as the development process of the actual programs or projects with the aim of achieving the result of selection and prioritisation. Therefore, if planning is context-based, programming is more technical-based where project proposals have entered the selection process. Programming related challenges include the absence of a standard selection framework or tool, the absence of program synchronisation and continuation, unclear time frames and unclear budget distribution.

The unavailability of a good tool or framework for selecting and prioritising infrastructure projects is one of the challenges that many respondents mentioned. Currently, there are a variety of procedures, techniques and methods used by each ministry and organisational unit, but there is no single integrated framework or tool that specifically manages the process of selecting and prioritising infrastructure projects in Indonesia. This was conveyed by R-16, who acknowledged:

> *But I think there is none. We only have SOP. There are standard procedures. But from what I see, none. ... There is no such framework.*

According to R-18, each ministry and directorate general has different fragmented techniques and methods for selecting projects. She mentioned:

> *Yes, there is no legal standard. It just exists at each directorate.*

For example, the 'readiness criteria' are well known at MPWH. Readiness criteria are criteria used to assess the level of project readiness before asking for funding. These criteria cover four aspects: feasibility study, design principles, environmental documents and land acquisition. To assess the readiness, they use a checklist to determine whether the documents for these aspects are available.

With a variety of techniques and methods being applied by the existing organisation units, certainly the process of infrastructure project selection and prioritisation becomes difficult. This is particularly crucial given the possibility that a project proposal change may occur during the selection process. This happens because there is no integrated tool or framework that will oversee the whole selection process. R-3 noted:

> *So, the problem is when we are compiling, their proposals may not be the same with the previous discussions.*

Similar issues were perceived by the respondent from MT. R-11 argues that MNDP as a think-tank institution for national development planning in Indonesia should issue guidelines and technical details for selecting and prioritising infrastructure projects in Indonesia. However, no such guide, tool or framework has been issued, making it challenging for professionals to undertake the selection with consistency.

Furthermore, poor programming is also seen in the absence of program synchronisation and continuation. Here, synchronisation refers to the integration of planning from various programs or projects, while continuation means the planning continuity of programs or projects. R-10 explained:

> *The challenge perhaps we have to choose, so that the available funding can be maximal, but also we can make milestones for the coming years. Don't let it become disconnected.*

R-4 agrees, highlighting:

> *Also, the problem of program synchronisation.*

The absence of clear time frames in the selection and prioritisation process of infrastructure projects is also one of the programming related challenges presented by the respondents. Currently, there is no clear time frame provided related to the deadline for submitting project proposals, how long it will take for each stage of the selection and prioritisation process, when the evaluation results are announced, etc. All of these must be clear and structured so that the programming process can be carried out on time. As R-17 conveyed:

> *Second challenge is about time frame problem.*

R-3 also complained about poor programming practice related to unclear budget allocation and distribution. In the current practice, it is normal that the obtained budget is shared with each organisational unit, e.g. directorate general, and then they will again allocate the funds without clear considerations. He described this as follows:

> *Whereas when the budget comes from the planning bureau, from the planning bureau goes to each directorate general, they determine by themselves, which province can get this much, just like that. So, it's like sharing the cakes.*

The third category is resources related challenges that refer to the challenges arise due to obstacles related to infrastructure project resources. These include three major challenges, namely: financial problems, human resource issues and geodemographic challenges. Each has several sub-challenges that affect the process of selecting and prioritising infrastructure projects.

Financial problems are a challenge that is often conveyed by respondents. It includes at least three aspects, namely: the limited budget, the allocation of funds and funding sources. The Indonesian government realises that infrastructure is the key to development in Indonesia. However, its limited budget is an obstacle to infrastructure development. Even though Indonesia is the largest economy in Southeast Asia, the budget structure needs to be allocated to many sectors. With the increasing numbers of infrastructure project proposals being submitted each year, the limited budget problem becomes a crucial factor in the process of project selection and prioritisation. Thus, allocation of funds must be done through careful consideration. The submitted project proposals must go through a selection mechanism to obtain project decisions in accordance with the nation's strategic needs. These selected projects will receive priority funding allocation. R-3 affirms these concerns, saying:

> *Now, our problem actually is the funding. ... But yes, the common obstacle is because the limited budget.*

Another problem relates to access to funding. The massive infrastructure need certainly requires a large amount of funds. Most infrastructure development is funded by the government through the national budget allocation. This is certainly not enough and thus, the government has been trying to promote other alternative funding sources, especially from the private sector and State-Owned Enterprises (SOEs). R-4 said:

> *Of course, the challenge related to funding is quite difficult for me. What is the source of funding? That's a challenge.*

Several respondents mentioned issues related to human resources as a challenge in the process of planning and selecting infrastructure projects in Indonesia. In planning and selecting infrastructure project proposals, reliable and capable human resources are required. But since the establishment of regional autonomy, with the transfer of power and authority to the local governments (decentralisation), there have been problems related to differences in human resources capability between the central and local governments. This was conveyed by R-13:

> *The diverse capabilities of human resources both in central and local government has made many projects become difficult to compare to be fairly selected.*

R-10 suggested similar concern that civil servants (especially in local governments) often have limited technical capability to identify, generate and interpret their data and needs. He said:

> *Sometimes it is too political to place people who don't have sufficient capacity or capability in the planning process. That's our role to help them identify their real needs. The challenge is more on that. We have to assist them.*

In addition, this human resource problem also refers to the limited number of human resources available. This occurs due to the limited ministry budget for hiring civil servants. R-6 acknowledged that:

> *Because we have limited space, this means that human resources sitting here cannot be too much.*

As for the option to recruit expert consultants who will assist in the planning and selection process, this is also constrained by the limited budget. As a result, there may be bargaining for contracts which can decrease the quality of work provided. This was conveyed by R-11:

> *The challenges in government is that our number is very limited. Then the expert consultants are also very limited, meaning that there are some good consultants, but is the government budget enough to hire them. So many of these studies done by consultants that don't really understand these variables. That's what I meant by challenges.*

The limited budget also can affect worker's morale and motivation. For instance, this issue can relate to income inequality. It can be a huge disparity in civil servants' salaries on some work structures. When civil servants are assigned to unfavourable work units, it may cause a decrease in their morale and motivation.

Another challenge presented by the respondents was work intensification (demand to work hard quickly). R-14 expressed:

> *Internal in the sense that we are sometimes asked to move quickly, to execute these programs [quickly].*

This happens due to three factors. First, infrastructure development targets have been increased from the previous period. Under President Jokowi's leadership, Indonesia gives a lot focus to the growth of infrastructure development in all regions. Second, there are limited human resources in the ministries. The addition of capable human resources has not matched the increasing number of projects that must be planned, selected and executed. Thus, it causes demand for existing employees to work harder and faster in completing their tasks. Third, there has been increased ordering of directive projects, which must be planned and executed immediately.

Finally, a fast job rotation can also be an obstacle to managing human resources. The planning and selection process of infrastructure projects requires skilled people who are familiar with the work. But fast job rotation may cause them to move to another department or work unit and start over again. R-11 explained:

> *Another challenge is that we always get staff rotation.*

Meanwhile, the geodemographic challenges refer to Indonesia's large population and vast area. While both of these can be seen as Indonesia's natural resources, they can also be seen as obstacles in infrastructure development. Indonesia is the fourth most populous country in the world with an estimated 264 million people in 2017. The need for infrastructure to improve the welfare of this massive population poses a challenge. R-10 said:

> *Because the need is massive, infrastructure [need] in Indonesia is very large.*

On the other hand, Indonesia is the largest archipelago in the world, with a vast maritime area. This also means that Indonesia has a lot of disconnected land masses, which poses a challenge in the development of land infrastructure. This is coupled with Indonesia's geographical conditions, being flanked by two oceans and two continents in the Ring of Fire. This condition is both a gift and a challenge because of the many potential disasters that may occur in Indonesia, such as earthquakes, tsunamis, volcano eruptions and tornadoes. Affected areas certainly need rapid post-disaster recovery, including the recovery of basic and supporting infrastructure. R-8 explained:

> *Our big challenges are three things. The first, demographic and geographic factors.* …

The fourth category is policy and political related challenges. It refers to the challenges arising from the direction of government policy as well as political influences in the process of infrastructure project selection and prioritisation. These include the decentralisation trap, global issue challenges and political influences.

Decentralisation is the transfer of authority from the central government to the local or regional governments. Decentralisation in Indonesia began in 1999 with the enactment of regional autonomy through Law Number 22 of 1999 concerning Local Governments. This transition provides greater authority, political power and financial resources to the local governments. One of these powers transferred is related to the infrastructure development sector. R-10 stated:

> *Because since autonomy, there is an authority division between the central and local governments.*

Although it aims to improve people's welfare by development of a region through its local government capitalising on the region's potential and resources, the transition of power from the previous centralised government system to local governments has several weaknesses. These are often referred to as decentralisation traps. According to R-5, this happened because of the unpreparedness of the previous government when deciding to implement decentralisation. These decentralisation traps can be seen in two aspects. First, the lack of local government capacity and financial resources for planning and development. Second, the lack of trained human resources required in the planning and development process. This means that some local governments are not yet ready to take the power in developing their own regions.

In its relation to the planning and selection of infrastructure projects, this has an impact on the complexity of power between the central and local governments. Specifically, for CK (human settlement) and housing infrastructure projects, there is a division of power between the central government and local governments whereby the local governments must provide and prepare the lands for development. Problem arises when in project planning and selection, the land that is designated for the project is not yet available. On the other hand, the central government cannot provide land acquisition because that is the authority of local government. This certainly has an impact on the execution delay of projects that have been planned and selected by the ministry.

One of the respondents, R-8 stated that global issues have been a challenge in the selection and prioritisation process of infrastructure projects in Indonesia. Global issues are adverse issues that can affect global communities, including Indonesia. R-8 continues:

> *Our big challenges are 3 things. ... The third is global factors. ... The rise of oil and gas prices, this dollar must be influential. That's the challenge.*

Even though the Indonesian economy grows at a steady rate of around 5%, Indonesia is experiencing a couple of global issues. These issues include the US-China Trade War and the fragile rupiah. The US and China are the two largest trading partners for Indonesia. The trade war between them has cause global economic uncertainty that can affect Indonesia's economic growth. On the other hand, the Indonesian rupiah has been long subject to inflation. Thus, the effect of global inflation can contribute to depreciation of the rupiah.

According to the respondents, politics have a big influence on the process of planning and selecting infrastructure projects in Indonesia. It was the most frequent challenge expressed by the respondents. One of them, R-15, acknowledged this by saying:

> *More on politics. So, for Indonesia, when we change the leader, sometimes the policies will change too.*

This political pressure not only comes from the government governed by the president. There are also several elite political actors who can influence the process of selecting and prioritising infrastructure projects in Indonesia, namely: the president, the ministers, the local/regional leaders and the House of Representative (DPR). The Indonesian president is still the most powerful political actor. Meanwhile, the ministers are the president's aides in carrying out his duties. Ministers who lead ministries related to infrastructure development (such as MPWH and MT) can also provide instructions to their staff.

In addition, there are also members of DPR who can propose new infrastructure projects during budgeting discussions. As a result of constitutional reform in early 2000, DPR has more power in law-making and budget approval. According to R-5, the selected projects can be partially rejected by DPR. He stated:

> *The ineffective one is that once it enters this post-technocratic process, we also cannot control it anymore.*

These politically nuance projects are often called directive projects. They must be carried out by the relevant ministries as executors. The existence of directive projects is quite complicated, for three main reasons:

(1) they are not put through a correct and appropriate selection process, so they are not known for their need analysis, benefit analysis, level of readiness and integration with other infrastructure
(2) they are usually initiated suddenly and must be carried out in a short time
(3) they become a priority so that the budget allocated for selected projects has to be slashed

R-2 clearly stated:

What bothered is this, since we are dealing with directive.

In addition to directive projects, political pressure can also occur in the case of choosing human resources. Here, politics may influence the placement of some human resources in strategic positions such as planning officers. As a result, those who use political power to be placed in this position may not have sufficient capability to carry out their duties and responsibilities. This was conveyed by R-10:

Sometimes it is too political to place people who don't have sufficient capacity or capability in the planning process.

Similarly, R-9 explained this political pressure problem at length. He argues that it is still rather difficult for Indonesia to put aside the role of politics in the infrastructure development process.

The fifth category is behaviour and coordination related challenges. This refers to challenges stemming from poor behaviour and coordination during the process of selecting and prioritising infrastructure projects. These include coercive actions, cultural challenges, and coordination problems such as sectoral ego, stakeholder's intervention, community reluctance and lack of private sector involvement.

Coercion is the practice of forcing others to behave as desired by using threats, intimidation or other forms of force. It is identified as one of the challenges in the process of selecting and prioritising infrastructure projects in Indonesia. One of the respondents, R-20 stated:

The challenges are, for example in infrastructure selection, the work units, we are at the planning, but the work units always insist that their projects are important. Yes, coercion!

It is evident that organisational units (such as BM and CK in MPWH, or land and sea directorates in MT) can act coercively to influence those (decision makers) whose job it is to select and prioritise infrastructure projects. They can threaten not to carry out the selected projects. This is also related to the cultural challenges in Indonesia such as a reluctance to say 'no'.

As a multi-ethnic country, Indonesia faces various differences in norms, values and culture. For that reason, it is important for Indonesian people to promote unity and harmony in their daily lives. This contributes to the formation of cultural values in society. Some dilemmas may arise due to the spirit of collectivism. For instance, it is common in Indonesia to take a more personal or informal approach in establishing business relationships. Another example was reflected in the statement of R-17:

Because as you know, we are Indonesians. We have the Indonesian culture. We talk about professionalism, but when we know it is our friend, there must be a dilemma. Gosh, he's my friend, he requests that. That happened in MPWH, especially in BM.

It is thus apparent that Indonesians in general also tend to find it difficult to say 'no' to their friends. This will make it difficult for decision makers when making decisions regarding infrastructure project selection when their friends (e.g. from the organisational units) ask to prioritise their proposals.

The coordination problem is another major challenge in infrastructure project selection and prioritisation process. It may occur within or outside the FEP team organisation. It involves many aspects including sectoral ego, stakeholder's intervention, community reluctance and lack of private sector involvement. R-14 acknowledged this saying:

The point is that coordination is the challenge.

Coordination problems occur as a consequence of many parties being involved in the decision-making process. As stated by R-14, the process of infrastructure project planning and selection involves many stakeholders/parties. These parties have diverse interests within an institution or ministry. For example, there are 16 different organisational units in MPWH, including SDA, BM, CK, housing and BPIW. BPIW as an infrastructure planning institution needs assistance from other units such as data input for planning integration. Thus, good coordination is needed to help the decision makers to make decisions regarding the selection of infrastructure project proposals. However, in practice there is a sectoral ego that impedes the coordination. R-4 said:

> *Not yet work optimally, I think. They just walk in sectoral, sectoral ego. That's a challenge in selection. Sectoral ego.*

Furthermore, stakeholder's intervention is also frequently mentioned by the respondents as a challenge. This can be seen from the intervention of high level officers and DRP in the process of selecting and prioritising infrastructure projects. High level officers and main supervisors can intervene in the results of project selection decided by the FEP team. The magnitude of this influence is mainly because the decision-making approach in ministries tends to be top-down. Similarly, DPR or parliament can also intervene in the process, as stated by R-17:

> *The problem is the parliament intervention. Because they also have the right in programming.*

One thing that should be highlighted is that this intervention can be exercised by people who do not necessarily understand the process of selection and prioritisation or planning integration. However, they have the authority to change the results of project selection carried out by the FEP team. As a result, the projects decided may be inappropriate. R-13 explained:

> *There are many involvements of stakeholders who have the power to intervene and determine matters while it is not in their expertise.*

Poor external coordination is manifested in community reluctance about the projects. The community is one of the most important aspects in planning public assets such as infrastructure. Unfortunately, not everyone properly understands the concept of planning and infrastructure development that will have an impact on improving the people's quality of life and increasing the economic value of a region. In fact, sometimes there can be community rejection of an infrastructure project development plan. R-18 pointed out that:

> *For instance, MWPH wants to build road, that's much easier because everyone needs roads. There is no rejection. But for sanitation-like projects, there are many rejections. Because it is deemed not important.*

Thus, community reluctance/rejection is a challenge in infrastructure project planning and selection. It can happen due to:

(1) reluctance to move to a new place
(2) deception regarding the sale and purchase of land, which leads to the reluctance of community to sell their land to the government
(3) certain types of infrastructure are not considered important by the community

Meanwhile, efforts to expand the role of the private sector in infrastructure development have been carried out by the Indonesian government. For instance, the government has established two major financial institutions that aim to promote the involvement of the private sector in infrastructure development in Indonesia. These are PT. Indonesia Infrastructure Finance (IIF) and PT. Indonesia Infrastructure Guarantee Fund (IIGF). However, these efforts have not created much interest from the private sector. This may be due to the involvement of private sector being limited to investment only. So, they are not actively involved in the planning and infrastructure development process. R-19 stated:

> *It should be further discussed, how and to what extent the private sector in infrastructure project development and management can be involved. ... For now, it is still from the government, not yet involved the private sector.*

The last category is regulatory related challenges. It includes two challenges. First, it is related to the poor regulatory framework in the planning process of infrastructure projects in Indonesia, specifically the process of infrastructure project selection and prioritisation. Second, it is related to the land acquisition problems as a result of the weak enforcement of land acquisition laws and regulations.

One of the challenges presented by the respondents is the poor regulatory framework. This can be interpreted in two ways, i.e. incomplete regulations and regulatory uncertainty. Incompleteness of regulations refers to the existing regulations lacking complete explanation regarding the procedures and mechanisms for planning and selection of infrastructure projects in details. This was recognised by R-16 who said:

> *And unfortunately, in the regulations it is not clearly explained what are the stages, what are the criteria, what are …*

In addition, incomplete regulatory also means that there is a lack of regulations related to selection and prioritisation process. One example was provided by R-5 who said it was important to have a regulation concerning the approval of infrastructure project selection and prioritisation result. He reckoned:

> *We have already made sure that it is integrated, for example this must definitely be built. But the budgeting policy says no, we switch it to others first. That's the challenge there. And we don't have regulations that can bind that commitment.*

Regulatory uncertainty includes political influence, overlapping and inconsistent regulations. Politics can affect the enforcement of regulations. This happened mainly during political transition. New political actors or leaders may have different visions and missions, so they may change the existing rules. R-1 conveyed the importance of legal certainty and law enforcement:

> *Indeed, the regulatory framework was still lacking and the legislative framework – meaning the people, the bodies, was still in a mess. But the problem is its enforcement.*

Land acquisition problems have long been a challenge in infrastructure development in Indonesia. Infrastructure projects usually require a vast amount of land and sometimes are located in strategic locations. Land acquisition problems can arise due to: (1) a lengthy negotiation process with many landowners, (2) the huge amount of land requiring substantial funds and (3) the existence of land disputes between two parties where one party occupies the land claiming to be the rightful owner and the other party has the evidence (such as a land certificate) confirming their ownership. Similarly, R-2 noted:

> *Moreover, if it is already concerning with large projects, concerning land acquisition, problematic.*

A more specific problem is experienced by several organisational units that require coordination with local governments. The Cipta Karya (human settlement) and Housing in the MPWH is one such example. Even though they have the authority to build infrastructure projects, they do not have authority in terms of land acquisition. This is because the type of infrastructure projects they build will be the assets of the local governments. So, their tasks are limited to planning and constructing the project, then transferring it to the local governments. For this reason, the local governments must provide lands and then receive assets for operation and maintenance. A problem arises when local governments cannot provide land acquisition on time so the planned project has to be postponed. R-6 affirms that:

The land acquisition is carried out by the local governments.

Despite various efforts having been made by the government to accelerate the land acquisition process such as issuing various laws and regulations, proper enforcement and implementation must be carried out so that the above land acquisition issues will not continue to be an obstacle in infrastructure development.

These challenges show the weaknesses of the current government decision-making process related to infrastructure project selection and prioritisation. The interview analysis results indicate that these weaknesses are mainly caused by the current practice being politically driven. Political influence is still considered substantial in the planning and project selection process. This is evident in the tendency to implement a top-down approach, the presence of stakeholders' intervention and directive projects. The effect of this political influence is quite significant. The implementation of projects resulted from the technocratic selection process may be prevented or postponed due to supervisor or DPR interventions. Therefore, in general, all respondents hoped that such political influence could be minimised.

5.4.3 Finding 3: Effects and Solutions of the Perceived Challenges to Infrastructure Project Selection and Prioritisation Process

While Finding 2 focuses on identifying challenges in the selection and prioritisation process of infrastructure projects in Indonesia, Finding 3 highlights the effects of and solutions for the perceived identified challenges. Recognising these effects allows us to understand the extent of the results or the consequences of the challenges faced during the process of selecting and prioritising infrastructure project proposals. Finding solutions involves discovering means by which expected to overcome the perceived challenges. In this study, effects and solutions were identified from expert respondents through interview analysis.

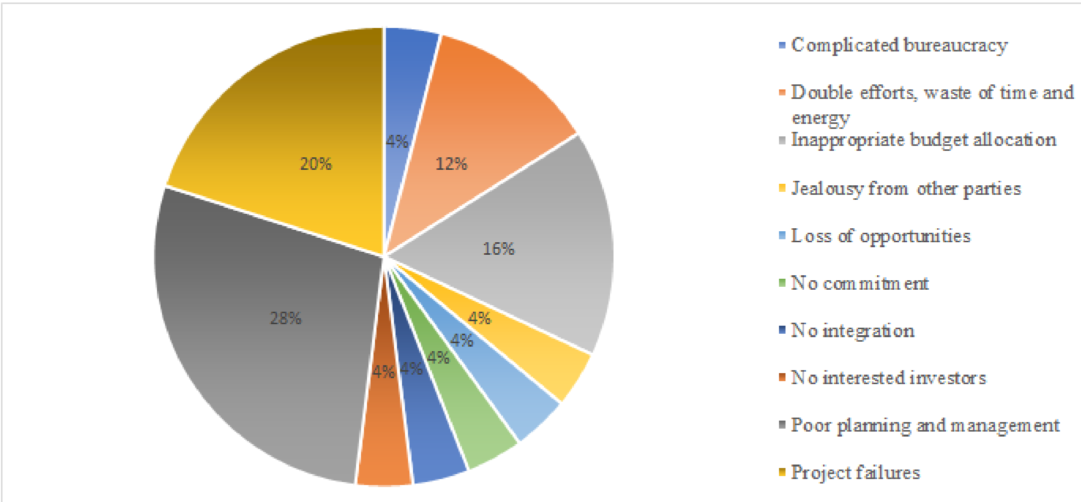


Figure 5.11 Response frequency to the effects of the perceived challenges

The first part of this section discusses the effects of the perceived challenges in infrastructure project selection and prioritisation process, as shown in Figure 5.11. A total of ten effects of the perceived challenges were obtained from the interview analysis (Figure 5.12). 'Poor planning and management' was the most frequent effect as a result of the challenges that have been delivered. These effects can further be grouped into three categories based on their similarities, namely: (1) planning related effects, (2) resources related effects and (3) behaviour and coordination related effects. Descriptions of these effects are discussed in detail as follows.

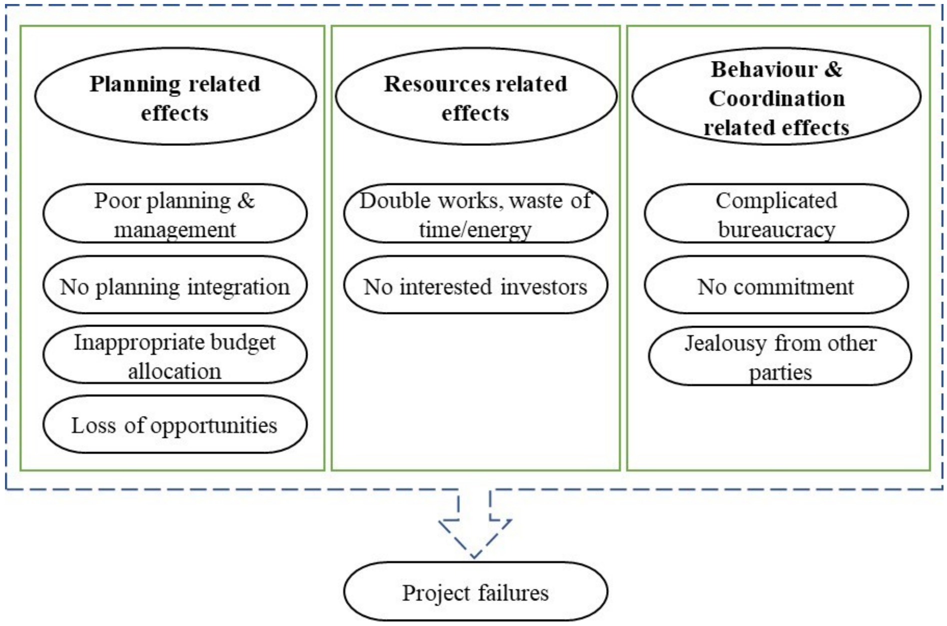


Figure 5.12 Classification of identified effects to the perceived challenges

The first category is planning related effects. This refers to effects that reflect poor planning practices during the process of selection and prioritisation of infrastructure projects. These include poor planning and management, no planning integration, inappropriate budget allocation, and loss of opportunities.

'Poor planning and management' is the most frequent effect mentioned by respondents. It happens due to several factors. First is the unavailability of standard framework or tools, thus creating unstandardised practice during the planning and selection process of infrastructure projects. This was illustrated by R-11:

> *So, when we give this to the consultants, please calculate the economic value. They don't do it in a standard way.*

Likewise, R-12 conveyed the possibility of mismanagement as a result of the absence of a framework or guidance:

> *The risk of maladministration is very high if the framework or guidance do not exist. ... As a result of the absence of this framework or guidance in selecting and prioritising infrastructure projects is that it is not clear how the process or selection of projects is, then how to prioritise it and what criteria are needed.*

The lack of a good framework or tool also contributes to the low level of transparency in the planning and selection process of infrastructure projects. R-12 explained:

> *Because without a clear framework, the selection of infrastructure projects cannot be measured clearly so that the risk of deviating from the targets is high, and it also raises suspicion in good governance practice.*

Similarly, R-9 said that transparency is needed in the process of infrastructure project selection and prioritisation because:

> *In my opinion, everything that is built must be explained to the public. Its transparency because this will convince the public that what we have built is right and on target.*

Furthermore, R-9 also explained that the unavailability of the framework has an impact on poor decision-making practice. This will lead to poor decisions being made by the FEP team or decision makers. He argued:

> *So, using the state funds or money that should be accountable only with poor decision-making. In essence, you will definitely need the framework.*

The second factor that causes poor planning and management is the presence of stakeholders' intervention whereby the decisions made in relation to the selection and prioritisation of infrastructure projects to be carried out are changed. R-20 affirms this, stating:

> *So, the development targets which have been targeted since the beginning, they may change. ...So, it is not in accordance with what have been planned.*

The presence of stakeholders' intervention is inseparable from the subjectivity problem and the political influence of the leadership actors in the planning and selection process. R-13 suggested:

> *Projects will be based on subjective considerations of those who are in power as persons to assess and decide a priority project.*

R-15 also recognised this subjectivity problem:

> *Sometimes when we want to build infrastructure, the objectivity is still lacking. It is still subjective.*

The third factor that contributes to poor planning and management is unclear time frames in the process of planning and selecting infrastructure projects. According to R-13, unclear timing in the submission proposal makes it difficult for decision makers to select proposals simultaneously. He said:

> *Project proposals may come at any time so it will be difficult to decide on which projects have higher priority than others.*

In addition to the above factors, poor planning and management can also be seen in the absence of continuity in the process of planning and selecting infrastructure projects. Unselected proposals tend to be ignored and records are not kept as to why they were not selected. This will lead to further work when assessing the same proposal in the future. A good planning and selection practices should take into account the continuity of existing project proposals. According to R-18:

> *It makes the proposals that cannot be approved this year will be forgotten without such framework. Next day, it will not be managed by them.*

Other factors that can cause poor planning and management practice may include work intensification and lack of capable human resources in completing the selection process. A planning and selection process carried out in a hurry and/or by people who are not capable will produce inappropriate decisions, which will ultimately lead to poor decisions. On the other hand, a lack of private sector involvement can also contribute to poor planning and management, although this is debatable. The private sector has only been involved as an investor and has not been actively involved in the planning, selection or construction process, so this depends on the expected type of involvement from the private sector.

Finally, the wrong mindset can also cause poor planning and management. A mindset that simply dictates spending existing funds is not appropriate to the FEP planning process and decision-making practice. In FEP, available funds must be utilised for the construction of appropriate projects. Therefore, it is important to change the mindset to focus on good FEP practice rather than merely spending the budget.

The absence of integration is one of the effects of these perceived challenges. This is mainly due to coordination problems related to the sectoral ego that exists in each organisational unit and institution. R-15 explains:

> *The subjectivity of each sector interest become prominent. So, it is not integrated for mutual benefits.*

Besides sectoral ego, the absence of integration is also apparent in terms of integration of infrastructure planning. Integrated infrastructure planning—meaning that all infrastructure projects are mutually integrated in order to increase the growth of the region—is experiencing obstacles due to Indonesia's vast demographics and geography. As the largest archipelagic country in the world, Indonesia must begin to focus on developing maritime infrastructure and to consider the integration of land and maritime infrastructure. Thus, to ensure integration of planning, a good FEP practice is needed. This can be reflected in the availability of a good DMF for the selection and prioritisation of infrastructure projects in Indonesia.

Inappropriate budget allocation is one of the most frequent effects highlighted by the respondents. One of them was R-17 who defined the inappropriate budget allocation as:

> *The money is given to the wrong place.*

This happens mainly because there is an unclear budget allocation procedure and heavy political influence during the process of planning and selecting infrastructure projects. Projects that are influenced by political pressure tend not to go through the correct planning and selection process. This will lead to poor decisions being made. R-14 provided a case that occurred in Aceh province:

> *And sometimes it is not as needed. Because there are some that were too politicised. ... Like the one in Aceh. It has a high political aspect.*

This inappropriate allocation of funds wastes money that should have been utilised for other projects that are better prepared and have gone through an effective process of selection and prioritisation. R-16 believed this was a waste of budget. Likewise, R-9 regretted this:

> *It will cause the state funds used to be not economical, not effective, and not appropriate on the target.*

Similar to the political pressure described above, inappropriate budget allocation can also occur due to coercion and stakeholders' intervention. Coercive action and stakeholder intervention (especially from top level officials) can influence the objectivity of the process of selection and prioritisation of infrastructure projects by planners. If the decision makers in charge of selecting and prioritising these infrastructure projects are not professional, then they may provide budget allocations to inappropriate projects.

Finally, issues related to human resources, especially the lack of reliable and capable human resources in planning and selecting infrastructure projects can cause inappropriate budget allocation as well. This happens because the available human resources are unable to make appropriate decisions relating to infrastructure project selection and prioritisation. This will lead to poor decisions being made regarding to budget allocation.

The loss of opportunities refers to scenarios in which more beneficial opportunities are not taken as a result of choosing another alternative. In this context, loss of opportunities occurs when the decision makers choose to implement a project that is actually less useful than a project that is not selected. Asked whether inappropriate budget allocation also means a loss of opportunity as the funds could have been used for other useful projects, R-9 agreed:

> *Correct. That's why we often hear that the Minister called it a total loss.*

This occurs because the poor identification of strategic needs and lack of information, particularly during the FEP phase. In general, FEP is a process for obtaining sufficient information for decision makers to manage risk and decide on their fund allocation to the right project. Thus, the significance of FEP is to prevent the team from wasting time, money and other resources on the wrong projects.

The second category is resources related effects, which refers to effects that arise due to resources inefficiency during the process of infrastructure project selection and prioritisation. Based on the interview analysis, the respondents mentioned two resources related effects, namely: double works/waste of resources and no interested investors.

One of the effects of these perceived challenges is double efforts or double works, which cause the FEP team's productivity potentially to decrease. This also means the loss of resources such as the time and energy of the workers that should have been utilised on other planning tasks. This phenomenon was recognised by several respondents. According to R-16, this can occur because there is no specific guideline for the process of planning and selecting infrastructure projects, so what is done by the FEP team deviate from what is required and later need to be revised. She said:

> *It just like working double the efforts. No guidance.*

Meanwhile, according to R-11, working without good guidelines can result in inappropriate planning, which eventually leads to waste of resources. He explained:

> *It is very unfortunate if for example we have invested time, money to do a study, but when it is going to be implemented, when we want to offer the project, there is no interested party. It will be a waste of time and energy.*

On the other hand, inflexibility can also lead to double efforts and waste of resources. In a rigid or inflexible organisational structure, important decisions can be delayed. This may cause loss of momentum in the right direction, causing project FEP and selection to be redone.

With limited funds available, Indonesia needs funding from investors to finance the construction of infrastructure projects. To be able to attract investors, a good planning and selection process is required so that projects submitted to investors are financially feasible. Thus, it is important to assess the feasibility of projects economically and financially in the process of selecting and prioritising infrastructure projects. To do this, reliable and capable human resources are needed. However, a lack of capable human resources has contributed to poor quality studies being conducted for planning and selection purposes. Such studies ultimately lead to doubts about the offered projects' feasibility, meaning no investors are interested (particularly in the context of the PPP scheme). R-11 said:

> *So, when we have prepared the resources for studies etc., the studies were poorly conducted. When we get into the market, we give it to the potential investors, no one would like to take the project because it is financially not feasible.*

The third category is behaviour and coordination related effects: effects that are caused mainly due to behaviour and coordination challenges. Based on the interview analysis, the respondents provided three effects, namely: complicated bureaucracy, absence of commitment and the occurrence of jealousy from other parties whose proposals were rejected.

Due to the decentralisation trap, the bureaucracy process in proposing infrastructure projects has become complicated. In the decentralised system, each local government has their own authorities and responsibilities. Unfortunately, not all local governments have enough capacity to develop their regions. R-5 provided an illustration of this, in which—due to decentralisation—there is a division of authority and responsibility between central and local government. When there is a proposal that is not within the responsibility of the central government, it must go through complicated bureaucracy by coordinating with many government agencies and local authorities, making the entire process more difficult.

The unavailability of a complete or jointly recognised framework or guide can cause disappointed parties not to commit to the results of the infrastructure project selection and prioritisation process. Because their proposals were rejected, disappointed organisational units may refuse or be reluctant to work on selected projects. This was conveyed by R-12:

> *The framework or guidance absence can also be used as an excuse by stakeholders to not implement the project prioritisation.*

Furthermore, the absence of a complete regulatory framework and legal certainty also contributes to a lack of commitment from parties to the results of project selection and prioritisation.

The occurrence of jealousy from other parties can be caused by political factors and stakeholders' intervention. When a supervisor exercises political influence (in the form of directive projects) or intervention in the process of selection and prioritisation of infrastructure projects, the project usually must be implemented immediately. This creates jealousy from organisational units who feel their projects are delayed and not prioritised. This was conveyed by R-12:

> *Other parties can be jealous because their projects are not being prioritised due to the subjectivity or politics of stakeholders.*

On the other hand, jealousy is also unavoidable given the limited funds as not all project proposals submitted by organisational units can be approved. This highlights the importance of project selection and prioritisation, hence many proposals must be postponed or rejected. Consequently, negative sentiments arise due to this practice.

The ultimate effect of these challenges in the infrastructure project selection and prioritisation process is project failures. Project failures can occur in three ways, namely: the project was cancelled/not resolved, the project was completed but its purpose is not fulfilled or the project did not bring about the expected benefits/impacts. These failures occur mainly due to poor FEP practice, which is characterised by the absence of a good DMF for infrastructure project selection and prioritisation. According to R-9, the unavailability of a framework in selecting and prioritising infrastructure projects can cause project cancellation:

> *The project will be chaotic. It can be cancelled. Because the sustainability has never been counted for, whether it can continue or not. ... Without it (the framework), the project will be very vulnerable to be not completed.*

Similar thoughts were conveyed by R-11 who said:

> *Cancellation, that is the first risk. ... If the studies were not done in a well manner, then at the end of the process, ... the risk is that the project will be stopped during the execution.*

Other than that, project cancellation can also occur when problems arise regarding land acquisition. For example, work on a project intended to be done on some designated land may have to be halted because of land disputes. Even though this scenario was not commented on by the respondents, this often happens in the process of building infrastructure projects in Indonesia. Similarly, weak regulatory enforcement, especially related to land acquisition laws and regulations, has contributed to project cancellation. Meanwhile, global issues such as a global economic crisis and inflation may also cause project cancellation. An example can be seen in the number of infrastructure projects that were forced to be stopped during the 1997 economic crisis.

Furthermore, project failure can also occur when the project is complete but not functioning properly. The botching of such projects can be caused by planning and construction failures, or failures of operation and maintenance assets. For example, if community reluctance to maintain and operate the assets properly has made the assets not function properly. This was expressed by R-18:

It has been built but in fact they don't use it. They don't maintain it. That becomes a problem. The process is not running. The investment becomes in vain.

Finally, project failure may occur because the completed project is not on target, so it does not deliver the maximum benefits. This happens due to poor identification of needs and the unavailability of frameworks in project selection. R-9 explained:

It will be very vulnerable if it has been built but cannot be used because we do not know where is the user demand. Then it will also very possible that it has no impact to the community.

In addition to giving opinions related to the 'challenges' and 'effects' that arise from these challenges, the respondents also provide some solutions to overcome and minimise the effects of these challenges. Thus, the second part of this section focuses on the solutions for the perceived challenges in the infrastructure project selection and prioritisation process, as shown in Figure 5.13. Some of these solutions have already been implemented, such as making integration efforts and developing a tool, but some are still just ideas that are expected to be possible solutions to these challenges.

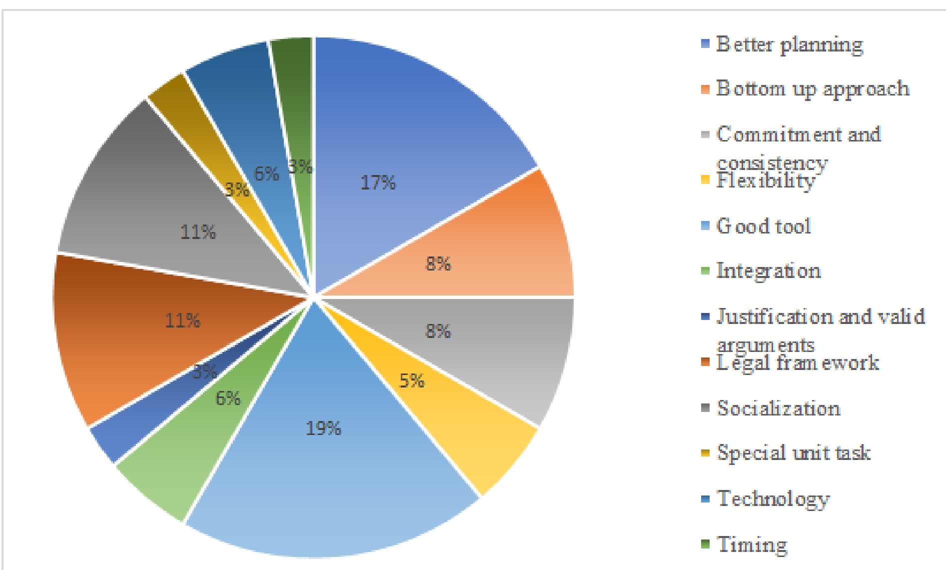


Figure 5.13 Response frequency of the solutions to the perceived challenges

To facilitate better understanding, Figure 5.14 presents 13 solutions as captured from the results of the interview analysis. Having a 'good tool' is the most frequent solution expressed by respondents (with seven people providing this answer), followed by 'better planning' (with six responses). Here, the identified solutions obtained from interview analysis can be further grouped into four categories based on their similarities, namely: (1) planning related solutions, (2) programming related solutions, (3) political and regulatory related solutions, and (4) behaviour and coordination related solutions. Detailed descriptions related to each solution are discussed as follows.

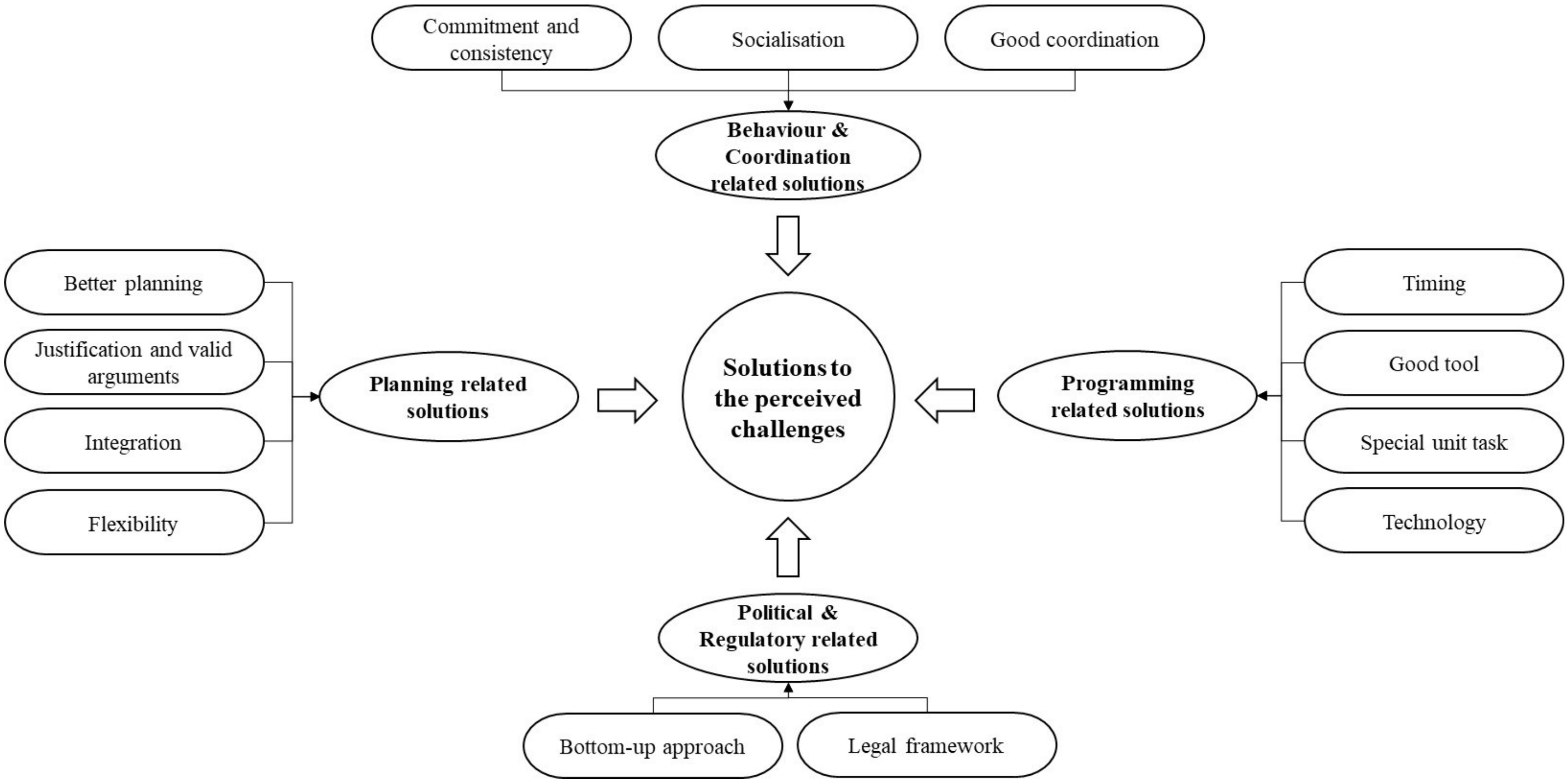


Figure 5.14 Classification of identified solutions to the perceived challenges

The first category is planning related solutions. This refers to solutions related to planning aspects in the process of selecting and prioritising infrastructure projects which include better planning, planning integration, providing justification and valid arguments, and planning flexibility.

Better planning is the most frequent solution provided from the interview analysis. This is reasonable, considering that planning related challenges are the most frequent challenges that many respondents expressed. Better planning covers several aspects. The first is related to the availability of sufficient time to carry out planning and decision making related to the infrastructure project selection process. In the process of selection and prioritisation, adequate data and information are needed (which can be obtained from studies) regarding the fulfilment of selection criteria and prioritisation. Thus, time is needed to obtain data and information. In addition, it also requires good procedures, frameworks or tools to select and prioritise these proposals. With this tool and framework, important points can be identified immediately. This was conveyed by R-10:

> *Studies cannot be pushed to be conducted in a short time… I think we have to come back to a good study… The procedure must be with correct mechanism, so that the decision-making can be accounted for.*

Better planning can also be done by hiring experts to assist the process of planning and selecting infrastructure projects. These experts can be asked to make toolkits or develop a system of selection and prioritisation that can be used by the ministry. This was conveyed by R-11:

> *We will also ask assistance from outside experts to guide and to make a toolkit.*

Thus, good cooperation between the government and academics from university should be encouraged. Formal and informal knowledge from academics can be valuable inputs into a project planning and development of infrastructure project selection and prioritisation system in the ministry. This is evident in the explanation given by R-10:

> *In my opinion when we conduct studies or planning, it can be more prepared, longer, comprehensive, involve researchers, for example from the universities [academics] to get involve in the study and planning scope.*

Furthermore, better planning can occur when it involves key stakeholders and is done comprehensively. Thus, the results of the selection are complete and can be accepted by various parties. This was conveyed by R-19:

> *And this planning should be comprehensive. So, all stakeholders should be involved since the start of planning.*

Finally, the planning must provide optimal impacts for achieving the organisation's strategic goals. Therefore, a good planning and selection process must be able to provide an overview of the extent to which the results of planning and selection make a positive contribution. The absence of studies related to the impact of planning and selection was identified as a problem by R-2:

> *There should be research. I actually have asked for R&D department to do it. … With that, people will see, oh that's right [that's the impacts]!*

The importance of studies evaluating the results of this selection and prioritisation was also emphasised by R-9:

> *In my opinion, it is indeed very important to be able to evaluate the effectiveness of the built infrastructure projects, as I have said earlier. How much is the economic improvement of the community due to the built infrastructure there.*

Thus, better planning practice will ensure that infrastructure project proposals are properly selected and prioritised, which eventually will ensure appropriate budget allocation and project success from the beginning at the FEP phase.

Another solution that is expected to be applied is to ensure integration in the project planning and selection process. This was covered by R-1 who highlighted the importance of integration. Furthermore, R-2 also explained that integration between stakeholders is important because currently the systems and procedures used are still sectoral. Each sector has its own way of selecting and prioritising project proposals. He said:

> *The ones that are sectoral, it should be integrated. That's it!*

One of the respondents, R-9 suggested that the process of selection and prioritisation must be done correctly, based on technical data and careful consideration, so the results can be justified and accounted for. The result of the selection in the form of a list of priority projects must be supported by valid and strong arguments. That way, the parties who feel disappointed/jealous about the result can accept it. This will also provide an easier path for the FEP team or decision makers to make firm decisions. He explained this solution further:

> *The best way is indeed to have justifications. So, our approach is to explain it technically. It is their right to be dissatisfied with our decisions. But it is also our right to convey the basic reasonings of our considerations.*

Having flexibility during the process of selecting and prioritising infrastructure projects is another possible solution. Here, flexibility may relate to the approval of various government institutions which can currently require a long and complicated process. According to R-9, the government should not be too rigid in implementing this budget approval process or it will be overly prolonged. He stated:

> *For example, when approving the national budget, we also need the support from legislature. If the government is too rigid, it will be a prolonged process.*

On the other hand, flexibility can also be interpreted as projects selected being flexible enough to adapt to changes in the situation and conditions of the country. In this sense, on certain levels, selected projects must not be too rigid.

The second category is programming related solutions which refers to solutions related to programming (technical) aspects during the process of infrastructure project selection and prioritisation. These include having a good tool/framework, forming a special unit task, technology utilisation and timing procedure.

Having and developing a tool or framework to select and prioritise infrastructure projects is the most frequent solution proposed in the interview analysis. It was provided by many respondents including R-1 who said:

> *Yes, there must be the tools, for the readiness.*

Similarly, R-7 stated that it is important to have a framework that has been developed objectively and scientifically proven. He said:

> *But if the current government has a model that is scientifically proven, made objectively, at least it can be a guidance – this is the way if you want to [select] build infrastructure projects.*

Thus, it is expected that this tool or framework can speed up the selection process and prioritisation, providing objective and precise results based on strong arguments. The form of this tool or framework varied among respondents. For example, R-11 said that this guide could be in the form of a toolkit or checklist to select. He said:

> *And that's like what I have said, for example, the project selection. It is like a toolkit, for checklists. So, maybe in the future we will be like that.*

The challenge of human resources, especially regarding rapid job rotation, needs to be addressed. One of the respondents, R-11 expressed the need to establish a special unit task that contained people with specific skills. This special task unit would be formed so that people involved in it did not experience job rotation quickly, meaning they could focus on the selection process. R-11 proposed the following:

> *Maybe the solution is to establish a special work unit that specifically only for PPP, and it may not be distracted from its work unit. It should focus to manage PPP projects only.*

On the other hand, the growing usage of technology was also emphasised by several respondents. By utilising technology, the process of selection and prioritisation can be more easily carried out and implemented. For example, this could be achieved by developing an online and integrated project data collection system. This was conveyed by R-6:

> *This means that we must be supported by fast wireless technology. Data must be collected properly and everyone knows where to look for it. Now, this is what we are trying to build.*

Similar views were conveyed by R-20, who stated that technological developments, especially IT, should be taken into consideration. He said:

> *The thing that needs to be considered is IT, the information technology.*

Timing is the solution delivered by one of the respondents, namely R-9. According to him, the process of selecting and prioritising infrastructure projects must consider timing factors so that selected projects can be carried out without experiencing obstacles, especially from political influences such as the government transition period. He explained:

> *The projects implemented between the government transition period will have a greater risk of not being completed. ... So, avoid projects that take a very long time… or for example, projects built between government transition period.*

In addition, this solution is also related to providing clear timing procedures in the process of infrastructure project selection and prioritisation. It means that, in the DMF, there must be a clear timing mechanism that explains the deadline for submitting project proposals, the duration of selection stages and the deadline for the selection result announcement.

The third category is political and regulatory related solutions. In this study, this refers to solutions provided in order to overcome political and regulatory problems. There are two solutions provided, namely: exercising more a bottom-up approach and providing a good legal framework.

A solution presented by some respondents is to exercise a more bottom-up approach. Even though a combination approach is currently implemented, some respondents felt that the process of selecting and prioritising infrastructure projects is still heavily influenced by politics and tends to be done in a top-down manner. A bottom-up approach is considered important because it is grassroot officers who understand the needs in the field most precisely. This was conveyed by R-3:

> *It should be from bottom, there project proposals should be from bottom, the field. Then being selected, prioritised by BPIW. Then, it can be translated in the programming center. Next, it can be spread to each unit. It should be like that ideally.*

Similarly, R-16 also preferred a bottom-up approach because the top-down approach is too politically influenced making it selection process seem forced on people from above. As a result, the projects do not go through a good selection process. She said:

For me, it will be better with the bottom-up [approach]. ... So, there will be more prepared considerations. ... I think the bottom-up is more effective than the top-down. While the top-down seems like being forced.

A different opinion was conveyed by R-18 who claimed that both top-down and bottom-up approaches have their advantages and disadvantages. While the bottom-up approach starts with grassroot officers who know the actual needs of a project, the budget approval may be slower as a consequence and it will still need to follow certain selection processes. On the other hand, the top-down approach provides a shortcut through the process and the budget is ready for use. However, it is politically-driven and may face problems in execution such as the aforementioned land acquisition problem. Figure 5.15 illustrates the characteristics of these two approaches.

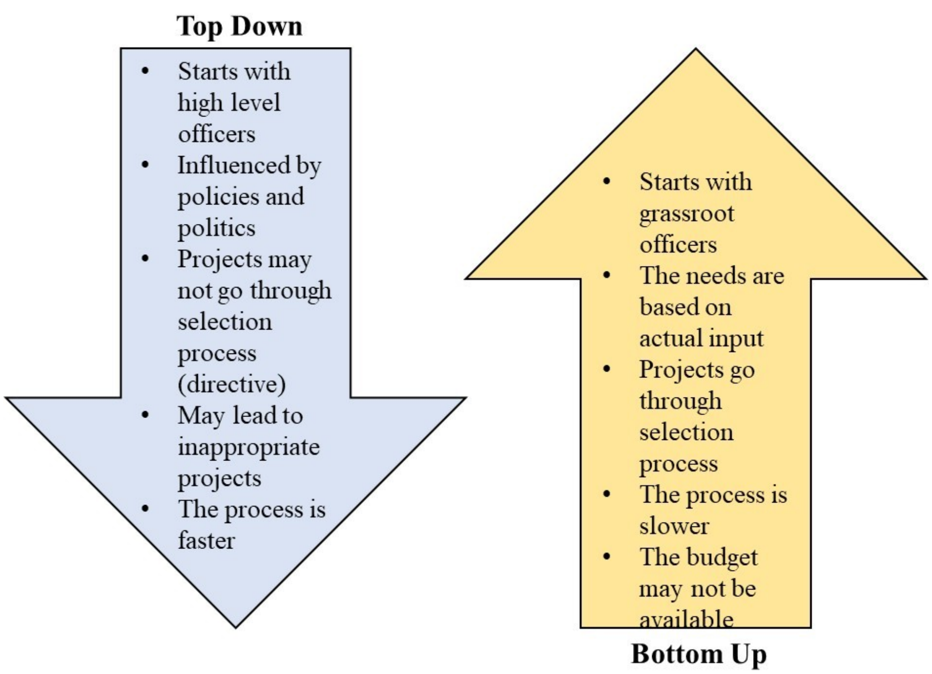


Figure 5.15 Characteristics of top-down and bottom-up approaches

The respondents said that one of the challenges faced by the current selection process and prioritisation of infrastructure projects is the poor regulatory framework. Therefore, one solution presented naturally relates to the importance of having a good legal or regulatory framework. Such a framework must be able to regulate the selection process and provide legal certainty. R-1 suggested:

> *The regulation framework should be correct, the legislative framework should be correct.*

According to R-18, there is currently no specific legal framework governing the decision-making process related to infrastructure project selection and prioritisation in Indonesia. According to her, it would be beneficial if there was a legal framework for that. In fact, there are actually several regulations that regulate the process of selection and prioritisation of infrastructure projects in Indonesia. For instance, the MNDP Regulation Number 4 of 2015 concerning Procedures for Public Private Partnership. R-4 mentioned:

> *For funding, we have already gazetted the regulation, Ministry Regulation No. 21 of 2018. That's about PPP.*

However, these regulations still do not explain in detail the required selection process, stages and criteria etc. in detail. These regulations are still new and may require improvements in the future given that this practice continues to grow.

The last category is behaviour and coordination related solutions which refers to solutions provided in order to overcome behaviour and coordination problems. These include establishing commitment and consistency, providing socialisation and establishing good coordination.

The commitment and consistency of the parties to implementing the selection results is one of the solutions provided by the respondents. For example, R-18 hoped for local governments' commitment from the beginning of the planning process and selection:

> *The solution is back to the local governments in which they must really need it and commit since the beginning.*

While R-15 emphasised the importance of consistency in the selection and prioritisation process so that the list of selected projects does not change and gets funding approval. She said:

> *Maybe the consistency, back to consistency.*

Related to this, R-10 provided an illustration of how advanced countries succeeded in building their infrastructure. According to him, this was due to a strong commitment from the government so that the implementation was a joint decision. In the context of infrastructure project selection, this means implementing a list of well-selected projects. He explained:

> *And one thing in my opinion, the good one is that their governments have commitment. The first thing must be commitment. Why? Stick to the masterplans, stick to the plans.*

Related to community reluctance, some respondents suggested the importance of socialisation, which is currently weak. As a result, there were public rejections of planned infrastructure projects. R-4 mentioned that socialisation of project plans in the community is weak. Likewise, R-18 commented:

> *The community, I think. For example, it will be great if it has been socialized so that there is no rejection when we have started the work.*

In addition to socialisation of the community, socialisation related to the selection and prioritisation process also needs to involve the stakeholders and government institutions involved so that they understand that the process of selecting and prioritising infrastructure projects is necessitated by the limited funds and other technical considerations. R-17 explained that:

> *Based on data, I told them about this and that. Indonesia is big. They understand that. But they should understand our process from the beginning as well. They don't want to understand that.*

Socialisation relating to changing the existing wrong mindset also needs to be done so that stakeholders (especially ministries and agencies) are aware that their performance assessment should focus on good planning practice and not just on spending the available budget.

The last solution is related to complicated bureaucracy caused by decentralisation. Such a bureaucracy is characterised by competition between government agencies to expand their power territory in order to obtain more resources. With decentralisation, planning between central and local government must go through complicated bureaucracy, coordinating with many government agencies and local authorities. Thus, establishing good coordination between government entities and agencies is needed so that the existing bureaucracy becomes simpler, faster and more flexible.

Based on the interview analysis, the main solutions provided by respondents related to the existence of a good tool or framework for infrastructure project selection and prioritisation, and better planning implementation. This is reasonable considering the absence of a tool or framework is a major challenge according to the previous analysis. A good and comprehensive tool or framework will facilitate the FEP team in selecting and prioritising infrastructure project proposals. Most respondents said that until now there has not been a tool or framework specifically designed to select and prioritise infrastructure projects. While an attempt has been conducted by BPIW (as part of MPWH) to develop an integrated selection tool, it is still in the trial and error stage and has not been fully utilised. Thus, there is no feedback yet related to the success of implementing this tool.

Better planning covers several aspects including: availability of sufficient time to conduct FEP and selection process, availability of appropriate data and information, involvement of key stakeholders during the FEP process and impact evaluation of selected projects. Generally, planning data and information can be obtained from various sources including technical data (from research and field studies), administrative data (from laws and regulations, etc.), expert advice (from consultants and academics) and community inputs. In order to obtain and assess these data, key stakeholders must be involved. These data could be a strong basis for considerations in making decisions regarding the selection and prioritisation of infrastructure projects. Finally, a causal relationship between the challenges, effects and solutions in infrastructure project selection and prioritisation process has been provided in Table 5.6. In addressing these matters, it is important for decision makers in the selection and prioritisation process to be objective and professional. Selection and prioritisation of infrastructure projects must be carried out through a transparent process with a strong basis for selection so that the list of project priorities produced can be acknowledged by all parties involved.

Table 5.6 Causal relationship of challenges, effects and solutions in the infrastructure project selection and prioritisation process

Challenges	Effects	Solutions
Planning inflexibility	Double works/waste of resources	Planning flexibility
Poor identification of strategic needs	Loss of opportunities	Better planning (availability of sufficient time to conduct studies)
	Inappropriate project needs & budget allocation	Having a good tool/framework, bottom-up approach
Lack of information	Poor planning & management	Better planning (adequacy of data and information, availability of sufficient time)
Wrong mindset	Poor planning & management (wrong focus)	Socialisation (to the stakeholders regarding focus on planning, not spending the budget)
Unavailability of standard framework/tool	Poor planning & management (unstandardised planning practice, mismanagement, low level of transparency, poor decision-making practice)	Better planning (availability of good framework/tool, hiring expert consultants to develop such tool/framework, academic involvement)
	Double works/waste of resources	Having a good tool/framework
	No commitment to follow the decisions	Commitment & consistency
	Project cancellation (inappropriate projects due to poor identification of needs & budget allocation)	Better planning (availability of good framework/tool)
No program synchronisation & continuation	Poor planning & management (reassessment & rework, no evaluation)	Better planning (impact analysis of the proposed projects), planning consistency
Unclear time frames	Poor planning & management (unclear timing procedure)	Provide a clear timing procedure
Unclear budget allocation & distribution	Inappropriate budget allocation	Better planning (availability of good framework/tool)
Financial problems	Inappropriate budget allocation (waste of funds)	Better planning (availability of good framework/tool, adequacy of data)
Human resource problems: • Work intensification • Lack of capable human resource	Poor planning & management (poor decisions)	Better planning (hiring expert consultants, academic involvement), formed a special unit task
	Inappropriate budget allocation	Better planning (availability of good framework/tool)
Geodemographic challenges	Difficulties in planning integration	Planning integration using technology

Decentralisation trap	Complicated bureaucracy	Good coordination
Global issue challenges	Project cancellation (e.g. global crisis, high inflation)	Better planning (adequacy of data, hiring expert consultants)
Political influences	Inappropriate budget allocation (not going through the correct selection process)	Bottom-up approach, correct timing
	Jealousy from other parties	Provide justification & valid arguments
Coercive actions	Inappropriate budget allocation (not going through the correct selection process)	Bottom-up approach
Cultural challenges	Inappropriate budget allocation (subjectivity of decisions)	Provide justification & valid arguments
Coordination problems: • Sectoral ego • Stakeholders' intervention • Community reluctance • Lack of private sector involvement	Poor planning & management (change of decisions due to intervention, subjectivity of decisions)	Better planning (key stakeholder involvement)
	No planning integration (due to sectoral ego)	Planning integration
	Inappropriate budget allocation (due to intervention)	Socialisation (to the stakeholders who may intervene)
	Jealousy from other parties	Provide justification & valid arguments
	Project cancellation (due to community rejection/reluctance to maintain the assets)	Socialisation (to the community)
Poor regulatory framework	Project cancellation (due to weak regulatory enforcement such as land acquisition laws)	Provide good legal framework
Land acquisition problems	Project cancellation (due to land disputes, etc.)	Better planning (adequacy of information), provide good legal framework

5.4.4 Finding 4: Criteria in Selecting and Prioritising Infrastructure Projects

Determining selection criteria is perhaps the most important step in developing a DMF. It is the first step in developing a model or framework to evaluate project proposals, followed by establishment of weight for each criterion, devising of the scoring method, calculation of the score and creation of a priority list based on the calculated scores. In the context of this research, these criteria will be part of the DMT in selecting and prioritising infrastructure project proposals. Figure 5.16 shows the interrelated components of selection criteria, DMT and DMF.

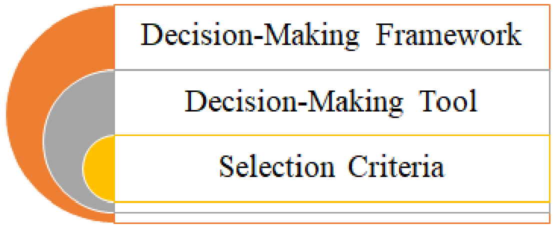


Figure 5.16 Interrelated components of selection criteria, DMT and DMF

Thus, the establishment of criteria should be carried out gradually and comprehensively. In addition to determining criteria through literature studies, this is also important in the context of the study in which the DMF will be applied—in this case is Indonesia. Therefore, investigations related to selection criteria are also carried out through interviews as discussed in this chapter. Next, the third stage (the final stage) of determining the criteria is achieved through questionnaires (quantitative analysis) to find out the important criteria that will be input material in the DMT and DMF development. Figure 5.17 illustrates the comprehensive process in establishing infrastructure project selection and prioritisation criteria.

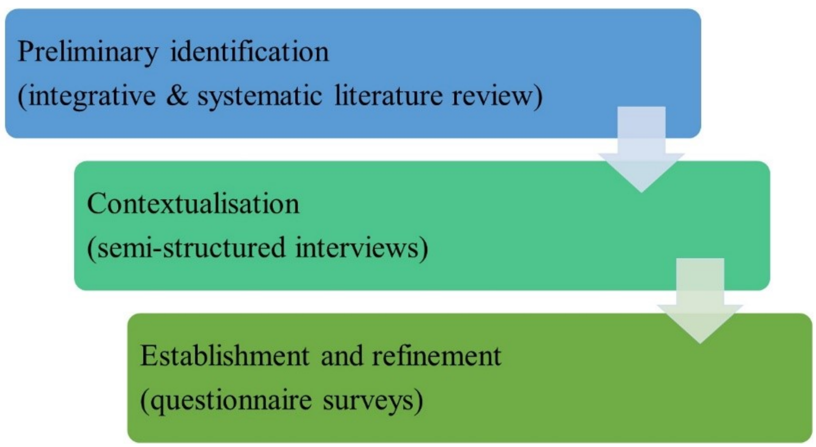


Figure 5.17 Criteria establishment process adopted in this study

In brief, selection criteria are used to assess the project proposals. Researchers have discussed various types of criteria that differ from each other depending on the scope and context of their research. In this study, the criteria were established through a qualitative approach, with expert interviews conducted in Indonesia in the context of infrastructure project selection and prioritisation. A total of 21 selection criteria have been identified based on the responses with 'funding & financing' and 'readiness criteria' being the most frequent criteria provided by the respondents. Response frequency to infrastructure project selection and prioritisation criteria is shown in Figure 5.18.

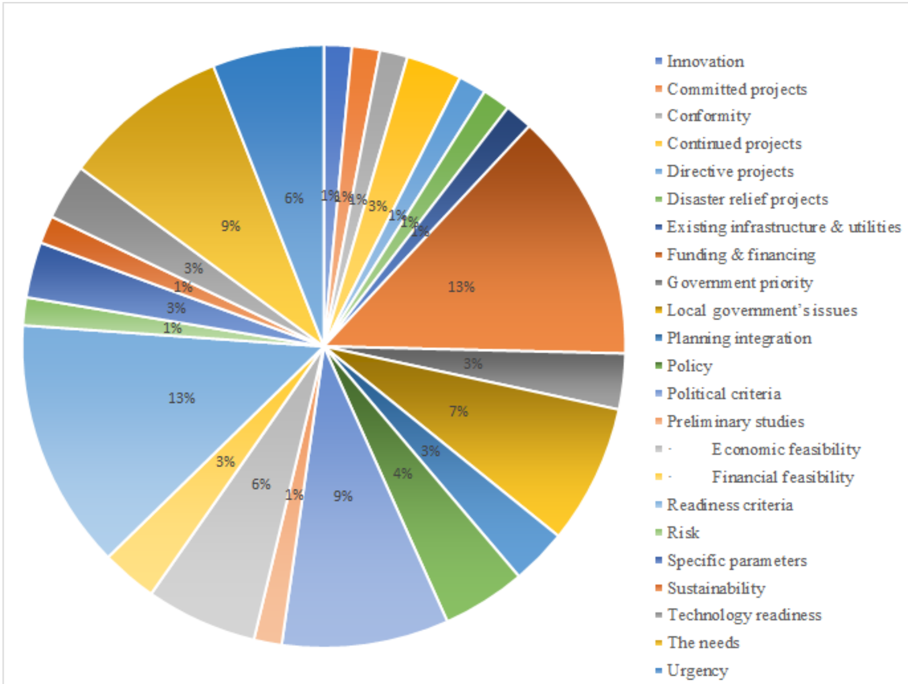


Figure 5.18 Response frequency of criteria in the infrastructure project selection and prioritisation process

However, some of these criteria can be debated, namely: 'continued projects', 'directive projects', 'disaster recovery projects' and 'specific parameters'. Furthermore, there are also several criteria that can be combined based on their similarities or characteristics. Criteria that can be combined are: 'committed projects' and 'government priority', which can be regarded as part of the 'policy' criterion. On the other hand, two of the four criteria under the 'readiness criteria' can be separated into 'design readiness' and 'land acquisition'. Meanwhile, 'feasibility study' can be combined into the 'preliminary study' criterion and 'environmental documents' can be included in the 'sustainability' criterion. Discussions regarding this have been provided in the section explaining each criterion.

Thus, there is a change in the number of criteria from 21 to 16 criteria, which can further be grouped into four categories, namely: (1) strategic fit, (2) politics and policy, (3) project requirements and (4) integration and sustainability. Using NVivo 12 Pro Mind-map, they are shown in Figure 5.19.

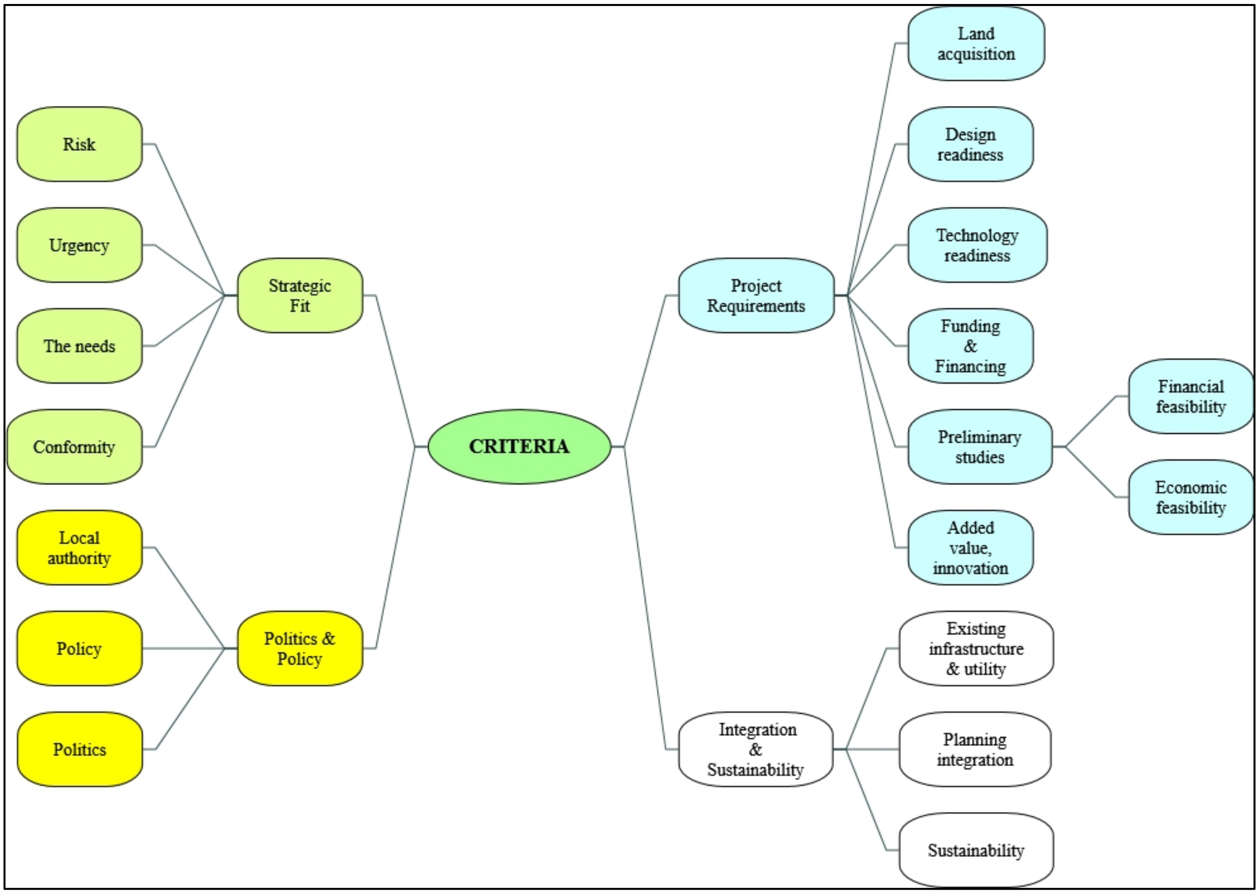


Figure 5.19 Selection criteria categorisation

The first category is strategic fit. In this research, this refers to the degree to which an organisation addresses project strategic issues that contributes significantly to the achievement of organisation's overall objectives. Thus, it covers both planning and managing strategies in infrastructure project development. These include four criteria, namely: needs, conformity, risk and urgency.

'The needs' is a key criterion identified from interview analysis. This criterion is also one of the most frequent criteria submitted by respondents besides the readiness criteria. It assesses the level of need for proposed projects by asking why this project is important to implement. This was conveyed by R-1:

> *First, why is there a need for the project, right? The parameters for the needs, for instance, there is a community need for economic development. For economic development, people usually need to move. So, there is a need for toll road for example.*

R-14 added that it is important to select projects based on their needs:

For selection stages, I think it should be according to the needs.

The need for this infrastructure project must then be checked according to the availability of the budget. Therefore, it is necessary to prioritise selected projects. This was reflected in the opinion expressed by R-9:

Yes, needs. ... With the existence of a budget constraint, people must be able to apply priorities, which ones must be addressed first.

Conformity is related to the fulfilment of standards, rules and requirements by the proposed projects. It reflects the government's compliance attitude in carrying out and enforcing standards and applicable laws in Indonesia. This was reaffirmed by one of the respondents, R-12, who said that in the selection and prioritisation process of infrastructure projects, the conformity criterion must be met. R-12 stated:

Priority projects must meet the following criteria: (1) relevance to the achievement of RPJMN goals and objectives and the National Priority Goals in the RKP, (2) conformity with the results of the mid-evaluation of RPJMN and/or the results of the previous year's development implementation, and (3) conformity with the thematic, holistic, integrative and spatial approaches.

The conformity criteria referred to by R-12 have been stipulated in the MNDP Regulation Number 13 of 2018 concerning Procedures for Managing Priority Projects, with article 4 describing the priority criteria and priority outputs.

Meanwhile, infrastructure projects are usually large-scale and complex projects that involve multiple parties. This increases the potential risk that will occur. Project risks are potential uncertain events or conditions that could affect the achievement of the project goals and objectives. Therefore, according to R-14 risk must be included as one of the project selection criteria. It will assess the level of risk that may exist from the proposed projects. He said:

First look at the risks. And the risks, sometimes there is a high-risk and there is not.

The last criterion in the strategic fit category is urgency. It refers to the degree to which it is important that a project be carried out immediately. Several respondents mentioned it as a criterion. One of them was R-19, who said:

We should look at the urgency first. How important is the project to be executed [soon]?

An example of an urgent project is a post-disaster rehabilitation project, which needs to get priority even if it occurs suddenly. This was also conveyed by R-6:

The urgency. The urgency aspect such as disaster.

In brief, 'the needs' relates to the strategic importance of a project to be done, while 'urgency' relates to the urgent necessity of a project to be done immediately. Thus, the urgency criterion will be given significant weight during the prioritisation process of the selected projects.

The second category is politics and policy criteria. These criteria are important because both are still major issues in the planning and selection process of infrastructure projects in Indonesia. These include political, policy and local authority criteria.

Political criterion relates to political influence in the process of selecting and prioritising infrastructure projects. In Indonesia, political influence has considerable weight, with numerous respondents referring to this criterion. In Indonesia, there are three divisions of political power, namely: the executive, the legislative and the judiciary. The first two have significant political influence in relation to infrastructure development in Indonesia. First, this criterion is related to the direction and political policy of the government (executive), especially by the president who has the power both as the head of state and head of government. Politics is also influenced by legislative power, which is vested in both the government and the two People's Representative Councils, especially the DPR. R-8 stated that this criterion is the first criterion of five parameters for the selection and prioritisation of infrastructure projects:

So, we have five parameters. There are political parameters, ….

R-17 also expressed the importance of including political parameters as a criterion in the process of selecting and prioritising infrastructure projects in Indonesia. He stated that this is due to the considerable political influence that exists in determining infrastructure development in Indonesia. This was also conveyed by R-1, who said:

> *Yes, sometimes there is also political criteria. For example, the Cipularang toll road. It was actually based on political need.*

If politics refers to the means applied by authorities to achieve their goals or interests, policy refers to a concept or principle that becomes the basis in carrying out a job. It relates to public policies made by the government, including both the central government through ministries and the local government. Policy can be one of the criteria in project selection and prioritisation. In this case, projects that support public policies will get higher weightage than projects that do not support public policies. For example, R-14 presented a prioritisation of a flyover project to reduce traffic congestion at the same level crossing:

> *The one that I have mentioned earlier, to eliminate the same level crossing. That is a policy in the regulations.*

Another example was also delivered by R-9:

> *The fourth, what are the underlying events, or what are the underlying phenomena.*

The last criterion in the politics and policy category is local authority/government criterion. It covers several aspects related to local governments. First, the capacity and capability of local governments including financial capacity, operational capability and so on. R-18 alluded to this:

> *Local government's financial capacity, I think. So, their readiness to manage the assets.*

Similarly, R-9's views on this related to local government capability to allocate operational and maintenance funds for assets that had been built. He explained further:

> *Because whatever is built by CK today will be handed over to the local government when it is completed. This means that the local government must allocate maintenance costs. ...*

If it turns out that local government does not have the capacity and capability to build infrastructure projects that are really needed, then local government can submit proposals to the central government. The central government will assess the proposal and if selected, the project can be implemented with special allocation funds. This was explained by R-10:

Because since autonomy, there is an authority division between the central and local governments. .... But we also need to accommodate the local government's needs that becomes his authority. We accommodate it through special funding allocation.

For this reason, according to R-19 local government must have the skills to identify their needs. They must prepare a proposal well and have the information needed to ensure that their proposal is required. She explained:

Usually we also look at the local governments, what do they want. Maybe that project is in province A. It means from province A, the local government should also have the inputs or general description of how important is this project for their province.

Finally, R-18 emphasised the importance of commitment by local government to building the project. Since the era of regional autonomy commenced, the division of tasks and authority between the central and local governments has been made quite clear. Therefore, a local government that requests the help of the central government to work on a project must be committed to receiving, operating and maintaining the assets that have been built. R-18 elaborated:

The important thing is that we should have a commitment letter from the local authority. So, inside that letter, they should state their interest to this program, also their willingness to allocate operational costs and to accept the asset.

The third category is project requirements. Project requirements criteria involves providing necessary information so that the proposed projects can be carried out properly. Compared to other categories, it deals with the detailed and technical information of a project. These criteria include funding and financing, preliminary studies, innovation, design readiness, technology readiness and land acquisition.

The 'funding and financing' criterion is the most frequent criterion offered by respondents. Nine respondents stated that this criterion is important in the process of selecting and prioritising infrastructure projects in Indonesia. This criterion relates to the funding sources and financing models needed by a project. Here, funding refers to the means to obtain the required capital to undertake a project, while financing refers to the process of managing and allocating available funds for proposed projects. Some respondents clearly stated that 'funding and financing' is a key criterion in infrastructure project selection and prioritisation in Indonesia. For example, R-10 said:

We determine the projects based on the limited funding.

Furthermore, R-4 also presented three sources of infrastructure funding in Indonesia:

Yes, so can it be funded using available budget, whether it will be fully funded from national budget, or by PPP, partnership between government and private company, or can it be fully funded by the private company. That can also be a consideration in the selection process.

Preliminary studies aim to analyse issues related to a proposed infrastructure project. They serve as an initial exploration of projects for review or evaluation. R-11 explained the importance of preliminary studies:

The first thing to do is to conduct preliminary studies. ... In the studies, there are many reviews or aspects to be reviewed. Those can be parameters in determining whether this project is actually feasible or not.

Since infrastructure projects are public assets that are built with the aim of improving people's welfare, not all infrastructure projects are built based on financial considerations (gain profits), such as sanitation projects and waste treatment plants or road projects in remote and disadvantaged locations. These projects must still be built as part of the government's role in ensuring people's welfare and equitable development. Thus, in this research context there are two feasibility aspects assessed in preliminary studies, i.e. economic feasibility and financial feasibility (Figure 5.20).

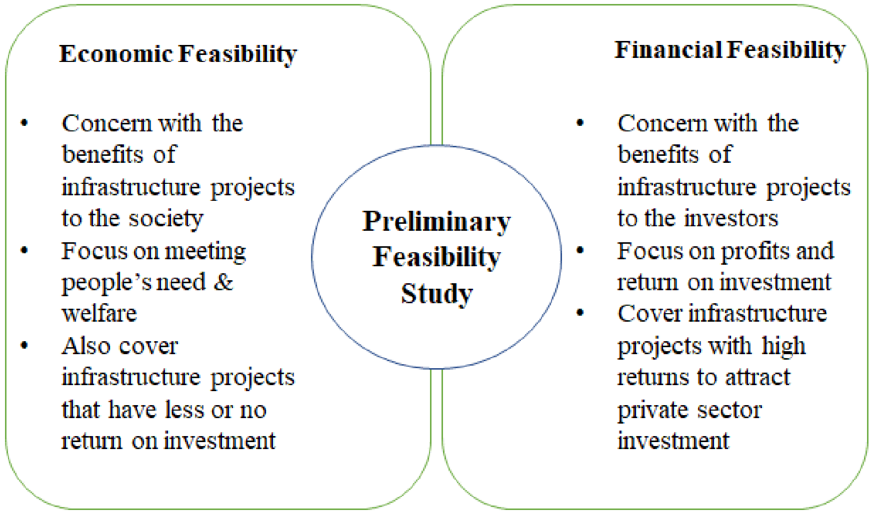


Figure 5.20 Economic vs. financial feasibility of infrastructure projects

Economic feasibility assesses the feasibility of a proposal on the economic side. The assessment covers the issues and impacts of a project on the economy such as project costs and benefits, economic stability, productivity, economic capability and global competitiveness. This was noted by R-19 who said:

> *There are ..., economical factor, and other factors that assess whether the project can be executed well or not. ... And we also look at the benefits towards people. If that project is executed, what are the impacts.*

In economic feasibility, the project is assessed based on the value of its benefits in meeting the needs and welfare of the community, increasing economic growth and ensuring national security. R-11 explained several ways to assess this economic feasibility:

> *First, it must be feasible economically. There are many methods for that. There are CBA, MCA, ENPV, etc. These toolkits are what we expect to be adopted by those in the ministries so that they can understand it easier.*

Meanwhile, financial feasibility refers to the financial and investment studies needed by a project. Some aspects assessed include project costs, funding and profitability. Projects are considered to be financially feasible when the return on investment is equal or greater than the proposed target. Several infrastructure projects require the fulfilment of financial profit targets, especially projects involving the private sector as investors. This is done so that the private sector is interested in investing in the construction of these infrastructure projects, such as toll roads. R-11 emphasised the importance of financial feasibility for these types of projects:

> *Just like what I have said, if for example the economic value is positive, it is good. But it does not mean that it is financially feasible.*

Innovation is related to the process of creative thinking that generates added value. The degree of innovation may influence the success of a project execution. Thus, innovation can be regarded as a criterion in selecting infrastructure project proposals. This notion is supported by R-7, who said:

> *And maybe there are other criteria. It can be added value, the innovation, for example. This is also included in the assessment. There is a percentage.*

Technology readiness is another criteria for selecting infrastructure project proposals mentioned by two respondents. R-14 said:

> *First is the technology. If the technology is okay, then we look at the specification used.*

In addition, the methods and technology for infrastructure projects development continue to grow. Therefore, technology readiness is also reflected in the extent to which domestic industries are ready and capable to implement the project. R-13 mentioned:

> *The fifth is whether the domestic industry has been able to do it. ... The capabilities of domestic industry to do the project.*

Finally, nine respondents (mainly from MPWH) stated that project readiness is an important criterion in infrastructure project selection and prioritisation. This criterion aims to measure the readiness level of the proposed project measured against four parameters (as conveyed by R-4), namely: feasibility study, design principles, environmental documents and land acquisition.

When viewed from these parameters, this criterion is actually a collection of four criteria, one of which is a feasibility study, similar to the criterion for preliminary studies that also has two feasibility aspects, i.e. economic and financial feasibilities. Thus, it can be included in the 'preliminary studies' criterion. Meanwhile, the environmental documents readiness relates to environmental protection, which can be included in the 'sustainability' criterion.

The other two criteria can stand alone, namely: the design principles and land acquisition. Design principles can be a criterion called ‘design readiness’. It assesses design readiness to ensure the success of the proposed project proposal. It includes the availability of preliminary drawings, specifications, methods and other constructability strategies. R-6 highlighted the importance of design readiness:

> *If it is a complex [project], basic design will be created first. But we called it as the engineering design framework.*

Meanwhile, land acquisition can become a criterion itself. This criterion assesses the readiness to acquire the land needed as the location for infrastructure development. Considering that land acquisition is still a major obstacle in the construction of infrastructure projects in Indonesia, it is likely that this criterion will have considerable weight. This was conveyed by some respondents, one of them was R-9 who said:

> *This land acquisition becomes a crucial point where if the land [location] is in a problematic situation, development activities cannot be carried out.*

The last category is integration and sustainability. In this research, integration refers to the act of integrating processes to ensure that various planning elements are well coordinated, while sustainability is defined as the ability to continue the benefits of the proposed projects far into the future. To achieve project sustainability, integration must be recognised and implemented. This category includes planning integration, existing infrastructure and utilities, and sustainability.

Planning integration is one of the criteria delivered by two respondents. R-8 mentioned it as one of five selection parameters:

> *So, we have five parameters. There are …., integration, ….*

Planning integration means the integration of the planning of various infrastructure projects to be carried out so that these infrastructure projects can be united in fostering the development of a region. R-5 illustrates this:

> *Then the third one, for example, we want to provide drinking water. So, we say okay, we will supply the city’s clean water needs by building drinking water supply system for*

> *example 200 l/s. So, we ask what year should it be needed. Okay, for 2020-2021. It is impossible that he does not have something to be processed for the supply system. It needs raw water, right? So, he must build an intake before 2020. That is the right thing. It's what we called as integration.*

One of the respondents stated that the 'existing utilities' must be considered as a criterion in the process of selecting new infrastructure projects. Existing infrastructure and utilities must be taken into consideration because these can affect the project's capacity, costs and duration. This is particularly influential when it comes to building new infrastructure projects in densely-populated areas, such as cities that already have infrastructure and utility networks. R-14 expressed that:

> *One more is utility. ... If the proposal is for the city infrastructure, automatically there will be a lot of fibre optics, water supply networks, electrical networks.*

Sustainability is a criterion that was highlighted by only one respondent, R-8, who said:

> *So, we have five parameters. There are ..., program sustainability, ...*

This criterion is related to two aspects. First, program sustainability. This refers to whether or not the incoming project proposal is a new development project, a completion project (from a series of previous projects) or a project for operation and maintenance. The second aspect of sustainability refers to environmental protection, meaning the extent to which infrastructure projects will affect the carrying capacity of the environment.

In addition to these 16 criteria described above, there are also several criteria identified from interview analysis that after thorough considerations, were not included in the four categories of criteria. Furthermore, there is also one criterion mentioned by the respondents that, after careful thinking, were decided to be broken down into several criteria. The considerations taken in these decisions are:

(1) Some of the criteria mentioned by respondents have similar characteristics or are part of an established criterion that is more appropriate to use. These include 'committed projects' and 'government priority' criteria which are considered as part of the 'policy' criterion.

(2) Some of the criteria mentioned by respondents are debatable because they do not play a role in the process of selecting and prioritising infrastructure project proposals. These include ‘continued projects’, ‘directive projects’, ‘disaster recovery projects’ and ‘specific parameters’.

(3) There is one criterion mentioned by respondents that can be further broken down, i.e. ‘readiness criteria’. It is actually a collection of four criteria; two of them can be separated into ‘design readiness’ and ‘land acquisition’, while the other two criteria can be combined into other established criteria.

From the conducted interview analysis, one respondent said that ‘committed projects’ is one of the criteria in the process of selecting and prioritising infrastructure projects in Indonesia. R-5 stated:

> *Yes. Then for the committed projects. For example, what we have entered into the World Bank programs. That is commitment.*

Thus, committed projects are infrastructure project proposals that are related to or constitute the realisation of commitments that have been approved by the government to be implemented. This includes the World Bank programs and the government’s commitment to the Sustainable Development Goals (SDGs) where one of the goals is to build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation. However, judging by its nature, this criterion can be included in the ‘policy’ criterion. This is because committed projects occur when there are policy directions determined by the central government so that commitments may take place.

Government priority criterion evaluates the impacts of the proposed project on the national economy at the central and regional levels. It includes programs that have been set out by the government as national priorities: for example, projects that have been included in strategic plans determined by the MNDP or related ministries, or which have become national policies. According to the respondents, this is one of the most important selection criteria. R-20 explained:

> *Others, like I said before, the national priority. It has become a national priority if it is for under developed regions.*

Similar to ‘committed projects’, this criterion can also be included in the ‘policy’ criterion. This is because ‘government priority’ can be regarded as a policy taken by the central government to accelerate development in Indonesia based on the level of importance.

According to the narratives of two respondents, ‘continued projects’ is an important criterion in the selection process of infrastructure projects. Continued projects are on-going projects that have not been completed in the previous fiscal year and thus must be budgeted so that they can be completed and function properly. Usually, this happens for projects with a multi-year contract system. R-5 provided the following statement:

> *... it has been continued. From last year, from multi-years contract, it will be continued this year. 200-300 M. Last year it costed 100, this year 100, next year 100. It will take the budget first. It may not be disturbed.*

The emergence of this criterion in the interview analysis is understandable because of the budgeting system in Indonesia, which occurs on an annual basis. Therefore, projects with a long contract duration (exceeding one year) will be treated as multi-year contract projects.

However, this is debatable. Judging from the explanations of the two respondents, the current practice of infrastructure project selection in Indonesia still does not distinguish between the selection of infrastructure project proposals and the budgeting process. The above responses show that the current practice in Indonesia confuses the proposal selection stage with the budgeting stage. These two stages should be separated given their different objectives and interests. The purpose of the infrastructure project selection and prioritisation stage is to assess and select new infrastructure project proposals so that a list of priorities can be obtained. This is certainly different from the context of the budgeting stage, which aims to allocate and control the available funds for the implementation of the selected infrastructure project proposals.

One respondent argues that ‘directive projects’ is one of the criteria in the process of selecting and prioritising infrastructure projects in Indonesia. R-4 stated:

> *Next, we look at the president’s directive. Is there, for example, president instructs a project?*

Here, directive projects refer to projects that have been ordered directly by top officials to be implemented. In Indonesian infrastructure development, the source of instruction may come from the president as the highest authority and the ministers as the president's assistants. Thus, directive projects certainly have a higher priority compared to other projects.

However, the inclusion of directive projects as a criterion in the process of infrastructure projects selection can also be debated. This is due to the nature of directive projects as ones that 'inevitably must be done'; hence, this criterion should no longer be one of the criteria in selecting new project proposals. Projects that are selected for implementation directly by the president and the ministers, certainly have their own portion in the budget and therefore, do not need to follow the selection procedure and assessment. Thus, the directive projects criterion is more appropriate to be considered as one of the criteria in the budgeting process, *not* in the selection process.

Disaster relief projects refer to projects responding to natural and human-made disasters. It involves dealing with and avoiding risks, providing basic infrastructure needed immediately by refugees and rebuilding infrastructure to accelerate the recovery process of the impacted region. Since Indonesia is a disaster-prone country, this type of project must be prioritised. R-4 agrees, stating:

> *The first one, for programs or projects regarded as projects to support disaster relieves, they will be directly approved.*

However, similar to the 'directive projects' criterion, the inclusion of this criterion in the selection and prioritisation process of new infrastructure project proposals is debatable given that it 'inevitably must be done'.

Specific parameters criterion refers to specific parameters intended for different types of infrastructure. In general, the types of infrastructure can be grouped into three: land, sea and air infrastructure. According to R-8, these different types of infrastructure means there are different characteristics that need to be assessed. He mentioned:

> *So, we have five parameters. There are …., and specific parameters of the organisational units.*

For example, the road infrastructure would require the cost of preservation of the national road network that needs to be assessed. This is not found in other types of infrastructure. However, this criterion will not be considered in this study. This is because this study aims to develop a DMF for general infrastructure project selection. Thus, it considers criteria that are commonly used to select and prioritise general infrastructure projects. Specific DMF development for certain types of infrastructure projects, such as land transport, sea transport and air transport projects, can be further developed in future studies.

Thus, the 21 criteria mentioned by respondents have been refined into 16 criteria. These criteria are parameters for selecting and prioritising infrastructure project proposals in Indonesia. The next step is criteria establishment through a questionnaire survey that aims to identify the most important criteria and to determine the weight of each criterion. Thus, the established selection criteria will be able to assist decision makers in selecting and prioritising project proposals based on the calculated score.

5.4.5 Finding 5: Factors Influencing the Decision-Making Process of Infrastructure Project Selection and Prioritisation

In practice, there are always many factors that influence a decision-making process. The same applies to the decision-making process related to infrastructure project selection and prioritisation. In this context, influencing factors are defined as factors that influence the decision makers in making decisions. Understanding how decision makers arrive at their decisions is a cognitive process characterised by learning and problem-solving abilities. Therefore, Finding 5 focuses on addressing factors that influence the decision-making process for infrastructure project selection and prioritisation.

In this study, identification of influencing factors was carried out through expert interviews in the Indonesian context. Interview analysis has successfully identified ten influencing factors. ‘Experience' is the most frequent factor conveyed by the respondents, as shown in Figure 5.21.

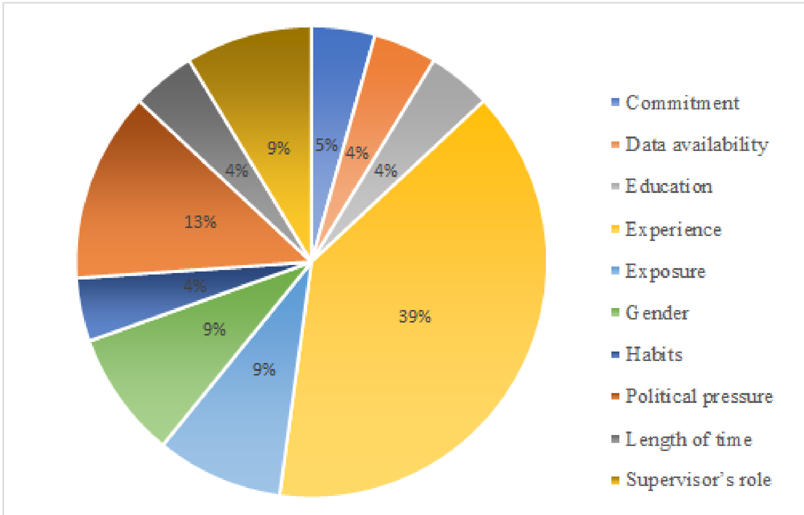


Figure 5.21 Response frequency of influencing factors in the infrastructure project selection process

In addition to the ten influencing factors mentioned by respondents, this study has also identified three additional factors that have not been mentioned by respondents, namely: age, social and cultural influences, and work settings. These three additional factors were obtained through observation and in-depth discussion about the analysis of the interviews that had been conducted.

These influencing factors can further be grouped into four categories based on their similarities, namely: (1) personal attributes, (2) cognitive ability, (3) technical and (4) interventions. Figure 5.22 illustrates the four categories of influencing factors in the infrastructure project selection and prioritisation process in Indonesia. These influencing factors can further be grouped into two wider categories, namely: internal and external factors. Internal factors refer to influencing factors within the FEP team or organisation. They may influence the FEP team or decision makers during the decision-making process for infrastructure project selection. Meanwhile, external factors refer to outside influences that can impact on the decision-making process by the FEP team or decision makers. Because this influence comes from outside, these external factors are more difficult to manage than internal factors. In relation to the development of DMF, identification of influencing factors will be useful in understanding how a decision is made by the decision makers.

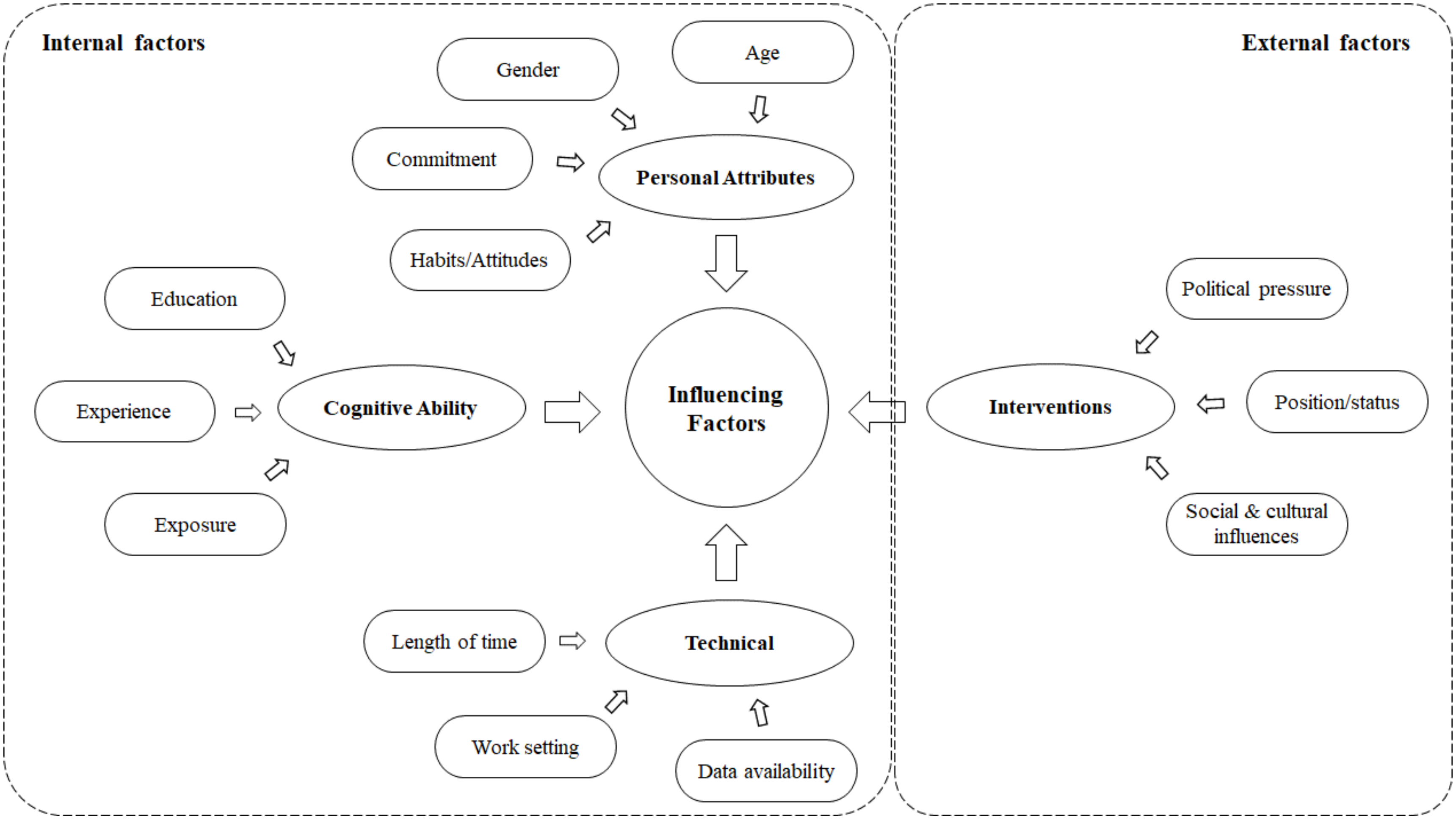


Figure 5.22 Classification of influencing factors in the decision-making process of infrastructure project selection and prioritisation

The first category is personal attributes which refer to characteristics of a person: in this context, a decision maker. These include gender, habits/attitudes, commitment and age. They are included as internal factors influencing the decision-making process for infrastructure project selection.

Some respondents mentioned that gender might influence the decision-making process. This influence can be seen in perceived differences in how men and women behave when making decisions, where men are perceived to be more rational than women who are perceived to be more emotional. This was conveyed by R-9:

> *Well, indeed like in many big projects, for some reasons it seems that the Minister also places men as the project managers. Because maybe in the decision-making process, men are usually more rational than women.*

In other words, there is a perception that women are more concerned with feelings and dynamism in the decision-making process, while men assign more importance to the rational aspects such as analysis and justification of the decision. A similar opinion was conveyed by R-1:

> *Actually, women can make decisions but maybe men are more rational, just like that.*

However, there was no significant gender difference in terms of cognition. Both men and women respondents affirm that, in the decision-making process related to the selection of infrastructure projects, everyone involved must go through a process to obtain information, gain knowledge, conduct analysis, consider alternatives and make logical decisions.

On the other hand, habits/attitudes are one of the personal attributes identified from the interview analysis. It refers to the regular tendencies of a decision maker in making decisions. This can be seen as a settled way of thinking or practical habits that are always done by the decision makers. Furthermore, these habits/attitudes are also related to as personal belief, where if someone believes in what they are doing, then they will tend to continue doing it until it develops into a habit/attitude. This was reflected in R-9's statement that:

> *The second is typical of the person himself. A lot of people who are typically have doubts, right? So, making decisions is difficult for them. For me, I have a principle. Today, another*

> *year or the next three years, in the end that decision must be made. The longer the decision is made, meaning pending the issue, it is getting longer and bigger.*

Thus, when the decision makers believe what they decide matters, they tend to make decisions more easily.

Commitment is also an important factor influencing the decision-making process. With commitment, a decision maker will make decisions more easily. This was conveyed by R-18:

> *But for those who understand, yeah… the influence is to the commitment.*

However, the level of commitment can have a bad influence on the decision-making process. This happens when there is an escalation of commitment that forces the decision makers to make decisions based on irrational judgment because they have committed themselves. In other words, this escalation of commitment is responsible for causing them to make risky decisions.

One influencing factor not mentioned by respondents regarding personal attributes is age difference. Age differences when making decisions can affect the quality of decisions made. This is also perceived to relate to the level of maturity a person has in dealing with problems and finding solutions. Here, older decision makers are considered more capable of carrying themselves and being calm in making decisions than young decision makers who are more enthusiastic and take a less detailed approach. Possibly this is also the reason why many respondents who occupy strategic positions can be categorised as older decision makers.

The second category is cognitive ability, which refers to the ability to make decisions more precisely and efficiently. In this study context, if personal attributes are related to aspects that are inherently given, cognitive abilities reflect the gradual improvement of one's abilities. In other words, cognitive abilities can be learned, trained and developed, generally through education, experience and exposure.

Educational background can influence the decision-making process. This is mainly related to the education process in both formal and informal schools that emphasise thinking and reasoning skills. These skills will ultimately help the decision makers make decisions. A similar notion was conveyed by R-1:

> *I think education too. I consider that insight will affect the way someone makes decisions. I see the higher educated, the more we enjoy reading. And it provides insights for us. Reading literature, reading news, etc. We can select which news is good as our information, which news should we dispose of. I think that this is an analysis ability.*

Besides that, experience is also one of the important factors forming cognitive abilities. It is the most frequent factor mentioned by the respondents. One of them was R-4, who said:

> *Experience I think is a factor in making decision for infrastructure project selection.*

As an element that forms a cognitive ability, experience (either good or bad) is a learning process that is obtained by making decisions. By learning through experiences, a decision maker can polish their cognitive abilities so that when experiencing similar problems in the future, they will be able to make decisions more precisely and efficiently. This was reflected by R-14's view:

> *If someone has experience in the same field, he should be better in choosing the methods and technologies to be used. It will definitely affect him.*

The last influencing factor in cognitive category is exposure ability. Different from experience, exposure refers to the state of being exposed to phenomena or experiences that ultimately affect the decision-making process. In this study, there are two ways that exposure occurs. First is through career attainment. One's career development will cause a person to be exposed to more experiences and broader new knowledge. This ultimately sharpens their cognitive abilities. This was conveyed by R-1:

> *It may also be that if we talk about experience, it means he is in a way, not a continuous experience, but gradually rising in his career, his knowledge becomes broader automatically. This means that he will make more macro decisions.*

Besides that, exposure can also occur through sharing experience/knowledge. This is done when someone asks for opinions or stories of experience from other people who have experienced similar problems before. In other words, they become exposed to other people's experience. Exposure through sharing experience/knowledge can also affect a person's cognitive abilities which ultimately affects the decision-making process. This was explained by R-16:

> *Also someone's else experience. I mean when we are sharing with others. We have this problem. ... We are sharing the experience with our friends. ... I learned more from my friend's experience.*

The third category is technical factors, which are technical aspects that influence the decision-making process. In the context of this study, technical factors are relevant to practical aspects during infrastructure project selection and prioritisation processes. These include data availability, length of time to make decisions and work setting.

Data availability can affect decision makers when making decisions. If in the decision-making process it turns out that the data to be processed as input material for consideration to assess alternatives are not available, insufficient or in poor quality, this can affect the duration of decision making and the quality of the decisions taken. R-14 claimed:

> *The less data I got, the higher risk I get. That is why in Bina Marga there is a need for data availability that must be as complete as possible.*

On the other hand, the duration to make decisions can also influence decision makers when making decisions. A duration that is too short will cause the decision makers to make decisions in a hurry. Conversely, a duration that is too long can cause decision makers to neglect to make decisions in a timely manner. The importance of determining an appropriate length of time in which to make decisions was reflected on by R-9:

> *I have targeted that every decision [I made] at the earliest three days and no later than 1 week. Because after 1 week, we will be worry that the timing of the issue will not be resolved.*

The last factor in the technical category is work setting. In the context of this study, work setting refers to the working environment that is formed in the organisation where the decision makers work. This working environment can influence the decision-making process. For example: Is there a clear infrastructure project proposal selection procedure? Has authority been clearly established? Is there a DMF or DMT that can be utilised in the infrastructure project selection and prioritisation process?

The last category is intervention, which refers to the factors that influence the decision-making process through interference. The factors included in this category are also external factors because intervention is usually from outside the FEP team or organisation involved as decision makers in selecting and prioritising infrastructure projects. This category includes political pressure, position/status and socio-cultural influences.

Intervention in the form of political pressure can certainly influence the decision-making process for infrastructure project selection. This is quite common in Indonesia, as stated by several respondents. Political pressure occurs because there are interests from political actors in Indonesia who intervene in the process of selecting and prioritising infrastructure projects. According to R-7:

> *The political biases must be considered. It must be very careful. It could be that we have tried, we have arranged a sophisticated model as possible, but at the end it is the human factor.*

Next, there is the job position/status factor. The higher the position or status of a person, the more easily they intervene and this is certainly the case in the process of selecting and prioritising infrastructure projects. Supervisors who are outside the FEP team can provide interventions related to the methods, procedures and results of the selection made. R-15 explains:

> *The supervisor will direct to A, then when the supervisor is changed, the direction is to B. So everyone has different way of thinking. According to A it is good but to B it is not, that's better. We as staffs should follow our supervisor's directions.*

If this continues to be carried out without proper justification, it can damage the existing project selection procedures.

The last is socio-cultural influences which can also influence the decision-making process. In the context of this study, socio-cultural influences refer to customs and values that become characteristic of a society. Many studies have shown that socio-cultural influences decision-making practice (Hampl 2012; Nooraie 2012; Dabić, Tipurić & Podrug 2015; Odongo 2016; Purwohedi 2017). As part of a community, the FEP team members or decision makers are influenced by local socio-cultural values that may differ from other places. This will ultimately influence decision-making processes such as: collectivism vs. individualism, dependent vs. independent decision-making manners, risk taking vs. risk avoidance, etc.

In conclusion, Finding 5 has succeeded in identifying several factors that influence the decision-making process. When viewed more broadly, these influencing factors not only influence the process of selecting and prioritising infrastructure projects but also other decision-making processes in general. Understanding these influencing factors are important to comprehending how decision makers make decisions and ultimately, what decisions are made. In other words, these factors may influence the decision-making process, which in the end, will impact the quality of decisions and outcomes.

5.4.6 Finding 6: Issues Related to the Decision-Making Framework Development for Infrastructure Project Selection and Prioritisation

Investigations conducted on the three ministries as case studies also succeeded in discovering various issues in the planning and selection of infrastructure projects in Indonesia. Identification of these issues is useful in developing a DMF for infrastructure project selection and prioritisation, which is the goal of this study. Thus, it is expected that the developed DMF should be able to respond to these issues so that it functions properly when being implemented.

Finding 6 focuses on various issues related to DMF development for infrastructure project selection and prioritisation. These issues were obtained from the interview analysis of three different ministries related to infrastructure planning and development, i.e. MNDP, MPWH and MT. To facilitate better understanding, these issues are grouped into three categories, namely: expected DMF characteristics, DMF features and future planning considerations. Figure 5.23 illustrates these three categories of DMF development issues and their subcategories.

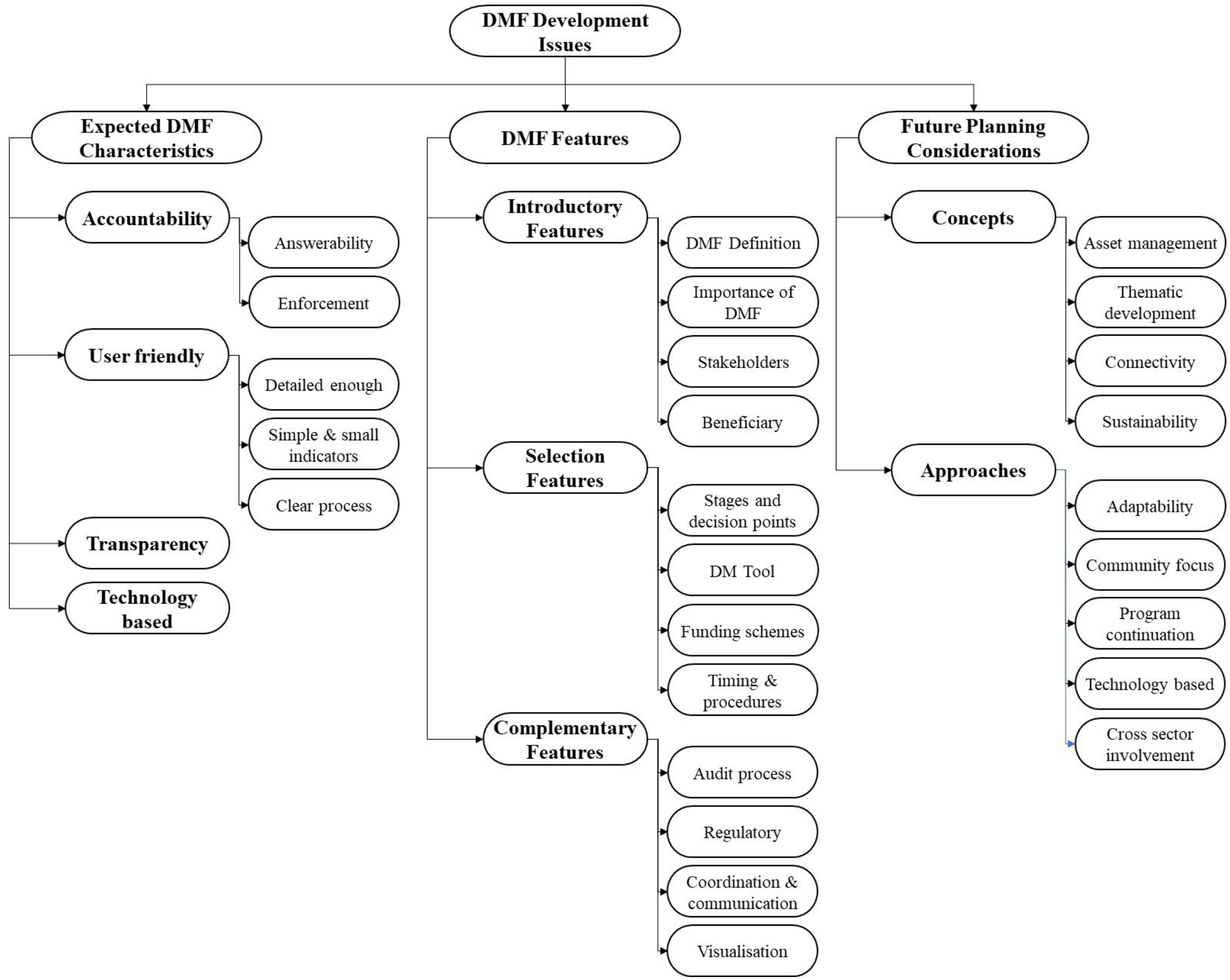


Figure 5.23 Classification of identified issues related to DMF development

The first issue is associated to expected DMF characteristics. This refers to what qualities are expected from the DMF to be developed. Here, the respondents provided four DMF characteristics that were expected to advance the performance of a DMF for infrastructure project selection and prioritisation. First is user-friendly, meaning the DMF to be developed is expected to be easily understood and used by the FEP team members or decision makers. This was conveyed by R-18:

> *Easy to be understood, easy to be implemented by the operators maybe, easy to be operated.*

This characteristic has several attributes including (Hansen, Too & Le 2020c):

(1) straightforward and clear process

The process for selection and prioritisation of infrastructure projects must be clear and straightforward. The DMF interface should be simple.

(2) detailed enough

The process should be detailed enough and includes key points so that users easily understand the intent of each point.

(3) simple and small indicators

The selection criteria should be small and simple.

A user-friendly DMF is one that aims to provide a good user experience. In addition, a user-friendly DMF will also facilitate the introduction and implementation of DMF to the FEP teams or decision makers so as to minimise the potential for rejection.

The second characteristic is accountability. In this study context, this refers to the responsibility of the parties involved in the decision-making process for infrastructure project selection. This is important considering the process of selecting and prioritising infrastructure projects uses public funds and involves many parties. Therefore, clarity about who is responsible and their accountability needs to be stated in DMF documents (Hansen, Too & Le 2020c). There are two elements of accountability:

(1) answerability

In the decision-making process, decision makers must be able to explain why the decision is taken. R-17 said:

Accountable as well. For example, province A got this much budget. Now we should be able to answer it why.

This can be done by providing information and justification regarding the outcome of the decision.

(2) enforcement

The results of the selection decision must be able to be enforced, meaning that all parties must be subject to, accept and execute the results of the decision.

The third characteristic is transparency which will allow accountability as well. In the context of this research, transparency refers to the FEP team or decision makers allowing other people to see and understand how they arrive at selection decisions. This will ensure that the FEP team or decision makers have conducted the decision-making process in an honest way. The importance of transparency was conveyed by several respondents including R-12:

> *Transparency is needed in carrying out prioritisation activities. Transparency here means transparency in the process and transparency in terms of data or information. ... Awareness of the importance of transparency in each process will play an important role in supporting the prioritisation of infrastructure projects to be effective and efficient.*

However, this does not mean all data and information should be made publicly available because some types of data and information are confidential. The most important information that should be made publicly available is a correct and clear procedure for selecting and prioritising infrastructure projects. Having a DMF that is able to provide this contributes significantly to transparency.

The last characteristic is technology based. Considering the current technological developments, it is expected that the DMF for infrastructure project selection and prioritisation can also utilise the application of technology (Hansen, Too & Le 2020c). Some forms of technology utilisation in the process of selecting and prioritising infrastructure projects may include:

- develop a DMF for infrastructure project selection that provides a DM tool based on proven MCDM techniques

- develop a system for collecting data or information online: for example, submitting infrastructure project proposals online
- developing a DMF for infrastructure project selection in the form of a software application

The second issue is related to DMF features. In the context of this study, features refer to the important parts of the DMF for infrastructure project selection. These features must be available in a DMF so that the decision-making process can run well and provide optimal results. Thus, identifying features are essential in the development of DMF for infrastructure project selection. The results of the analysis provide three sub-categories of DMF features, namely: introductory features, selection features and complementary features (Hansen, Too & Le 2020c).

Introductory features refer to important features in the introduction section of the DMF. As an introduction section, these features aim to explain at least four aspects, namely: definition of the DMF, importance of the DMF, who the stakeholders involved are and who the beneficiaries of this DMF decision are.

It is important to convey the definition for the DMF in the DMF or DMT document so that users (the FEP team or decision makers) understand the intent and purpose of providing the DMF. In this study, the DMF is interpreted as a structured and systematic approach to problem solving and decision making in complex situations that serves as a guide for decision makers in achieving their organisational objectives and goals. It covers several aspects that assist in the process of selecting and prioritising infrastructure projects, including selection stages and selection criteria.

In addition to defining the DMF, it is crucial to emphasise the importance of the DMF for infrastructure project selection and prioritisation. The DMF is needed to bridge the effective decision-making process between multiple decision makers involved in infrastructure project planning and selection. It is a vital managerial tool used to select and prioritise various infrastructure project proposals. By using the DMF, decision makers will more easily be able to reach a high-quality decision, i.e. which projects are selected and prioritised. Without the presence of the DMF, the selection process will not be easily measured and carried out, increasing the risk of making the wrong decision (i.e. inappropriate project selection, which leads to inappropriate budget allocation). In fact, all respondents who were asked stated that it was important to have DMF for infrastructure project selection and prioritisation.

The stakeholders involved also need to be explained in the introduction section. In the process of selecting infrastructure projects in Indonesia, the key stakeholder is the central government consisting of strategic ministries such as MPWH and MT. In addition, the selection process can also involve local governments, funding agencies, public communities and private sector companies interested in investing in infrastructure development. Since the process of selecting and prioritising infrastructure projects involves many parties, the DMF must identify who the stakeholders may be and the extent to which they are involved in each stage of the selection and prioritisation process.

Finally, beneficiaries from the results of the decision on the selection of infrastructure projects also need to be delivered. As a DMF that aims to select and prioritise infrastructure projects, the beneficiary in general is the public community, as well as the private sector. This is important to emphasise especially for infrastructure projects that use public funds.

Next, there is a selection features sub-category that refers to key features that must be available in the DMF. This feature is important because it answers the purpose of this study, namely developing a DMF that can be used to select and prioritise infrastructure project proposals in Indonesia. Without the selection features, the DMF developed will not be able to serve this purpose. There are at least four key features included in the selection features, namely: selection stages and decision points, Decision-Making Tool (DMT), timing and procedure, and funding schemes (Hansen, Too & Le 2020c).

Selection stages and decision points are important features in the selection process. In the context of this study, selection is interpreted as the process of sorting and selecting the right infrastructure project proposals that meet the requirements for funding and execution. This process also includes the stages of prioritisation. In practice, there are various selection stages to adjust the needs of the organisation. For example, R-11 proposed a selection process in the DMF consisting of two stages, namely: economic assessment followed by financial assessment, while R-19 proposed two stages of selection in the form of stage 1 (needs assessment) and stage 2 (further studies).

However, all of these selection processes have a systematic procedure for selecting and prioritising alternatives so that a selection decision can be made. To simplify the process, a decision points or decision gates are provided at the end of each stage during the selection process.

Another important feature in the selection process is the Decision-Making Tool (DMT). This feature was the most frequently mentioned by respondents including R-7, R-12 and R-19. It is used to assist decision makers in making decisions based on an established systematic selection procedure. Although it usually employs quantitative techniques, the DMT can also be developed using qualitative techniques (such as decision trees, expert judgment and the Delphi technique). In the context of this study, the DMT will be developed using a quantitative approach based on Multi-Criteria Decision-Making (MCDM) techniques such as AHP, NSFDSS and Electre. This is because the process of selection and prioritisation of infrastructure projects involves many stakeholders to assess various project proposals against multiple criteria. Thus, there are two aspects that must be addressed in the DMT, i.e. which MCDM technique is to be employed and what the selection criteria to be used are.

Furthermore, other features that must be available are timing and selection procedures. This feature is important to ensure that the mechanism for selecting and prioritising infrastructure projects can run smoothly. In practice, all decision-making processes will require clear timing and procedures. This was also expressed by R-13:

> *In the framework, of course it must be clear when the proposal period and when the approval is made, ...*

If the duration of decision making is too short, this can cause the process to be reckless, while if the duration is too long, this can cause delays in decision making and loss of momentum, each of which will eventually lead to poor decisions. Determining the right duration of the decision-making process for infrastructure project selection will depend on three aspects:

(1) availability of information
    The amount of data and information available to be processed before a decision is made affects the duration of decision-making process.

(2) availability of time resources
    The amount of time available to make a decision-making process also affects the quality of the decision. The time pressure factor (the presence of deadlines) can cause decision makers to make decisions in a hurry. Likewise, if time resources are too extensive, this does not necessarily produce better decisions.

(3) clarity of selection procedures

Clarity of selection procedures can also affect the decision-making process. Internal procedures for selecting and prioritising infrastructure projects must be established to ensure that the process flow runs smoothly.

Finally, the selection features also include funding schemes. This refers to options to finance a project. In the selection and prioritisation process, different selection weights can occur in different funding schemes, such as if the project is fully funded from the state budget, PPPs, or the private sector. This was conveyed by R-4:

> *Yes, so can it be funded using available budget, whether it will be fully funded from national budget, or by PPP, partnership between government and private company, or can it be fully funded by the private company.*

The last subcategory in the DMF features is complementary features. This refers to features that complement the two prior features in the DMF for infrastructure project selection. With these complementary features, DMF's performance will be better and make it more comprehensive in assisting decision makers to make high quality decisions. In other words, these features make the DMF more complete (Hansen, Too & Le 2020c).

Having an audit process is an important feature as a complement to the DMF. Although this feature is not directly related to the selection and prioritisation process of infrastructure projects, it is useful for ensuring that all of the processes and selection procedures in the DMF have been properly and correctly carried out by its users. This is similar to what was conveyed by R-1:

> *Actually, in my opinion, the audit process is necessary to ensure that the entire framework is implemented well, that all parties are indeed involved and know how.*

This audit process covers all stages of the selection and prioritisation of infrastructure projects, starting from the beginning until a decision is made regarding the list of priority projects. It can be carried out by a special team that handles the audit process.

Next, clear coordination and communication must also be established in the DMF. This is due to the large number of stakeholders involved in the selection and prioritisation process, meaning synchronisation of different responsibilities and interests is required. Both are key management processes in decision-making practice. Identification of stakeholder involvement at each stage of infrastructure project selection is critical. In this case, good coordination arises from good communication. The importance of understanding this feature was conveyed by several respondents, one of which was R-15:

> *The feature maybe the involvement of all elements. So, the communication between ministries, departments must exist. So far, it is like fragmented. I think it is important.*

Another complementary feature that must be available in the DMF according to some respondents is the regulatory feature. This feature has two aspects. First, that the entire process of selection and prioritisation of infrastructure projects as contained in the DMF must be in accordance with applicable laws and regulations. Here, the DMF for infrastructure project selection must be devised in a way that considers other existing regulations related to infrastructure development in Indonesia. This was affirmed by R-19:

> *It should be opened and in accordance with the applicable regulations.*

The second aspect of regulatory feature is that the DMF for infrastructure project selection must be a standard practice and become a guideline for planning infrastructure development that is also authorised as part of regulation. Until now, there has been no standard DMF for infrastructure project selection in Indonesia. Each ministry, department and agency has their own procedures for selecting infrastructure projects, which are not necessarily put through the correct DMF establishment and development process. By becoming part of regulation, the DMF for infrastructure project selection can ensure the involved stakeholders utilise and standardise their selection and prioritisation methods in order to increase the efficiency of the decision-making process and provide high-quality decisions.

The last complementary feature is visualisation. Visualisation is an important technique to present data and information to users so these are easily understood. In the context of this research, data visualisation will help decision makers in selecting and prioritising infrastructure projects, while decision visualisation will assist stakeholders to understand the results of the selection process. R-9 noted:

> *The feature that I think is important is how this planning can be visualised. Usually these people, our people in my opinion will understand better something that is shown visually.*

Although visualisation is often presented in a graphical display of data or information, the purpose of providing visualisation is to gain insights from the information displayed. Visualisation is a feature to help decision makers make decisions efficiently because, when data are properly visualised, they become easier to read and understand. Thus, there are several benefits of this feature:

- visualisation can bridge the gap between data and insights: for example, what types of infrastructure projects are highly dependent on land acquisition?
- visualisation can establish patterns and relationships: for example, why do water management related infrastructure projects receive smaller budget approval than transport infrastructure projects?
- visualisation can predict trends: for example, what is the annual trend of funding schemes for infrastructure projects?

The last issue is related to future planning considerations. In the interview session, several respondents gave their responses regarding several future planning considerations. Although not directly related to the current process of selecting and prioritising infrastructure projects, these considerations may have an effect on the future selection process in Indonesia. The results of the analysis produce two sub-categories of future planning considerations, namely: concepts and approaches.

The first subcategory is concepts. In the context of this study, this refers to the fundamental concepts and theories in planning infrastructure projects. In Indonesia, some of these planning concepts have actually been considered, even though their implementation has not been fully completed in terms of quality and quantity. These include asset management, connectivity, sustainability and thematic development.

Managing infrastructure as an asset is actually not a new concept in Indonesia. However, in the context of infrastructure development planning, infrastructure asset management rarely receives attention. Indonesia's development planning system tends to focus on building new infrastructure as a new asset. Meanwhile, all the infrastructure that has been built and become physical assets must be operated and maintained so that they can function properly. The importance of infrastructure asset management in planning future infrastructure development was confirmed by R-2:

> *In the future, with the decline of projects, it will certainly go to asset management. We have to be ready to go there.*

Similarly, efforts are needed to integrate this aspect into the new infrastructure selection process. Integration between the new infrastructure development and the existing infrastructure also must be considered. This is related to connectivity between the planned infrastructure and other existing infrastructure. Infrastructure connectivity plays an important role in bridging various regions in Indonesia, which face their own challenges as part of the largest archipelago country. Infrastructure development as a physical asset must be connected in order to increase regional economic growth.

Another concept that should be taken into consideration in planning future infrastructure development is thematic development. In the context of this study, thematic development refers to the efforts of infrastructure development to pay attention to the advantages of each region. The advantages of each region are further developed into nodes based on their themes. This strategy has been implemented by MPWH through BPIW. They have established thematic development as an infrastructure planning strength not found in other government agencies in Indonesia. They introduced the Strategic Development Regions (WPS/*Wilayah Pengembangan Strategis*), which were based on the potential advantages of regional development. However, the concept of infrastructure thematic development still faces challenges and has not been fully integrated in all aspects of infrastructure planning and development in Indonesia.

Finally, the last concept for future planning is sustainability. It also includes environmental protection aspects. Future infrastructure development must pay close attention to the sustainability of the projects and their impact on the environment. Infrastructure development that aims to improve people's welfare can have negative impacts on the environment if not planned properly. Integrated infrastructure planning should consider indicators of sustainable infrastructure development such as local economic growth, availability of infrastructure budgets, availability of clean water systems, air quality and community participation.

The second category is approaches, which refers to various methods of infrastructure development planning. The application of these approaches is the part of a strategic planning that aims to utilise resources to achieve development goals. Based on the results of the interview analysis, five approaches were found to be considered in future infrastructure planning, namely: adaptability, community focused, program continuation, technology based and cross sector involvement.

Adaptability is defined as the ability of a planning system to adapt itself efficiently. In the context of this study, infrastructure planning system and its outcomes (selection decisions) are expected to adapt efficiently and quickly to changed circumstances. The most important elements of adaptability are flexibility and responsiveness. The first refers to the degree to which adjustment occurs easily and quickly, while the latter refers to the ability to respond to a change quickly. R-19 illustrates:

> *Maybe the government should be more responsive with the people's condition, be responsive with the developing technology, and be anticipative. Don't let the problem occurred and then create the rules. The government should also think in the long term, what are the possibilities in the next 5 years, 10 years, 20 years; what kind of technology, what kind of people are there. Be more responsive, faster. The regulations must be able to develop as well. If there is a change, the government should become more responsive and adjust it faster.*

The second is a community-focused approach to infrastructure development planning. Infrastructure are public assets that aim to improve people's welfare. Therefore, infrastructure planning must focus on community needs as stated by R-13:

> *The first consideration is that the project must be a community need for both short and long terms. If the project is not needed by the community, it will be of less use.*

Although this is a general approach that should be carried out, in practice it is quite common for infrastructure development to not be based on community needs. Here, political interests and sectoral ego play a crucial role in the selection process of infrastructure projects. The result is inappropriate budget allocations and community dissatisfaction because the built infrastructure does not fit their needs.

The third approach is program continuation. It refers to continuation of infrastructure planning and development over time. It is quite common to find large-scale and massive infrastructure projects so that planning is not possible at one time. These large infrastructure projects usually require planning and development in stages. This is an important factor in the process of selecting and prioritising infrastructure projects, which are usually carried out annually. Thus, program continuation of these large projects must be prioritised in the selection process. Otherwise, the program that has been implemented is not completed as a whole, so it does not provide maximum benefit.

The fourth approach offered by respondents is technology-based planning. Future infrastructure planning must consider the use of technology in the process of selection and prioritisation. By utilising technology, the planning and selection process will run more quickly, efficiently and transparently. A similar idea was conveyed by R-19. In addition, the use of environmentally-friendly technology to build infrastructure can also be an added point in project selection.

The last approach is cross sector involvement. The involvement of cross sector involvement will be increasingly crucial in the future infrastructure development planning process. This was stated by several respondents including R-6, R-18 and R-19. Various efforts have been made by the government to increase private sector involvement in infrastructure development: for example, by initiating PPP projects to be offered to the private sector.

However, the government has not yet focused on involving public community. So far, community involvement is still limited to participation in the execution of government programs or activities (as workers or contractors), even though community participation is not only needed during execution, but also starts from the planning and decision-making phase. Here, the government must be aware of the importance of community involvement in the process of planning and selecting infrastructure projects, including, among others: (1) to get public support for infrastructure project development plans, (2) as a strategy to obtain input from the community (because the community has the right to be consulted), (3) as a strategy for disseminating infrastructure project plans and (4) as a strategy in resolving disputes. Thus, it is expected that community reluctance or rejection of the planned infrastructure projects can be detected early.

5.5 Chapter Summary

This chapter has provided a detailed description of the current decision-making practices of infrastructure project selection and prioritisation in the Indonesian context. It has investigated the challenges, effects and solutions of these current practices from three different ministries. Additionally, it has also succeeded in identifying criteria for infrastructure project selection and prioritisation. Considering decision makers are also influenced by several factors during the selection and prioritisation process, this chapter has established four categories of influencing factors. Finally, this chapter has also described in detail several issues related to DMF development. The next chapter will present the establishment of selection criteria based on the quantitative approach.

CHAPTER 6. ESTABLISHMENT OF SELECTION CRITERIA FOR INFRASTRUCTURE PROJECT SELECTION AND PRIORITISATION

6.1 Introduction

This chapter presents the quantitative data analysis and findings garnered from the questionnaire responses. It focuses on establishing infrastructure project selection criteria using larger respondents in Indonesia. As a quantitative approach, this chapter emphasises objective statistical measurements of data collected through questionnaire distributions. Exploratory Factor Analysis (EFA) was used to analyse the data and this was conducted using IBM SPSS Statistics 26 software. The objectives of conducting this analysis are: (1) to validate the identified selection criteria (from the literature review and interview analysis) based on a large number of respondents in Indonesia and (2) to refine the selection criteria based on questionnaire responses. Thus, the findings contributed to the development of a Decision-Making Framework (DMF) by identifying the key selection criteria that will be used as inputs in the assessment process.

6.2 Identification of Preliminary Set of Selection Criteria

According to Purnus and Bodea (2014), it is crucial to establish a list of project selection criteria before various project alternatives can be evaluated. Since this research is a comprehensive study that applies conceptualisation and contextualisation to identify selection criteria for infrastructure project proposals, the identification of selection criteria involves three stages: integrative literature review, semi-structured expert interviews and questionnaire survey. First, through an integrative and systematic literature review of previous publications, this study has identified 34 criteria for the infrastructure project selection and prioritisation problem as presented in Table 6.1 (Hansen, Too & Le 2019).

Table 6.1 Identification of infrastructure project selection criteria based on desktop study

No	Criteria	Description	References
1	Needs and purposes	assesses the need and purpose of a project	CDIA (2010), Infrastructure Australia (2018), Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013)
2	Consistency	assesses the conformity of the proposed project to the National Development and Defence Goals	Infrastructure Australia (2018), KPPIP (2016)
3	Government priority	assesses the significant impacts of the proposed project on the national economy at the central and regional levels	Infrastructure NSW (2016), KPPIP (2016)
4	Investment studies	relates to the feasibility and other investment studies required during a project planning process	Frame (2003), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Queensland Treasury (2015), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013), Blocksidge and Zurawski (2007), Cheung and Chan (2009)
5	Economic issues and impacts	examines the issues and effects of a project on the economy	CDIA (2010), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013)
6	Social issues and impacts	examines the issues and effects of a project on the well-being of the community	CDIA (2010), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013), Doloi (2012), Shiau (2014)
7	Environmental issues and impacts	examines the issues and effects of a project on the environment. It mainly focuses on environmental protection	CDIA (2010), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013), Doloi (2012)
8	Team member and stakeholder coordination	assesses the positive alliance among all key stakeholders and team members of a proposed project	Infrastructure NSW (2016), CII (2013)
9	Public involvement	assesses the level of public involvement as well as public attitudes regarding the proposed project	CII (2013), Goodrum, Wan and Fenouil (2009)
10	Good governance	assesses the level of good governance implementation	OECD (2015)

11	Design philosophy	examines the general design principles to ensure a successful project	Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013), Blocksidge and Zurawski (2007)
12	Operating philosophy	examines 'the level of service desired at a sufficient capacity over an extended period of time'	Queensland Treasury (2015), Yadollahi and Zin (2011), CII (2013)
13	Maintenance philosophy	examines the 'guidelines to maintain adequate and safe operations over an extended period of time'	Queensland Treasury (2015), Yadollahi and Zin (2011), CII (2013)
14	Future expansion	assesses the possibility of expansion and/or alteration of the proposed project	CII (2013)
15	Innovation	assesses the degree of innovation of the proposed project throughout its life cycle	Goodrum, Wan and Fenouil (2009)
16	Risks	assesses the level of risks and uncertainties involved of the proposed project	Infrastructure Australia (2018), Yadollahi and Zin (2011), CII (2013)
17	Contractual conditions and procurement model	examines the contractual conditions and procurement model that the proposed project might take into consideration	Frame (2003), Infrastructure Australia (2018), Infrastructure NSW (2016), Cheung and Chan (2009), Sciulli (2008), Iyer and Balamurugan (2006)
18	Funding and programming	assesses the sources of funding provided for the proposed project	Queensland Treasury (2015), CII (2013), Cheung and Chan (2009), Sciulli (2008), Iyer and Balamurugan (2006)
19	Preliminary project schedule	analyses the preliminary schedule of the proposed project	Queensland Treasury (2015), Le et al. (2014)
20	Contingencies	examines the allocated contingencies in order to mitigate project's risks	CII (2013)
21	Project objectives statement	assesses the proposed project objectives and priorities	CII (2013)
22	Functional classification and use	examines the functionality of the proposed project	Queensland Treasury (2015), CII (2013)
23	Evaluation of compliance	analyse the adherence requirements of the proposed project to various existing plans, standards and regulations	CII (2013)
24	Existing environmental conditions	examines the existing environmental conditions to enable better decision making and allow adequate time to address and mitigate any problem arise	Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013)
25	Site characteristics	assesses 'the discrepancy between the available site characteristics and the required site characteristics'	Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013)
26	Dismantling and demolition	evaluates the dismantling and demolition requirements of the proposed project	CII (2013)
27	Determination of utility impacts	analyses 'the adjustment of utilities to accommodate the design and construction of the proposed project'	CII (2013)

28	Work force	assesses the work force requirement of the proposed project	Frame (2003), Lindhard and Wandahl (2013)
29	Resource handling and utilisation	examines the resource handling and utilisation	Frame (2003), Lindhard and Wandahl (2013), Blocksidge and Zurawski (2007)
30	Scope of work	examine the scope of work of the proposed project whether it has been developed or not	CII (2013)
31	Value engineering procedures	assesses whether the proposed project has followed a VE procedure or not	CII (2013)
32	Design simplification	identifies strategies to reduce the number of process steps or the amount of equipment needed in the design	CII (2013)
33	Material alternatives	considers material alternatives for the proposed project	CII (2013)
34	Constructability procedures	assesses the level of constructability of the proposed project	Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013), Blocksidge and Zurawski (2007), Goodrum, Wan and Fenouil (2009)

These 34 criteria identified from the literature review can be further grouped into five main categories, i.e. strategic fit, owner philosophies, project funding and timing, project requirements and value engineering. Strategic fit refers to criteria that will address project strategic issues. It consists of criteria number 1 to 10. Owner philosophies is related to criteria that provide necessary information to understand the project from the owner's perspective. It consists of criteria number 11 to 17. Project funding and timing deal with specific project goals related to funding and timing. It consists of criteria number 18 to 20. Project requirements provide necessary information regarding project requirements and consist of criteria number 21 to 30. Finally, value engineering examines project function in order to enhance its value. It consists of criteria number 31-34.

Identification of selection criteria through integrative literature analysis is the first important step in establishing appropriate criteria for infrastructure project selection. Contextualisation follows by conducting expert interviews which was discussed in Chapter 5. The findings of the literature review and expert interviews were synthesised based on their similarities and scope of the terms as used in the Indonesian context, to establish a set of 23 preliminary selection criteria as shown in Table 6.2. These 23 criteria were then measured statistically through questionnaires and analysed using EFA to determine the key selection criteria in infrastructure project proposals.

Table 6.2 Preliminary set of infrastructure project selection criteria in the Indonesian context

No	Criteria	Literature review sources	Interview analysis
I	**Strategic Fit**		
1	The needs	CDIA (2010), Infrastructure Australia (2018), Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013)	*identified*
2	Conformity	Infrastructure Australia (2018), KPPIP (2016)	*identified*
3	Risk	Infrastructure Australia (2018), Yadollahi and Zin (2011), CII (2013)	*identified*
4	Urgency	-	*identified*
5	Private sector & community involvement	CII (2013), Goodrum et al. (2009), Sciulli (2008), Iyer and Balamurugan (2006), Wan and Fenouil (2009)	-
6	Good governance	OECD (2015)	-
II	**Politics & Policy**		
7	Local government issues	-	*identified*
8	Policies	Infrastructure NSW (2016), KPPIP (2016)	*identified*
9	Politics	-	*identified*
III	**Project Requirements**		
10	Innovation/added value	CII (2013), Goodrum et al. (2009)	*identified*
11	Design readiness	Queensland Treasury (2015), Yadollahi and Zin (2011), CII (2013), Lindhard and Wandahl (2013), Blocksidge and Zurawski (2007), Goodrum et al. (2009)	*identified*
12	Funding & financing	Queensland Treasury (2015), CII (2013), Cheung and Chan (2009), Sciulli (2008)	*identified*
13	Preliminary & feasibility studies	Frame (2003), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Queensland Treasury (2015), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013), Le et al. (2014), Blocksidge and Zurawski (2007), Cheung and Chan (2009)	*identified*
14	Technology readiness & transfer	Frame (2003), Lindhard and Wandahl (2013), Blocksidge and Zurawski (2007)	*identified*
15	Land acquisition	-	*identified*
16	Team member & stakeholder coordination	Infrastructure NSW (2016), CII (2013)	-
17	Operational & Maintenance readiness	Queensland Treasury (2015), Yadollahi and Zin (2011), CII (2013)	-
18	Contractual conditions & procurement model	Frame (2003), Infrastructure Australia (2018), Infrastructure NSW (2016), Cheung and Chan (2009)	-
19	Project scheduling & programming	Queensland Treasury (2015), CII (2013)	-

20	Project resources management	Frame (2003), Lindhard and Wandahl (2013)	-
IV	**Integration & Sustainability**		
21	Planning integration	-	*identified*
22	Existing infrastructure & utilities	CII (2013)	*identified*
23	Sustainability & environmental issues	CDIA (2010), Infrastructure Australia (2018), Infrastructure NSW (2016), KPPIP (2016), Yadollahi and Zin (2011), Quadros and Nassi (2015), CII (2013), Lindhard and Wandahl (2013), Doloi (2012)	*identified*

6.3 Questionnaire Data Collection

Questionnaire surveys have been distributed from July to November 2019. Specific groups have been targeted as respondents in this study, i.e. professionals working in the construction-related ministries, professionals working in the construction-related sector (such as contractors, consultants and developers), and professionals from construction associations and academics. Hence, this study used purposive sampling as it regards the target groups as the appropriate respondents to provide information.

The questionnaire distributions were conducted in two phases, i.e. online and offline. During the first phase (July to mid-October 2019), questionnaires were distributed using a web-based survey tool called Qualtrics (Appendix 4). The tool was provided by RMIT University and has been used frequently by researchers to analyse their survey data. After three months of distribution, it was found that the online data collection was not as effective as had been expected due to many incomplete responses. Thus, offline distribution was conducted in October and November 2019 by distributing the survey forms directly at three different events: one international conference and two workshops.

There were 302 responses in total, but only 104 responses were complete and valid for data analysis. Given the number of valid responses, the response rate was 34.44% which is within acceptable range to represent the sample (>30%) according to Sekaran and Bougie (2016). The number of valid responses is also acceptable (>100 responses) for conducting factor analysis (MacCallum et al. 1999, Hair et al. 2010). Based on the ratio calculation with the number of variables, a ratio of 4.52:1 is found which is also acceptable (Cattell 1978).

The questionnaire form consists of three parts, i.e. respondent's profile, project profile and data gathering of selection criteria. Table 6.3 presents a recap of the respondent and project profiles. Based on their educational background, 88% of the respondents majored in a construction-related discipline, while 12% of them did not. While this minority of respondents did not major in a construction-related disciplines, they have worked in the construction industry and have the necessary training and experiences to support their opinions.

Table 6.3 Questionnaire respondent and project profiles

Respondent Profiles	Number	%
Educational Background		
Construction related	92	88%
Not related	12	12%
Total	104	100%
Level of Education		
Bachelor/Diploma	68	65%
Master	26	25%
Doctoral	6	6%
Others	4	4%
Total	104	100%
Working Experience		
<5 years	48	46%
5-10 years	30	29%
10-20 years	12	12%
>20 years	14	13%
Total	104	100%
Affiliation		
Ministries & Gov. Agencies	42	40%
Contractors	11	11%
Consultants	18	17%
Others	33	32%
Total	104	100%
Current Job Position Level		
Staff/executor	50	48%
Junior manager/supervisor	16	15%
Senior manager/supervisor	13	13%
Head of department/director	12	12%
Others	13	13%
Total	104	100%

Project Profiles	Number	%
Project Type		
Railways	5	5%
Airports	4	4%
Dams, flood controls	8	8%
Ports	2	2%
Buildings	26	25%
Roads, bridges & toll roads	45	44%
Power plants	3	3%
Others	10	10%
Total*	103	100%
Project Amount		
<IDR 50 billion	35	34%
IDR 50 - 100 billion	8	8%
>IDR 100 billion	60	58%
Total*	103	100%
Project Duration		
<12 months	39	38%
12-24 months	25	24%
>24 months	39	38%
Total*	103	100%
Project Status		
On-going	50	49%
Completed	53	51%
Total*	103	100%

**there is 1 response that did not provide project description*

Regarding level of education, the majority of respondents had attained an undergraduate education (65%), while the rest had attained a postgraduate degree (31%), with the remainder of 4% having other education levels. Almost half of the respondents have working experiences of fewer than five years (young professionals), having just started their careers in the construction industry as project staffs. Meanwhile, based on their affiliations, the results show that 40% of the respondents work at the ministries and government agencies, while the rest work at contractor companies (11%), as consultants (17%), or others (32%). Figure 6.1 presents the survey respondent profiles.

Figure 6.1 Questionnaire respondent profiles

In terms of the project profiles, the majority of the respondents (55%) provided their opinions based on transport projects (railways, airports, roads, bridges, ports, and toll roads). The remainder offered their opinions based on their experiences in building projects (25%) and other projects (20%), such as dams, flood controls, power plants, etc. More than half of these projects were worth more than IDR 100 billion, while 34% were worth less than IDR 50 billion and 8% were in between. In terms of project duration, projects with a duration of less than a year and more than two years were equal with 38% each respectively, while projects with a duration between one to two years was 24%. Finally, in regard to project status, half of them (51%) have been completed while the remainder (49%) are still on-going (as per the date of filling out the responses). Figure 6.2 presents the project profiles based on the survey.

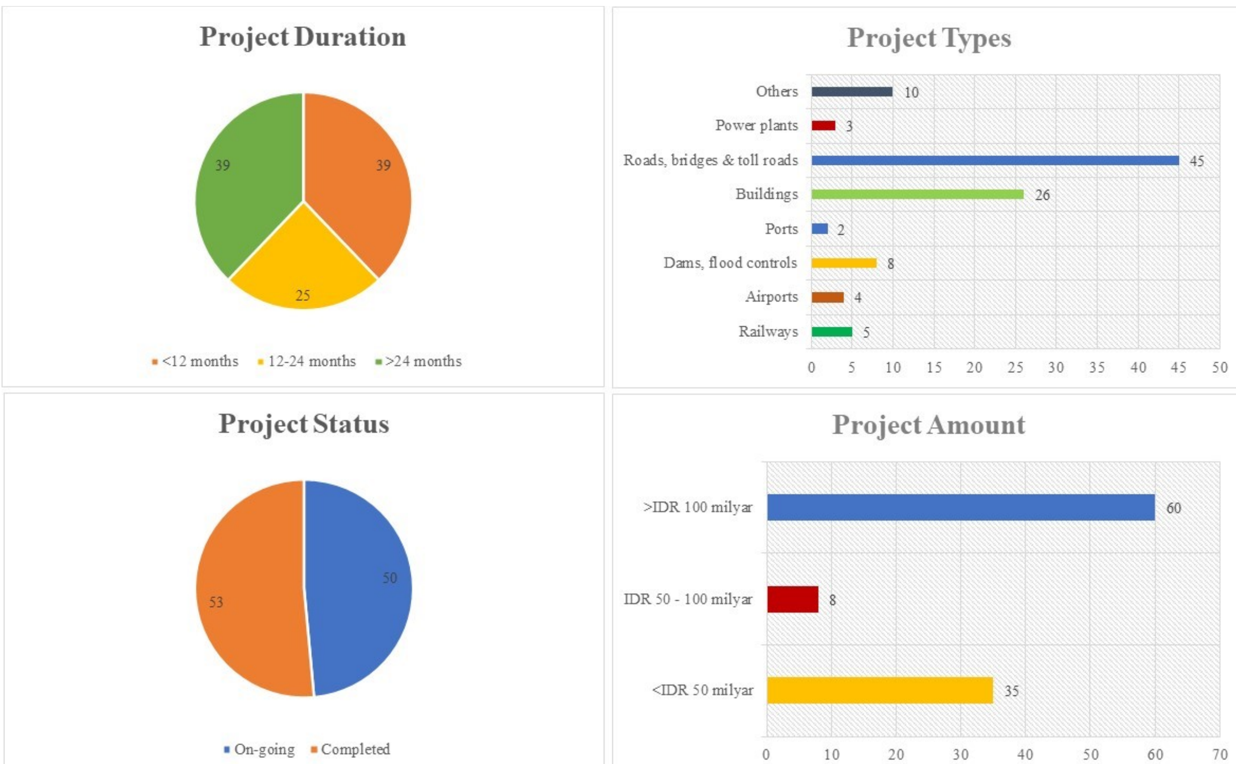


Figure 6.2 Project profiles

6.4 Questionnaire Methodology and Data Analysis

To understand the flow of the quantitative approach adopted in this study, Figure 6.3 presents the surveying steps in detail. It starts with identification of selection criteria based on the qualitative approaches previously completed, i.e. integrative literature review and semi-structured expert interviews. The identified selection criteria were reviewed, combined and discussed with other academics before they were included in the survey. The questionnaire was then developed using a web-based platform and tested on five professionals to ensure its face and content validity. The feedback was reviewed so that the questionnaire model could be refined and improved.

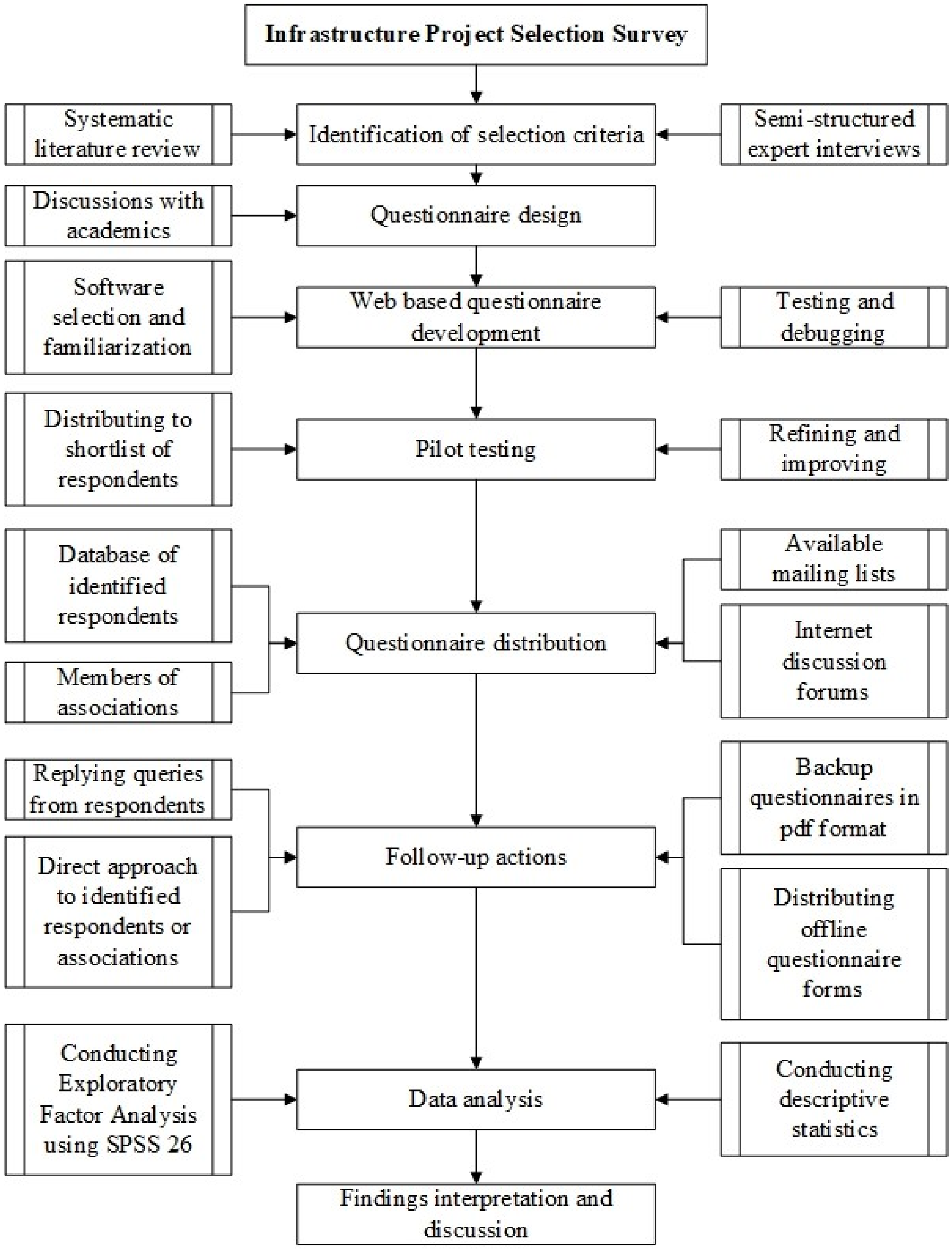


Figure 6.3 Surveying methodology adopted in this study

6.4.1 Validity Assessment of Input Criteria

The first step of analysis was to check the validity of the selection criteria in infrastructure project proposals based on the majority opinion of the respondents in Indonesia. For this purpose, a weighted arithmetic mean or average index can be utilised. Since a 10-point Likert scale was used, it can be calculated using the Equation 2.

Equation 2: Average Index

$$Av.I = \frac{\sum_{i=1}^{10} a_i * x_i}{\sum_{i=1}^{10} x_i}$$

where,

$Av.I$ = average index

a_i = constant expressing the weight given to i

x_i = variable expressing the response score for i

To identify the value of the majority opinions from respondents, a Likert scale classification was developed to capture responses, as shown in Table 6.4.

Table 6.4 Likert scale classification adopted in this study

Scale Level	Default value	Value range
Unimportant	1-2	1.00 ≤ Value < 2.50
Less important	3-4	2.50 ≤ Value ≤ 4.50
Moderately important	5-6	4.50 ≤ Value ≤ 6.50
Important	7-8	6.50 ≤ Value ≤ 8.50
Very important	9-10	8.50 < Value ≤ 10.00

A Top Box method was used to summarise the positive responses from the survey data. It combines the highest two scale levels (two top boxes) to reflect the most favourable values on the scale. According to Table 6.4, values equal to or greater than 6.50 indicate the positive responses of “important” and “very important”. The average index values shown in Table 6.5 fall in these two positive ranges. Hence, all selection criteria were validated by the majority opinions of respondents. Therefore, all criteria were used in the next phase of data analysis, i.e. exploratory factor analysis.

Table 6.5 Distribution of response data and results of validity check

Criteria		Scale										Total	Total Weights	Average Index	Validated or not
		1	2	3	4	5	6	7	8	9	10				
F1	The Needs	0	0	0	1	3	4	12	30	18	36	104	889	8.55	Yes
F2	Conformity	0	0	0	0	3	5	12	25	22	37	104	897	8.63	Yes
F3	Risks	1	1	0	0	6	7	14	30	26	19	104	837	8.05	Yes
F4	Urgency	0	0	0	3	5	7	19	18	20	31	103	846	8.21	Yes
F5	Private Sector & Community Involvement	0	2	1	2	6	7	19	29	19	19	104	813	7.82	Yes
F6	Good Governance	0	1	1	1	5	5	12	38	23	18	104	839	8.07	Yes
F7	Local Government Issues	1	2	0	2	4	6	21	26	24	18	104	820	7.88	Yes
F8	Policies	0	1	1	1	2	6	17	34	28	14	104	838	8.06	Yes
F9	Politics	5	0	4	6	11	15	10	25	14	14	104	722	6.94	Yes
F10	Innovation/Added Value	0	0	1	2	6	9	18	31	19	18	104	820	7.88	Yes
F11	Design Readiness	0	0	2	2	3	1	5	22	30	39	104	906	8.71	Yes
F12	Funding & Financing	0	0	3	1	2	5	8	17	22	46	104	903	8.68	Yes
F13	Preliminary & Feasibility Studies	0	0	2	1	3	2	11	17	34	34	104	896	8.62	Yes
F14	Technology Readiness & Transfer	0	0	2	1	5	10	20	27	22	16	103	809	7.85	Yes
F15	Land Acquisition	2	2	4	0	1	3	5	15	21	50	103	885	8.59	Yes
F16	Team Member & Stakeholder Coordination	2	0	1	1	2	6	6	19	31	35	103	878	8.52	Yes
F17	Operational & Maintenance Readiness	0	2	0	0	4	5	9	30	26	27	103	861	8.36	Yes
F18	Contractual Conditions & Procurement System	0	1	1	1	2	3	9	22	29	35	103	887	8.61	Yes
F19	Project Scheduling & Programming	2	0	0	0	4	3	11	19	32	32	103	877	8.51	Yes
F20	Project Resources Management	0	2	0	0	0	3	9	30	34	25	103	881	8.55	Yes
F21	Planning Integration	0	0	2	1	1	3	11	25	28	31	102	872	8.55	Yes
F22	Existing Infrastructure & Utilities	1	0	2	3	0	9	11	30	23	24	103	837	8.13	Yes
F23	Sustainability & Environmental Issues	0	0	1	1	3	4	15	26	22	31	103	867	8.42	Yes

6.4.2 Factor Analysis of Selection Criteria

In this study, EFA was used to pinpoint the most critical criteria of infrastructure project selection from a large number of identified criteria. The standard procedures for EFA includes five steps: (1) assessment of data suitability, (2) determination of factor extraction method, (3) justification of factor rotation, (4) interpretation and discussion and (5) reliability check. The result of this analysis is a valid and reliable selection criteria list.

Step 1: Assessment of data suitability

Assessment of data suitability is a preliminary analysis to be performed before conducting a factor analysis. It can be determined from the factorability of the correlation matrix, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The factorability of the correlation matrix should be used since it exhibits the relationships between individual variables (Williams, Onsman & Brown 2010). A correlation coefficient of 0.30 is the minimum value recommended by Tabachnick and Fidell (2013). This indicates that the factors account for an approximately 30% relationship within the data. If no correlation coefficients go beyond 0.30, the researcher should reconsider whether factor analysis is suitable for the data analysis (Williams, Onsman & Brown 2010). Hair et al. (2010) further categorise these coefficients as ≥0.30 (minimal), ≥0.40 (important) and ≥0.50 (practically significant). Field (2005) notes that variables with fewer correlations with other variables should be excluded before conducting the factor analysis. On the other hand, variables that are highly correlated (extreme multicollinearity) and variables that are perfectly correlated (singularity) must be avoided when conducting factor analysis.

The next step was to check the sample's adequacy for factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling can be used to check the adequacy of the sample (Field 2017). The KMO index ranges from 0 to 1, with 0.50 considered barely acceptable for conducting factor analysis (Kaiser 1974). Further, Hutcheson and Sofroniou (1999) provide detailed ranges for the KMO index acceptability level, as presented in Table 6.6.

Finally, Bartlett's test of sphericity was carried out to examine whether the correlation matrix resembles an identity matrix. If the correlation matrix resembles an identity matrix, this means that every variable poorly correlates with the other variables (Field 2017). Thus, Bartlett's test should be significant ($p<.05$) for factor analysis to be suitable (Pallant 2007).

Table 6.6 Acceptability level of KMO index value ranges

KMO value range	Acceptability level
0.500 – 0.700	Mediocre
>0.700 – 0.800	Good
>0.800 – 0.900	Great
>0.900	Superb

Step 2: Determination of factor extraction method

Factor extraction is utilised to determine the smallest number of factors needed to represent the interrelations among a set of variables (Pallant 2007). There are several methods for extracting factors including: Principal Component Analysis (PCA), Principal Axis Factoring (PAF), maximum likelihood, unweighted least squares, generalised least squares, alpha factoring and image factoring. Of these, PCA and PAF are the most commonly used (Henson & Robert 2006, Tabachnick & Fidell 2013, Thompson 2004). While there is no significance difference between the two, Thompson (2004) found that PCA is the default method in many statistical programs. PCA is also recommended for studies when no priori theory exists (Gorsuch 1983).

Factor extraction uses the Eigen value as the basis. It signifies the amount of the total variance explained by the factor. Based on Kaiser's criterion, factors with an Eigen value greater than 1.0 are considered important. Another way that is recommended for deciding how many components to retain is the scree plot. The rule is to extract the number of components just before the line starts to level off (point of inflexion). According to Field (2017), researchers can come to a judgment as to whether or not to choose the Kaiser's criterion or scree plot based on two grounds:

- If there are less than 30 variables and communalities after extraction are greater than 0.7 or if the sample size exceeds 250 and the average communality is greater than 0.6, then retain all factors with Eigen values above 1 (use Kaiser's criterion)
- If none of the above applies, a scree plot can be used when the sample size is large (above 300 cases)

Step 3: Justification of factor rotation

Factor rotation is used to produce a more interpretable and simplified solution (Williams, Onsman & Brown 2010). It maximises the loading of each variable on one of the extracted factors whilst minimising the loading on all other factors (Field 2005). There are two common approaches to rotation: orthogonal and oblique. Orthogonal rotations are used when the factors are independent, while oblique rotations are more preferable when the factors are correlated (Kalutara 2013). According to Field (2017), some experts argue that orthogonal rotations should never be used in real problem situations, especially for data involving human opinions. In this study, Promax oblique rotation was used to investigate the factor analysis.

There are two matrices produced when an oblique rotation is performed, i.e. the pattern matrix and the structure matrix. The pattern matrix presents factor loadings for each variable onto each factor after rotation. On the other hand, the structure matrix takes into account the relationship between factors (Field 2017). Both matrices can be used to interpret the findings. Here, only values above the selected suppressed factor loading are displayed. In many studies, the absolute value of 0.3 is considered significant enough to be used (Field 2017). However, according to Stevens (2009), the significance of a factor loading will depend on the sample size. A larger sample size requires a smaller factor loading value as shown in Table 6.7. Since the number of valid responses obtained in this study was slightly more than 100, the suppressed factor loading of 0.512 was used as absolute value.

Table 6.7 Sample size and factor loading value

Available sample size	Suppressed factor loading value
50	>0.722
100	>0.512
200	>0.364
300	>0.298
600	>0.210
1000	>0.162

Step 4: Interpretation and discussion

The result based on the selected suppressed factor loading value will provide the factor solution. A pattern matrix will be produced and displays all the factors/components with underlying variables (ignored variables below the suppressed factor loading). Labelling and interpretations must be assigned to factors based on the commonality of underlying variables. There is no specific rule to label and interpret the factors, hence it is a subjective process (Pett, Lackey & Sullivan 2003). Ultimately, it is dependent on the researcher to provide meaningful interpretations of the derived factors (Henson & Roberts 2006). In this study, the researcher sought his supervisors' opinions for labelling the components.

Step 5: Reliability check

The reliability of the derived factors is determined using the Cronbach's Alpha formula, which is a common way to check the internal consistency of the variables that comprise each factor. Generally, Cronbach's alpha above 0.7 is considered reliable (Kalutara 2013, Kline 1999).

In this study, there are 23 selection criteria as input variables for factor analysis. The findings from the EFA are further explained below. Meanwhile, the details of the EFA SPSS output are presented in Appendix 8.

6.5 Factor Analysis Results

Step 1: Assessment of data suitability

The variables used for the analysis were 23 selection criteria for infrastructure project selection. They were represented by the codes F1, F2… F23 as shown in Table 6.5. The first step in factor analysis is to assess the data suitability, which can be done by checking the correlation coefficient (factorability), KMO measure of sampling adequacy and Bartlett's test of sphericity. The correlation coefficient was presented in Figure 6.4. With all variables, the determinant of the correlation matrix was greater than 0.00001.

Correlation Matrix

	SMEAN(F1)	SMEAN(F2)	SMEAN(F3)	SMEAN(F4)	SMEAN(F5)
SMEAN(F9)	.346	.265	.001	.337	.191
SMEAN(F10)	.001	.001	.318	.006	.000
SMEAN(F11)	.002	.000	.058	.002	.004
SMEAN(F12)	.011	.003	.044	.020	.003
SMEAN(F13)	.000	.000	.041	.004	.000
SMEAN(F14)	.000	.000	.022	.000	.000
SMEAN(F15)	.007	.001	.030	.061	.012
SMEAN(F16)	.003	.008	.099	.000	.000
SMEAN(F17)	.002	.001	.000	.000	.000
SMEAN(F18)	.000	.000	.002	.002	.006
SMEAN(F19)	.002	.002	.000	.000	.006
SMEAN(F20)	.000	.000	.036	.000	.000
SMEAN(F21)	.000	.000	.082	.001	.000
SMEAN(F22)	.000	.000	.342	.001	.000
SMEAN(F23)	.000	.000	.096	.000	.000

Figure 6.4 Output 1: Correlation matrix

Further checks for assessing the suitability of data for factor analysis were conducted by examining the value of the KMO measure of sampling adequacy and Bartlett's test of sphericity. These values are shown in Figure 6.5. According to these values, the KMO measure of sampling adequacy was 0.891 which is beyond the minimum requirement of 0.50 (Kaiser 1974). Based on the KMO index acceptability level (Hutcheson & Sofroniou 1999), it falls into the range of being "great". Meanwhile, the Bartlett's test of sphericity shows 0.000 significance value, which is less than 0.05. Hence, the R (correlation) matrix is not an identity matrix but is significant. Therefore, the data are suitable for factor analysis.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.891
Bartlett's Test of Sphericity	Approx. Chi-Square	1590.898
	df	253
	Sig.	.000

Figure 6.5 Output 2: KMO and Bartlett's test values

Step 2: Factor extraction

SPSS output 3 lists the variable communalities which reflects the degree of their variance accounted for by all the factors. Communalities below 0.4 are low and variables below this value may be removed. Since all variables were beyond 0.4, all variables were retained (Figure 6.6). Next, SPSS output 4 presents the Eigen values before extraction, after extraction and after rotation. According to output 4 (Figure 6.7), the analysis extracted five factors for which Eigen values were greater than 1 (important) based on the Kaiser criterion. These five factors/components explained 70.45% of the variance. Meanwhile, Figure 6.8 illustrates the scree plot, which graphs the Eigen value vs. component number.

Communalities

	Initial	Extraction
SMEAN(F1)	1.000	.716
SMEAN(F2)	1.000	.683
SMEAN(F3)	1.000	.737
SMEAN(F4)	1.000	.630
SMEAN(F5)	1.000	.649
SMEAN(F6)	1.000	.614
SMEAN(F7)	1.000	.719
SMEAN(F8)	1.000	.703
SMEAN(F9)	1.000	.655
SMEAN(F10)	1.000	.805
SMEAN(F11)	1.000	.821
SMEAN(F12)	1.000	.797
SMEAN(F13)	1.000	.667
SMEAN(F14)	1.000	.599
SMEAN(F15)	1.000	.771
SMEAN(F16)	1.000	.666
SMEAN(F17)	1.000	.698
SMEAN(F18)	1.000	.765
SMEAN(F19)	1.000	.795
SMEAN(F20)	1.000	.689
SMEAN(F21)	1.000	.722
SMEAN(F22)	1.000	.647
SMEAN(F23)	1.000	.659

Extraction Method: Principal Component Analysis.

Figure 6.6 Output 3: Communalities

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	10.314	44.841	44.841	10.314	44.841
2	2.010	8.739	53.580	2.010	8.739
3	1.629	7.081	60.661	1.629	7.081
4	1.218	5.295	65.956	1.218	5.295
5	1.035	4.499	70.455	1.035	4.499
6	.875	3.802	74.258		
7	.669	2.910	77.168		
8	.614	2.669	79.837		
9	.568	2.469	82.306		
10	.540	2.346	84.653		
11	.487	2.116	86.769		
12	.417	1.814	88.582		
13	.399	1.733	90.315		
14	.391	1.702	92.017		
15	.349	1.519	93.537		
16	.297	1.292	94.829		
17	.246	1.068	95.896		
18	.205	.892	96.788		
19	.190	.825	97.613		
20	.166	.722	98.335		
21	.152	.661	98.996		
22	.129	.563	99.559		
23	.101	.441	100.000		

Figure 6.7 Output 4: Total variance explained

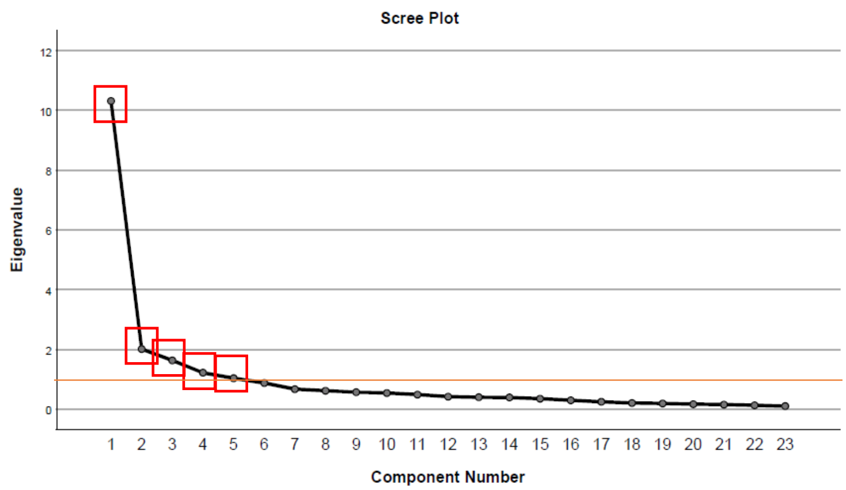


Figure 6.8 Output 5: Scree plot

Step 3: Factor rotation

SPSS output 6 (Figure 6.9) shows the un-rotated component matrix, which by default will display all loadings. Since the sample size is slightly more than 100, this study selected 0.512 as the supressed factor loading. Consequently, is shows only the loadings above 0.512.

Component Matrix[a]

	Component				
	1	2	3	4	5
SMEAN(F21)	.815				
SMEAN(F20)	.804				
SMEAN(F11)	.790				
SMEAN(F17)	.786				
SMEAN(F18)	.778				
SMEAN(F13)	.770				
SMEAN(F19)	.765				
SMEAN(F22)	.756				
SMEAN(F12)	.752				
SMEAN(F15)	.720				
SMEAN(F8)	.719				
SMEAN(F16)	.707				
SMEAN(F14)	.689				
SMEAN(F6)	.688				
SMEAN(F23)	.661				
SMEAN(F7)	.656				
SMEAN(F2)	.574				
SMEAN(F5)	.541				
SMEAN(F4)					
SMEAN(F1)	.560	.565			

Figure 6.9 Output 6: Un-rotated component matrix

This study applied promax oblique rotation for the problem because factors are expected to be correlated. SPSS output 7 (Figure 6.10) presents the pattern matrix, while output 8 (Figure 6.11) shows the structure matrix. Here, the pattern matrix is preferable for interpretation. According to Figure 6.10, some features are visible. It was found that F13, F19, F20 and F22 are not compiled in any factor (due to the suppressed factor being 0.512). F10 is the only variable representing Factor 5.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
SMEAN(F15)	.997				
SMEAN(F12)	.970				
SMEAN(F11)	.954				
SMEAN(F16)	.817				
SMEAN(F18)	.762				
SMEAN(F17)	.530				
SMEAN(F13)					
SMEAN(F22)					
SMEAN(F20)					
SMEAN(F8)		.829			
SMEAN(F7)		.826			
SMEAN(F6)		.807			
SMEAN(F14)		.680			
SMEAN(F5)		.673			
SMEAN(F21)		.542			
SMEAN(F19)					
SMEAN(F1)			.898		
SMEAN(F4)			.870		
SMEAN(F2)			.835		
SMEAN(F23)			.670		
SMEAN(F3)				.818	
SMEAN(F9)				.671	
SMEAN(F10)					.832

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Figure 6.10 Output 7: Pattern matrix

Structure Matrix

	Component				
	1	2	3	4	5
SMEAN(F11)	.903	.579			
SMEAN(F12)	.880	.553			
SMEAN(F15)	.861				
SMEAN(F18)	.845	.583	.555		
SMEAN(F16)	.766				
SMEAN(F17)	.748	.685			
SMEAN(F13)	.741	.702	.550		
SMEAN(F22)	.714	.691	.541		
SMEAN(F8)	.588	.807			
SMEAN(F21)	.701	.789	.630		
SMEAN(F7)		.779			
SMEAN(F6)	.558	.772			
SMEAN(F14)		.748			
SMEAN(F19)	.712	.734			
SMEAN(F20)	.678	.693	.671		
SMEAN(F5)		.640			.548
SMEAN(F1)			.837		
SMEAN(F2)			.820		
SMEAN(F23)	.520		.768		
SMEAN(F4)			.752		
SMEAN(F3)				.817	
SMEAN(F9)				.667	
SMEAN(F10)					.858

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Figure 6.11 Output 8: Structure matrix

Finally, a correlation matrix between factors is shown in Figure 6.12 (SPSS output 9). This matrix presents the correlation coefficients between factors. Here, it is found that component 1 and 2, component 1 and 3, and component 2 and 3 are interrelated to some degree; while component 4 and 5 have little relationships with other factors (correlation coefficients are low). Therefore, this matrix provides strong reasons as to why an oblique rotated solution is preferable in this study (i.e. the fact that correlations exist between variables).

Component Correlation Matrix

Component	1	2	3	4	5
1	1.000	.671	.531	.165	.088
2	.671	1.000	.607	.230	.221
3	.531	.607	1.000	.041	.188
4	.165	.230	.041	1.000	-.016
5	.088	.221	.188	-.016	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Figure 6.12 Output 9: Component correlation matrix

Step 4: Interpretation

The next step is to interpret the factors/components. This is achieved by looking at the factors with their associated variables. Here, a factor or component is translated to the relevant criterion according to the context of the problem investigated in this study. Table 6.8 presents the extracted factors and their associated variables.

Table 6.8 Extracted factors

Components	Codes	Variables	Factor loading
1	F15	Land Acquisition	0.997
	F12	Funding & Financing	0.970
	F11	Design Readiness	0.954
	F16	Team Member & Stakeholder Coordination	0.817
	F18	Contractual Conditions & Procurement System	0.762
	F17	Operational & Maintenance Readiness	0.530
2	F8	Policies	0.829
	F7	Local Government Issues	0.826
	F6	Good Governance	0.807
	F14	Technology Readiness & Transfer	0.680
	F5	Private Sector & Community Involvement	0.673
	F21	Planning Integration	0.542
3	F1	The Needs	0.898
	F4	Urgency	0.870
	F2	Conformity	0.835
	F23	Sustainability & Environmental Issues	0.670
4	F3	Risks	0.818
	F9	Politics	0.671
5	F10	Innovation/Added Value	0.832

Step 5: Reliability analysis

Using SPSS 26 software, the reliability of the derived factors/components was checked separately with respect to their associated variables. For example, component 1 is comprised of F15, F12, F11, F16, F18 and F17, and the same for other components. Hence, the reliability analysis was performed for each component and the results are shown in Figure 6.13 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 0.7). 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 (1999) argues that this kind of result is expected to occur for social science data.

Component 1

Reliability Statistics

Cronbach's Alpha	N of Items
.917	6

Component 2

Reliability Statistics

Cronbach's Alpha	N of Items
.855	6

Component 3

Reliability Statistics

Cronbach's Alpha	N of Items
.817	4

Component 4

Reliability Statistics

Cronbach's Alpha	N of Items
.446	2

Figure 6.13 Output 10: Cronbach's alpha for component 1 to 4

An alternative method to Cronbach's alpha is Composite Reliability (Peterson & Kim 2013). It is noted that Cronbach's alpha is sensitive to the number of variables in the component and tends to underestimate the true reliability of a measure (Osburn 2000). Thus, it is understandable that the reliability results for component 4 and 5 are low due to small number of variables in the scale. Therefore, this study suggests the use of Composite Reliability as opposed to Cronbach's alpha for the factor analysis. The Composite Reliability can be computed using the following formula (Equation 3).

Equation 3: Composite Reliability

$$CR = \frac{\left(\sum_{i=1}^{p} \lambda_i\right)^2}{\left(\sum_{i=1}^{p} \lambda_i\right)^2 + \sum_{i}^{p} V(\delta)}$$

where,

CR = Composite Reliability

λ_i = factor loading for indicator *i*

V(δ) = variance of the error term for indicator *i*

p = number of indicators

The scale is regarded to have a reasonable internal consistency if the CR value is 0.6 or higher (Kamyabi 2012; Lawson-Body & Limayem 2004). According to the results reported in Table 6.9, all components had good CR values, ranging from 0.692 to 0.940. Consequently, these results confirm that the variables in this study are reliable.

Table 6.9 Composite reliability statistics for all components

Component 1

	λ	λ^2	$1-\lambda^2$
F15	.997	.994	.006
F12	.970	.941	.059
F11	.954	.910	.090
F16	.817	.667	.333
F18	.762	.581	.419
F17	.530	.281	.719
Total	**5.030**	**4.374**	**1.626**

N	6
Average Variance Extracted	.729
Composite Reliability	**.940**

Component 2

	λ	λ^2	$1-\lambda^2$
F8	.829	.687	.313
F7	.826	.682	.318
F6	.807	.651	.349
F14	.680	.462	.538
F5	.673	.453	.547
F21	.542	.294	.706
Total	**4.357**	**3.230**	**2.770**

N	6
Average Variance Extracted	.538
Composite Reliability	**.873**

Component 3

	λ	λ^2	$1-\lambda^2$
F1	.898	.806	.194
F4	.870	.757	.243
F2	.835	.697	.303
F23	.670	.449	.551
Total	**3.273**	**2.709**	**1.291**

N	4
Average Variance Extracted	.677
Composite Reliability	**.892**

Component 4

	λ	λ^2	$1-\lambda^2$
F3	.818	.669	.331
F9	.671	.450	.550
Total	**1.489**	**1.119**	**.881**

N	2
Average Variance Extracted	.560
Composite Reliability	**.716**

Component 5

	λ	λ^2	$1-\lambda^2$
F10	.832	.692	.308
Total	**.832**	**.692**	**.308**

N	1
Average Variance Extracted	.692
Composite Reliability	**.692**

6.6 Reporting

A principal factor analysis was conducted on the 23 variables with oblique rotation (promax). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .891 ('great' according to Field 2017), which is well above the acceptable limit of .5 (Field 2017). Bartlett's test of sphericity—χ^2 (253) = 1590.898, $p < .001$—indicated that correlations between items were sufficiently large for PCA. An analysis was run to obtain eigenvalues for each component in the data. Five components had eigenvalues over Kaiser's criterion of 1 and in combination explained 70.455% of the variance. The scree plot turned out to fulfill the Eigen value 'greater than one' criteria. Given the medium sample size, and the convergence of the scree plot and Kaiser's criterion on five components, this is the number of components that were retained in the final analysis. Table 6.7 shows the factor loadings after rotation. The items that clustered on the same components suggest that component 1 represents technical criteria, component 2 represents administrative criteria, component 3 represents strategic fit criteria, component 4 represents risks and political criteria and component 5 represents innovation criteria. Regarding reliability analysis, the composite reliability test was recommended. The results confirm that the variables in this study are reliable, with CR values ranging from 0.692 to 0.940.

6.7 Chapter Summary

This chapter intended to refine the identified selection criteria for infrastructure project proposals from the integrative literature review and expert interviews. Using Exploratory Factor Analysis (EFA), the findings further validate the listed criteria based on the larger opinions of the Indonesian professionals working in the construction industry. The EFA was conducted in five steps: assessment of data suitability, determination of factor extraction method, factor rotation, interpretation and reliability check. The next chapter will discuss the determination of these criteria weights based on NSFDSS-II as an MCDM technique.

CHAPTER 7. DETERMINATION OF CRITERIA WEIGHTING

7.1 Introduction

The development of a DMF and DMT is a complicated and lengthy process. It requires a comprehensive approach to structuring and defining elements in the decision-making process. Muñoz, Romana and Ordóñez (2016) believe that it is a very laborious and complex process that includes identifying the objectives, identifying viable alternatives, establishing the selection criteria and quantifying the subjective variables. They further state that the most important thing in the process is to determine the relative importance of a selection criterion compared to the rest to calculate an objective weighting. Similarly, Chen, Yu and Khan (2010) highlight that the determination of criterion weights is a very crucial aspect of MCDM technique.

This chapter focuses on determining the weighting of each selection criterion. This is achieved by pairwise comparison of each criterion. To obtain a more accurate judgment, the Delphi method is applied as a means of pairwise comparison. Next, the results of the pairwise comparison are analysed using an MCDM technique, NSFDSS-II. The final result of this analysis is the weighting for each criterion. Thus, while the previous chapter dealt with identification of key selection criteria, this chapter's findings contribute to the development of a DMF by determining the criterion weights. These selection criteria and weights will be an important part of the DMT.

7.2 Reduction of Key Selection Criteria

In this study, EFA is applied to explore the correlation of variables based on available data sets to obtain data reduction and grouping patterns. The reduced variables (from 23 to 19) will then be used as inputs in the DMF development through an MCDM technique, i.e. NSFDSS-II. The advantage of this technique is the determination of criteria weightings through pairwise comparisons. In brief, it compares the relative importance, preference or likelihood of two variables (Han 2016). The number of pairwise comparisons needed can be calculated using the Equation 4.

Equation 4: Number of Pairwise Comparison

$$Npw = \frac{n\,(n-1)}{2}$$

where,

Npw = the number of pairwise comparisons

n = the number of criteria or variables

The more reduced variables, the greater the number of pairwise comparisons performed. Therefore, it is important to note the number of reduced variables. According to Han (2016), the proper number of criteria in the case of a single decision maker is 7 ± 2. However, often the number of criteria is more than 10 or even 20 in the case of real selection problems (Han 2016; Lau et al. 2018; Patel & Jha 2017; Yau 2012) which can complicate the analysis process.

The same phenomenon was experienced in this study. The large number of selection criteria made the process of collecting data for NSFDSS-II difficult. This is because the process of collecting NSFDSS-II input data applies the principle of comparative judgment which is also widely applied to other MCDM techniques such as AHP. The principle of comparative judgment is carried out by constructing pairwise comparisons of the relative importance of elements with respect to a shared criterion (Tam, Tong & Zhang 2007). Thus, the number of pairwise comparisons is very influential in the data collection process. Table 7.1 shows the number of criteria and the number of pairwise comparisons that must be performed.

Table 7.1 Number of criteria vs. number of pairwise comparisons

No. of criteria	No. of pairwise	No. of criteria	No. of pairwise	No. of criteria	No. of pairwise	No. of criteria	No. of pairwise
1	0	6	15	11	55	16	120
2	1	7	21	12	66	17	136
3	3	8	28	13	78	18	153
4	6	9	36	14	91	19	171
5	10	10	45	15	105	n	n(n-1)/2

Therefore, for 19 criteria, 171 pairwise comparisons were needed; a very time- and energy-consuming process. Other researchers agree and therefore recommended keeping the number of criteria below ten (Han 2016; Mu & Pereyra-Rojas 2017; Russo & Camanho 2015). However, direct weighting using pairwise comparisons is often criticised for the inconsistent results produced when a large number of criteria are involved (Polatidis et al. 2009). Considering the practicability and creditability of the weighting exercise, the 19 selection criteria that were previously identified were grouped based on the nature of their aspects and similarities to ten key selection criteria. Grouping by reducing the number of criteria is also recommended by Yau (2012) and Mu and Pereyra-Rojas (2017). Thus, only 45 pairwise comparisons were needed for each assessment parameter. The definition and consideration of the combination are displayed in Table 7.2.

Table 7.2 Final set of key selection criteria used in this research

Code	Criteria	Elements		Explanations
1	Strategic Fit	The Needs	related to the strategic need and purpose of a proposed project	The decision makers have to choose the projects that better fits the needs of their countries/cities. It involves many variables such as local geography, demography, GDP, existing laws, economic backgrounds and other social variables (da Cruz & Marques 2014). 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. Thus, the urgency criterion will have a significant weight during the prioritisation process. 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. Government policies play an important role in the development of construction industry in Indonesia. For example, projects that support public policies will be prioritised such as flyover projects to reduce traffic congestion. Another example from China is the policy on nuclear power development which has changed from being a moderate priority development to a priority one (Hou et al. 2011). These four elements refer to the strategic considerations when selecting and prioritising infrastructure projects.
		Conformity	related to the conformity of the proposed project to the National Development Goals and commitments, applicable laws & regulations	
		Urgency	related to the urgency of the proposed project to be executed immediately	
		Policies	related to projects supporting policies taken to solve actual problems that exist in society, including government priority/policies, etc.	
2	Readiness Criteria	Design Readiness	related to the readiness of design principles, including life time expectancy, aesthetics requirements, design for safety, functionality, scope of work, constructability, etc.	Project readiness is critical for project success (Mostaan & Ashuri 2017). It can be assessed from four technical criteria: land acquisition, design readiness, OM readiness and technology readiness. Land acquisition is still a major issue in Indonesia. Infrastructure projects are usually huge projects that require a considerable amount of land acquisition for project execution. Issues arise due to the increased number of people and less land available so that the land prices are inevitable to rise (Bian et al. 2019). Thus,

		Land Acquisition	related to the readiness to acquire land needed for the proposed project	land acquisition readiness is a key criterion in selecting infrastructure project proposals, i.e. projects with easy land acquisition process or where the land/site is ready may be prioritised over projects requiring a difficult land acquisition process. Design readiness ensures the success of proposed projects. It includes the availability of basic drawings, specifications, methods and constructability strategies. Meanwhile, OM readiness is also important as a criterion in selecting infrastructure projects. Identifying an equitable optimal allocation of budget to asset systems is still a major challenge since the maintenance needs of all assets should be addressed and the objectives of asset systems should be achieved optimally (Fwa & Farhan 2012). The OM costs are the most significant expenses in the project life cycle (Cuéllar-Franca & Azapagic 2014); for this reason, OM readiness should become a consideration. Similarly, the construction industry is being impacted by the adoption of new technologies, which influences the efficiency and effectiveness of the construction process. Thus, it is clear that it is important to consider technology readiness and transfer during project selection. The introduction of new technologies for a certain project must be followed by the technology transfer to ensure the local capability in using and adopting the technology.
		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.	
		Technology Readiness & Transfer	related to the readiness of technology as well as technology transfer of the proposed project	
3	Innovative Planning	Innovation/ Added Value	related to the degree of innovation/added value of the proposed project throughout its life cycle, VE implementation	Innovation is related to the process of creative thinking that generates added values. The degree of innovation influences the success of a project. For example, a limited opportunity for innovation can be a major barrier for private sector involvement (Mostaan & Ashuri 2017). The process of innovation is mainly done during the planning phase. It involves creativity manifestation, conceptualisation and strategizing. On the other hand, Indonesia is

		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.	currently promoting planning integration to achieve full coordination between various planning processes. This involves integrating planning processes to ensure various infrastructure projects can foster integrated development in the region. This will improve the resource utilisation efficiency as well. Both innovation and planning integration can be grouped into innovative planning since both are conducted during the planning phase.
4	Risks & Politics	Risks	related to the proposed project's level of risks and uncertainties involved	Risks and politics are two barrier factors that may influence the selection of infrastructure projects. Infrastructure projects are large and complex projects characterised by the high degree of risks and uncertainties involved. These risks may include political risks, legal risks, demand risks, financial risks, technical risks, contract risks, market risks, etc. Major project risks such as ROW, utilities and permitting risks may result in significant delays. Thus, it is necessary for the decision maker to ensure that these risks are identified and mitigated during the FEP phase. Similarly, tenure and steadiness of political officials are major barriers that can disrupt project development and even result in project cancellations (Mostaan & Ashuri 2017). This may be in form of lack of understanding of political actors in infrastructure project selection, change of government officials, government interventions and expropriation (Shrestha et al. 2017).
		Politics	related to the political issues/influences and impacts of a proposed project	

5	Contract & Governance Issues	Contractual Conditions & Procurement System	related to the contractual conditions and procurement system that will be adopted by the proposed project	Due to strong investments in infrastructure, the government has encouraged private sector involvement. However, this creates challenging contractual conditions. The government and private sector enter into a contractual relationship with all the problems of bilateral monopolies (Crocker & Masten 1996), which is difficult to handle especially if the projects are traditionally unprofitable (da Cruz & Marques 2014; Gwilliam 2002). The quality of such contracts needs to be assessed. Thus, concerns with contractual conditions and procurement systems should be a priority when selecting project proposals. Whenever private delivery is preferred, the government ought to consider the proper ways of enforcing the contractual clauses while avoiding disputes. If the choice is public delivery, then the right level of autonomy should be secured. From a governance perspective, it is difficult to suggest either public or private delivery as the right choice. Every governance structure should be analysed in terms of contract design since it relates to the contractual relations between the competent authorities and the operators (da Cruz & Marques 2014).
		Good Governance	related to the level of good governance implementation of the proposed project	
6	Funding & Financing	Funding & Financing	related to the sources of funding, financing schemes, allocation for contingencies, etc.	Although national and local governments have critical roles in providing capital to fund infrastructure projects, the adoption of various types of funding sources is inevitable. These include national and local government budgets, private sector investments, bank loans, equity contributions, etc. When selecting a project proposal, funding sources from non-governmental budgets are encouraged. This must be supported through the available financing approaches. Innovative financing schemes such as PPPs, credit enhancement tools and new bond instruments have become an important consideration when selecting project proposals.

7	Team Member & Stakeholder Coordination	Team Member & Stakeholder Coordination	related to the degree of alliance among all key stakeholders and team members of a proposed project	Coordination can be defined as the task of managing dependencies between activities (Malone & Crowston 1994). It can happen during all project phases, including at the FEP phase. Coordination between parties involved in a project planning consists of micro coordination (between team members) and macro coordination (between stakeholders) during project planning and selection. It is a crucial criterion in selecting project proposals since many problems can be resolved if the stakeholders and team members are actively engaged in FEP and fully integrated into the project team (Jergeas & der Put 2001). A lack of coordination and a lack of information flow between stakeholders are critical factors that contribute to a project's failure to meet its desired objectives and benefits (Mahalingam, Yadav & Varaprasad 2015).
8	Private Sector & Community Involvement	Private Sector & Community Involvement	related to the level of private sector and public involvement, as well as public attitudes regarding the proposed project	Private sector and community/public involvement are two external forces that may influence project success. Private sector involvement is encouraged especially in assisting the government to finance infrastructure projects. Infrastructure projects as public assets mainly use public funds to finance the projects. In recent decades, private sector investment has become inevitable (Zahed, Shahandashti & Najafi 2018). Thus, the degree of private sector involvement has become a critical consideration in selecting project proposals. On the other hand, assessment of public perceptions is an essential consideration in the implementation of infrastructure financing policies (Mostafavi et al. 2012). This community involvement involves public knowledge, awareness and attitude, as well as public perceptions towards the proposed projects. Public opposition to controversial projects has been found to be a primary challenge in project development (Mostaan & Ashuri 2017).

9	Local Government Issues	Local Government Issues	related to the local government issues, including the local gov proposals, local gov commitment, local capabilities, etc.	Since the autonomy order has been applied in Indonesia, local/provincial governments have more freedom in managing their own assets and budgets. Here, they may allocate their own local budgets to fund local infrastructure projects as they deem necessary. However, 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 limited local resources. For example, difficulties arise when local government officials are unfamiliar with the management of PPPs and when there is a lack of efficient risk management (Shrestha et al. 2017).
10	Sustainability & Environmental Issues	Sustainability & Environmental Issues	related to the sustainability issues and environmental impacts of the proposed project	There is an increased concern about the sustainability and environmental issues in Indonesia. This is evident in the infrastructure project planning and selection process. Project sustainability refers to the continuity of proposed projects, as infrastructure projects are normally large and take a long time to complete. For example, road projects may be divided into packages that will be completed in a duration of ten years. Another aspect of sustainability is environmental protection. Here, decision makers may consider environmental impacts such as project site and activities cleanliness, noise issues and air pollution from construction activities and energy conservation, as proposed by the projects.

7.3 NSFDSS-II Data Collection

This study applies NSFDSS-II as an MCDM analysis technique to determine the weight of key selection criteria in infrastructure project selection and prioritisation problems. It follows three operation principles, i.e. decomposition, comparative judgment and synthesis of priorities (Tam, Tong & Zhang 2007). Figure 7.1 illustrates the decomposition principle in which a problem is structured into elements of different levels. The structuring process works downwards from the goal on the top level (in this case, obtaining criteria weightings) through to the criteria bearing on the second level (in this case, the three assessment parameters) to the sub-criteria on the third level (in this case, the ten key selection criteria identified).

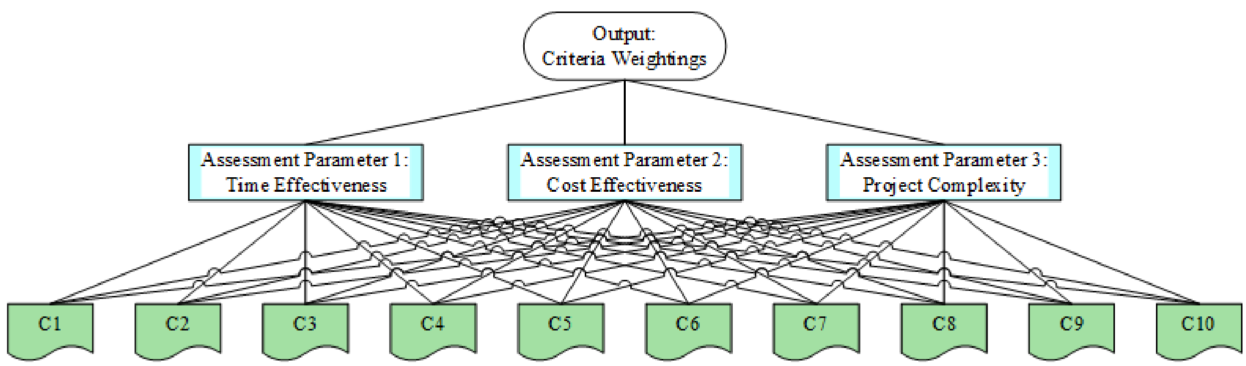


Figure 7.1 Decomposition of infrastructure project selection and prioritisation problem

Meanwhile, the principle of comparative judgment offers a method for assessing two criteria by means of comparing their strengths with respect to the provided assessment parameters. Synthesis of priorities follows, which is achieved by multiplying local priorities with the priority of their corresponding criterion and weighting each element according to the criteria it affects (Tam, Tong & Zhang 2007). NSFDSS-II is chosen for infrastructure project selection and prioritisation problem because:

(1) it is a new technique developed in 2000 and has never been used in the infrastructure project selection problem;
(2) similar to AHP, it breaks the problem down into many pairwise comparisons;
(3) similar to AHP, it applies logical consistency checks to the pairwise comparisons;
(4) similar to Fuzzy AHP, it uses semantic operators that integrate the strength of fuzzy set theory;

(5) different to AHP, it is simpler since it adopts only three semantic operators compared to nine in AHP;
(6) different to AHP, it has a procedure of priority ordering to quantity the difference in magnitude of the first ordered decision and others;
(7) different to NSFDSS-I, it allows the decision makers to define the importance of assessment parameters within the system and the importance of each element under different assessment parameters;
(8) it applies fuzzy analysis which is suitable for infrastructure project selection problem; and
(9) thus, overall, it is a scientific and systematic approach for decision making that can effectively eradicate personal biases in the selection of infrastructure project proposals.

NSFDSS-II data were collected in the form of pairwise comparisons on ten key selection criteria through the Delphi method as conducted by eight experts. The guidelines for collecting NSFDSS-II data consider various aspects, as summarised in Table 7.3, which outlines the requirements of expert criteria for NSFDSS-II pairwise comparisons applied in this study.

Table 7.3 Guidelines for the NSFDSS-II data collection procedure

Characteristics	Requirements by Lau et al. (2018) - NSFDSS	Requirements by Lembo et al. (2017) - NSFDSS	Requirements by Tam, Tong & Wong (2004) - NSFDSS	Requirements adopted in this study
Identifying potential expert respondents	Based on personal attribute: • Having physical disability • Having visual impairment	Based on job title: • Fishermen • Representatives of fisheries associations • Representatives of environmental NGOs	• Professionals working in construction sectors • At least 15 years of on-site experience	• Professionals/academics working in construction-related sectors with at least ten years of working experience • Have a construction-related educational background with a minimum of Master's degree • Member of a construction-related professional organisation • Have a minimum one academic publication/journal • Have been involved in infrastructure project planning and/or execution • Have a manager/above position • Diversity of expertise and diversity of organisation/location
Expert respondent criteria	Meet one of the above requirements	Meet one of the above requirements	Meet all the above requirements	Meet five out of seven of the above requirements
Number of respondents	6	12	12	8
Data collection technique	Workshop	Questionnaire	Structured interview survey	Delphi Method Questionnaire
Measuring method	Pairwise comparisons	Pairwise comparisons	Pairwise comparisons	Pairwise comparisons

The Delphi method was carried out in two rounds with the distribution of the first questionnaire round lasting for two weeks (22 January 2020 - 4 February 2020). After the analysis in round one, it was seen that the distribution of the second round questionnaire was carried out within two weeks (10-23 February 2020). Questionnaires were distributed online using RMIT University's Qualtrics Survey Software. The questionnaire form consists of two parts, i.e. expert's profile and pairwise comparisons. Table 7.4 presents the experts' profiles, while the questionnaire template can be seen in Appendix 5.

Table 7.4 Pairwise comparison expert profiles

Expert Profiles	Number	%
Educational Background		
Construction related	8	100%
Not related	0	0%
Total	8	100%
Level of Education		
Master	7	88%
Doctoral	1	13%
Total	8	100%
Working Experience		
<10 years	1	13%
≥10 years	7	88%
Total	8	100%

Expert Profiles	Number	%
Affiliation		
Ministries & Gov. Agencies	4	50%
Others	4	50%
Total	8	100%
Current Job Position Level		
Manager	3	38%
Head of department	5	63%
Total	8	100%

7.4 Pairwise Comparisons through the Delphi Method for NSFDSS-II Input

In this study, NSFDSS-II data collection in the form of pairwise comparison matrix was done using the Delphi method. The pairwise comparison technique is a widely-used technique implemented to tackle the subjective and objective judgments in MCDM (Kou et al. 2016). To obtain a more accurate judgment, the Delphi method is applied as a means for pairwise comparison. The Delphi method is a systematic and interactive technique for obtaining judgments from a panel of independent expert on a specific topic. Experts are selected based on predefined guidelines to participate in two or more rounds of structured surveys. During each round, the researcher provides an anonymous result of the experts' judgment from the previous round as a part of the subsequent round. Here, experts are encouraged to review the result and consider revising their previous judgment. This process is repeated until a group consensus has been achieved (Hallowell & Gambatese 2010). The Delphi method procedure adopted in this study is illustrated in Figure 7.2.

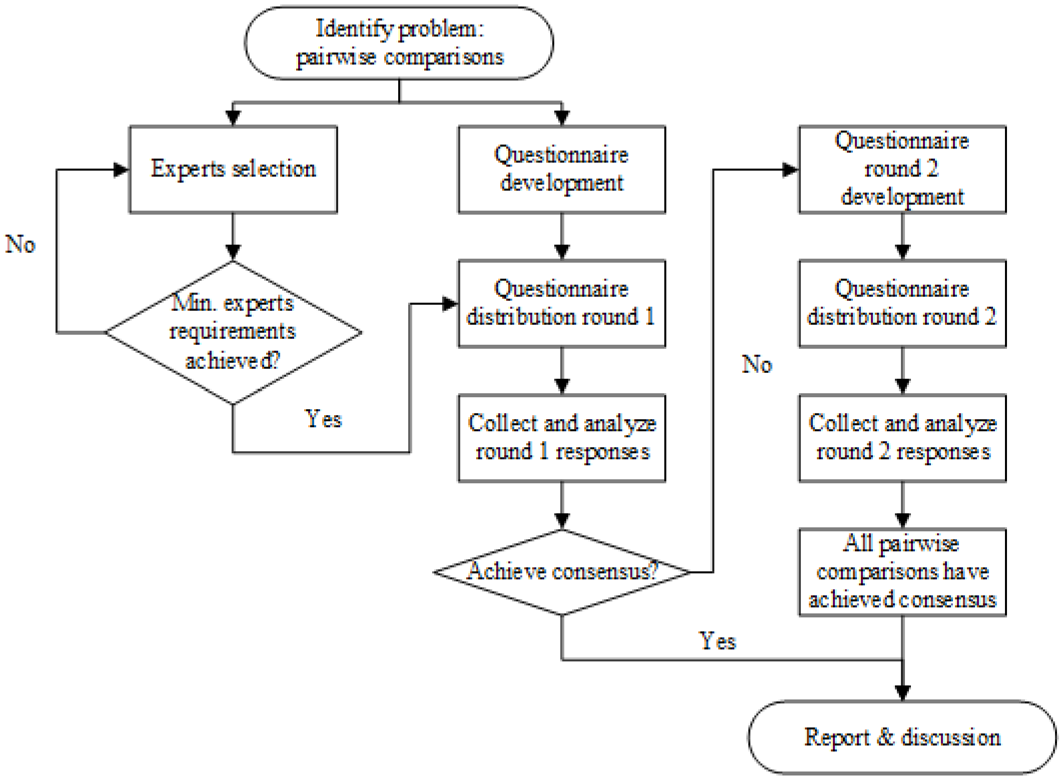


Figure 7.2 The Delphi method procedure adopted in this study

Furthermore, to ensure that research is rigorous and defendable, Hallowell and Gambatese (2010) recommend several methods to minimise bias in judgment of experts. In this research, six types of judgment-based bias were identified as potential biases that may adversely affect the quality of the Delphi result. These include collective unconscious, contrast effect, Von Restorff effect, primacy effect, recency effect and dominance. Collective unconscious refers to the scenario where the experts tend to unconsciously conform to the common or popular agreement within a group. Contrast effect refers to situations where the experts' judgment of a criterion be directly influenced by the value of the immediately preceding subject. The Von Restorff effect refers to the condition where the experts tend to provide judgment based on their extreme experiences. Primacy effect refers to cases where the experts tend to provide more important judgment for the initial questions rather than the final question. Recency effect refers to the tendency to artificially inflate the ratings because similar experiences have recently occurred. Finally, dominance effect occurs when a vocal expert exhibits dominance over the ratings of the other experts.

These six biases could occur if the pairwise comparisons using the Delphi method in a study are not well designed. Therefore, the researcher has taken steps to control and minimise these effects as shown in Table 7.5. The design of the questionnaire in each round was carried out by considering the existing strategies.

Table 7.5 Strategies to control the possible biases

Strategy	Bias
Provide reasons in the controlled feedback to the experts	Collective unconscious, Von Restorff effect
Conduct multiple rounds	Von Restorff effect, Recency effect
Randomise the order of questions	Contrast effect, Primary effect
Ensure anonymity of expert panellists	Dominance
Remove experts experiencing recent events	Recency effect

In this study, pairwise comparisons were carried out on ten key selection criteria against three assessment parameters. The advantage of NSFDSS-II is its ability to evaluate the relative importance of various elements in a system where they co-exist under the same situation (Tam, Tong & Zhang 2007). Thus, NSFDSS-II enables decision makers to determine the importance of assessment parameters within a system and the importance of each selection criteria under different assessment parameters.

In this study, integrative literature review was used to identify three assessment parameters that often affect the process of selecting infrastructure projects in Indonesia. They are time effectiveness (P1), cost effectiveness (P2) and project complexity (P3) as described in Table 7.6.

Table 7.6 Assessment parameters for the infrastructure project selection and prioritisation problem

Assessment Parameters (Pi)		Description
P1	Time effectiveness	Time is essential for construction projects as it is directly related to cost (Tam et al. 2002a). Therefore, the time required to complete a project is a consideration in infrastructure project selection and prioritisation.
P2	Cost effectiveness	This refers to the effectiveness of the overall construction costs required to complete an infrastructure project.
P3	Project complexity	Infrastructure project complexity can be a consideration when selecting which projects to be funded. He et al. (2015) proposed six dimensions of project complexity for infrastructure projects: technological, organisational, goal, environmental, cultural and information complexities. The more complex the project, the lower its chance of being funded.

According to the pairwise comparisons questionnaire template provided (Appendix 5), in total there were (45 x 3) + (3 x 1) = 138 pairwise comparisons done by each expert. In NSFDSS-II, there are only three scales used in the pairwise comparisons (Tam, Tong & Zhang 2007), as shown in Table 7.7. A sample of input matrix for NSFDSS-II used in this study is illustrated in Table 7.8. It includes the ten key selection criteria as described in Table 7.9.

Table 7.7 Pairwise comparison scales for NSFDSS-II

Scale	Implications
0	Alternative *x* is worse than alternative *y*
0.5	Two alternatives are the same value
1	Alternative *x* is better than alternative *y*

Table 7.8 Input matrix template for NSFDSS-II

Ci	1	2	3	4	5	6	7	8	9	10
1	0.5	C1-2	C1-3	C1-4	C1-5	C1-6	C1-7	C1-8	C1-9	C1-10
2		0.5	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
3			0.5	C3-4	C3-5	C3-6	C3-7	C3-8	C3-9	C3-10
4				0.5	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
5					0.5	C5-6	C5-7	C5-8	C5-9	C5-10
6						0.5	C6-7	C6-8	C6-9	C6-10
7							0.5	C7-8	C7-9	C7-10
8								0.5	C8-9	C8-10
9									0.5	C9-10
10										0.5

Table 7.9 Codes for the 10 key selection criteria

Code	Selection Criteria
C1	Strategic fit
C2	Readiness criteria
C3	Innovative planning
C4	Risks & politics
C5	Contracts & governance issues
C6	Funding & financing
C7	Team member & stakeholder coordination
C8	Private sector & public involvement
C9	Local gov issues
C10	Sustainability & env issues

The implementation of pairwise comparisons with the Delphi method is declared sufficient when consensus has been reached. In this study, there are three conditions used to determine whether pairwise comparison variables have reached consensus or not, namely:

(1) if the value (mode) of a scale was equal or above 50% of the total responses, then consensus is reached
(2) if none of the scale has a value equal or above 50%, then consensus was not achieved and variables need to be reiterated in the next round
(3) similarly, in case of equal value between two dominant scales, consensus was not achieved and variables need to be reiterated in the next round

For example, in Round 1, the responses from eight experts for C1-2 ('strategic fit' compared to 'readiness criteria') against P1 (time effectiveness) were one response (for scale 0 or 'worse than'), five responses (for scale 0.5 or 'the same') and two responses (for scale 1 or 'better than'); thus it was concluded that a group consensus had been achieved, with the final judgment being 0.5, meaning that 'strategic fit' is of the same value as 'readiness criteria'.

Another example for describing condition (2) is given as follows. In Round 1, the responses from eight experts for C1-4 ('strategic fit' compared to 'risks & politics') against P2 (cost effectiveness) were two responses (for scale 0 or 'worse than'), three responses (for scale 0.5 or 'the same') and three responses (for scale 1 or 'better than'). This means that none of the scale had a value above 50% and thus consensus was not achieved. This variable therefore needed to be reiterated in the second round of the Delphi method.

Finally, condition (3) is illustrated as follows. In Round 1, the responses from eight experts for C6-7 ('funding & financing' compared to 'team member & stakeholder coordination') against P3 (project complexity) were 0 responses (for scale 0 or 'worse than'), four responses (for scale 0.5 or 'the same') and four responses (for scale 1 or 'better than'). This means that there are two dominant scales with equal responses (each with 50% responses); thus, consensus was not achieved and it needed to be reiterated in the second round.

The Delphi method round 1 analysis results show that for P1 (time effectiveness), 12 of 45 pairwise comparison variables had not reached consensus, namely: C1-4, C1-9, C2-7, C2-10, C4-8, C4 -9, C4-10, C5-9, C7-9, C7-10, C8-9 and C9-10. For P2 (cost effectiveness), 12 out of 45 pairwise comparison variables had not reached consensus, namely: C1-3, C1-4, C1-7, C1-8, C2-6, C2-7, C4-7, C4-10, C5-10, C7-8, C8-10 and C9-10. Finally, for P3 (project complexity), 12 pairwise comparison variables had not yet reached consensus, namely: C1-2, C1-4, C1-5, C1-6, C1-7, C3-5, C4-6, C4- 10, C5-8, C6-7, C8-10 and C9-10. On the other hand, for the assessment parameter itself, one of three pairwise comparison variables had not reached consensus, namely P1-2. Table 7.10 summarises the pairwise comparison results for the two Delphi rounds.

Table 7.10 Summary of Delphi rounds

Round 1	Round 2
No. of experts participated: 8	No. of experts participated: 8
For P1 (time effectiveness), out of 45 variables 33 reached consensus and 12 went to the 2nd round	For P1 (time effectiveness), all variables reached consensus
For P2 (cost effectiveness), out of 45 variables 33 reached consensus and 12 went to the 2nd round	For P2 (cost effectiveness), all variables reached consensus
For P3 (project complexity), out of 45 variables 33 reached consensus and 12 went to the 2nd round	For P3 (project complexity), all variables reached consensus
For the parameters, out of 3 parameters 2 reached consensus and 1 went to the 2nd round	For the assessment parameters, all variables reached consensus

7.5 NSFDSS-II Analysis

The following describes the NSFDSS-II analysis procedure. It consists of five steps, namely:

- Step 1: Pairwise comparison
- Step 2: Output matrices
- Step 3: Priority ordering and assignment of priority scores
- Step 4: Derivation of weights
- Step 5: Determination of the results

7.5.1 Pairwise Comparisons

The first step is to conduct pairwise comparison between elements (in this case, the ten key selection criteria) and evaluation factors (in this case, the three assessment parameters). In this study, pairwise comparison was performed using the Delphi method and produced input matrices as presented in Table 7.11. In total, there are four input matrices (three for the pairwise comparison result of the ten key selection criteria against each assessment parameters and one for the pairwise comparison result of the assessment parameters themselves).

Table 7.11 Input matrices for the infrastructure project selection and prioritisation problem

For P1 - Time Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10
1	0.5	0.5	1	1	0.5	0.5	1	0.5	1	0.5
2		0.5	0.5	0	0.5	0.5	0.5	0.5	0.5	0.5
3			0.5	0	0.5	0.5	0.5	0.5	1	0.5
4				0.5	0.5	0.5	1	0.5	1	1
5					0.5	0.5	0.5	0.5	0	0.5
6						0.5	0.5	0.5	0.5	0.5
7							0.5	0.5	1	1
8								0.5	1	0.5
9									0.5	0.5
10										0.5

For P2 – Cost Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10
1	0.5	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5
2		0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5
3			0.5	0.5	0.5	0.5	0.5	0.5	1	0.5
4				0.5	1	0.5	1	0.5	1	0.5
5					0.5	0.5	0.5	0	1	0.5
6						0.5	1	0.5	1	1
7							0.5	0	1	0.5
8								0.5	1	0.5
9									0.5	0
10										0.5

For P3 - Project Complexity

Ci	1	2	3	4	5	6	7	8	9	10
1	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5
2		0.5	0.5	1	1	0.5	0.5	0.5	1	0.5
3			0.5	0.5	1	0.5	0.5	0.5	1	0.5
4				0.5	0.5	1	1	0.5	1	0.5
5					0.5	0.5	1	0.5	1	0.5
6						0.5	0.5	0.5	1	0.5
7							0.5	0.5	1	0.5
8								0.5	0.5	0.5
9									0.5	0.5
10										0.5

For Decision Parameters

Pi	P1	P2	P3
P1	0.5	1	1
P2		0.5	1
P3			0.5

7.5.2 Output Matrices

Following the above inputs, consistency checking was conducted for all matrices. Consequently, four output matrices were generated and presented in Table 7.12.

Table 7.12 Output matrices for the infrastructure project selection and prioritisation problem

For P1 - Time Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10	Sum
1	0.5	0.5	1	1	0.5	0.5	1	0.5	1	0.5	7
2	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5	0.5	0.5	4.5
3	0	0.5	0.5	0	0.5	0.5	0.5	0.5	1	0.5	4.5
4	0	1	1	0.5	0.5	0.5	1	0.5	1	1	7
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	4.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5
7	0	0.5	0.5	0	0.5	0.5	0.5	0.5	1	1	5
8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	5.5
9	0	0.5	0	0	1	0.5	0	0	0.5	0.5	3
10	0.5	0.5	0.5	0	0.5	0.5	0	0.5	0.5	0.5	4

For P2 - Cost Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10	Sum
1	0.5	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	6
2	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	5.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	5.5
4	0.5	0	0.5	0.5	1	0.5	1	0.5	1	0.5	6
5	0.5	0.5	0.5	0	0.5	0.5	0.5	0	1	0.5	4.5
6	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	1	1	6.5
7	0	0.5	0.5	0	0.5	0	0.5	0	1	0.5	3.5
8	0	0.5	0.5	0.5	1	0.5	1	0.5	1	0.5	6
9	0.5	0.5	0	0	0	0	0	0	0.5	0	1.5
10	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	1	0.5	5

For P3 - Project Complexity

Ci	1	2	3	4	5	6	7	8	9	10	Sum
1	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	5.5
2	0.5	0.5	0.5	1	1	0.5	0.5	0.5	1	0.5	6.5
3	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	1	0.5	6
4	0.5	0	0.5	0.5	0.5	1	1	0.5	1	0.5	6
5	0	0	0	0.5	0.5	0.5	1	0.5	1	0.5	4.5
6	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5	1	0.5	5
7	0.5	0.5	0.5	0	0	0.5	0.5	0.5	1	0.5	4.5
8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5
9	0.5	0	0	0	0	0	0	0.5	0.5	0.5	2
10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5

For Decision Parameters

Pi	P1	P2	P3	Sum
P1	0.5	1	1	2.5
P2	0	0.5	1	1.5
P3	0	0	0.5	0.5

7.5.3 Priority Ordering and Assignment of Priority Scores

The sum of each output matrices is then subjected to the assignment of priority scores. This process is presented in Table 7.13. Meanwhile, the priority scores were taken from Chen's work (1998) for the formulation of the semantic operators as shown in Appendix 9.

Table 7.13 Assignment of priority scores for infrastructure project selection and prioritisation problem

For P1 - Time Effectiveness

Ci	Sum	Score
1	7	1
4	7	1
8	5.5	0.667
6	5	0.538
7	5	0.538
2	4.5	0.481
3	4.5	0.481
5	4.5	0.481
10	4	0.379
9	3	0.25

For P2 - Cost Effectiveness

Ci	Sum	Score
6	6.5	1
1	6	0.818
4	6	0.818
8	6	0.818
2	5.5	0.739
3	5.5	0.739
10	5	0.6
5	4.5	0.538
7	3.5	0.379
9	1.5	0.143

For P3 - Project Complexity

For Decision Parameters

Ci	Sum	Score
2	6.5	1
3	6	0.818
4	6	0.818
1	5.5	0.739
6	5	0.6
8	5	0.6
10	5	0.6
5	4.5	0.538
7	4.5	0.538
9	2	0.176

Pi	Sum	Score
P1	2.5	1
P2	1.5	0.429
P3	0.5	0.111

7.5.4 Derivation of Weights

After the priority scores are confirmed, the next step is to determine the weight (w) of the elements ('selection criteria'). This is done through the normalisation of their corresponding priority scores. The results of normalisation and the summary are shown in Table 7.14 and Table 7.15 respectively. The weights as the result of normalisation can be converted into percentage distribution for easy calculation.

Table 7.14 Normalisation of priority score for the infrastructure project selection and prioritisation problem

For P1 - Time Effectiveness

Ci	Priority scores	Normalisation	Weight (w)	w (%)
C1	1	1.000/5.815	0.172	17.20%
C2	0.481	0.481/5.815	0.083	8.27%
C3	0.481	0.481/5.815	0.083	8.27%
C4	1	1.000/5.815	0.172	17.20%
C5	0.481	0.481/5.815	0.083	8.27%
C6	0.538	0.538/5.815	0.093	9.25%
C7	0.538	0.538/5.815	0.093	9.25%
C8	0.667	0.667/5.815	0.115	11.47%
C9	0.25	0.250/5.815	0.043	4.30%
C10	0.379	0.379/5.815	0.065	6.52%
sum	5.815			100.00%

For P2 - Cost Effectiveness

Ci	Priority scores	Normalisation	Weight (w)	w (%)
C1	0.818	0.818/6.592	0.124	12.41%
C2	0.739	0.739/6.592	0.112	11.21%
C3	0.739	0.739/6.592	0.112	11.21%
C4	0.818	0.818/6.592	0.124	12.41%
C5	0.538	0.538/6.592	0.082	8.16%
C6	1	1.000/6.592	0.152	15.17%
C7	0.379	0.379/6.592	0.057	5.75%
C8	0.818	0.818/6.592	0.124	12.41%
C9	0.143	0.143/6.592	0.022	2.17%
C10	0.6	0.600/6.592	0.091	9.10%
sum	6.592			100.00%

For P3 - Project Complexity

Ci	Priority scores	Normalisation	Weight (w)	w (%)
C1	0.739	0.739/6.427	0.115	11.50%
C2	1	1.000/6.427	0.156	15.56%
C3	0.818	0.818/6.427	0.127	12.73%
C4	0.818	0.818/6.427	0.127	12.73%
C5	0.538	0.538/6.427	0.084	8.37%
C6	0.6	0.600/6.427	0.093	9.34%
C7	0.538	0.538/6.427	0.084	8.37%
C8	0.6	0.600/6.427	0.093	9.34%
C9	0.176	0.176/6.427	0.027	2.74%
C10	0.6	0.600/6.427	0.093	9.34%
sum	6.427			100.00%

Table 7.15 Summary of weights for the infrastructure project selection and prioritisation problem

Ci/Pi	P1	P2	P3
C1	0.172	0.124	0.115
C2	0.083	0.112	0.156
C3	0.083	0.112	0.127
C4	0.172	0.124	0.127
C5	0.083	0.082	0.084
C6	0.093	0.152	0.093
C7	0.093	0.057	0.084
C8	0.115	0.124	0.093
C9	0.043	0.022	0.027
C10	0.065	0.091	0.093

Besides the elements, the weights of evaluation factors ('assessment parameters') should also be calculated using the same normalisation process which is presented in Table 7.16.

Table 7.16 Weights of assessment parameters for the infrastructure project selection and prioritisation problem

Pi	Priority scores	Normalisation	Weight (w)	w (%)
P1	1	1.000/1.540	0.649	64.94%
P2	0.429	0.429/1.540	0.279	27.86%
P3	0.111	0.111/1.540	0.072	7.21%
sum	1.540			100.00%

Figure 7.3 illustrates a weights-allocation diagram which is constructed when all the percentage distribution of elements ('selection criteria'/Ci) and evaluation factors ('assessment parameters'/Pi) are obtained. It shows the relative importance of each element under each evaluation factor. The pie chart illustrates the weights allocation (in %) of assessment parameters (Pi), while the bar chart illustrates the weights allocation (in %) of each element (Ci) under the category of each assessment parameter (Pi).

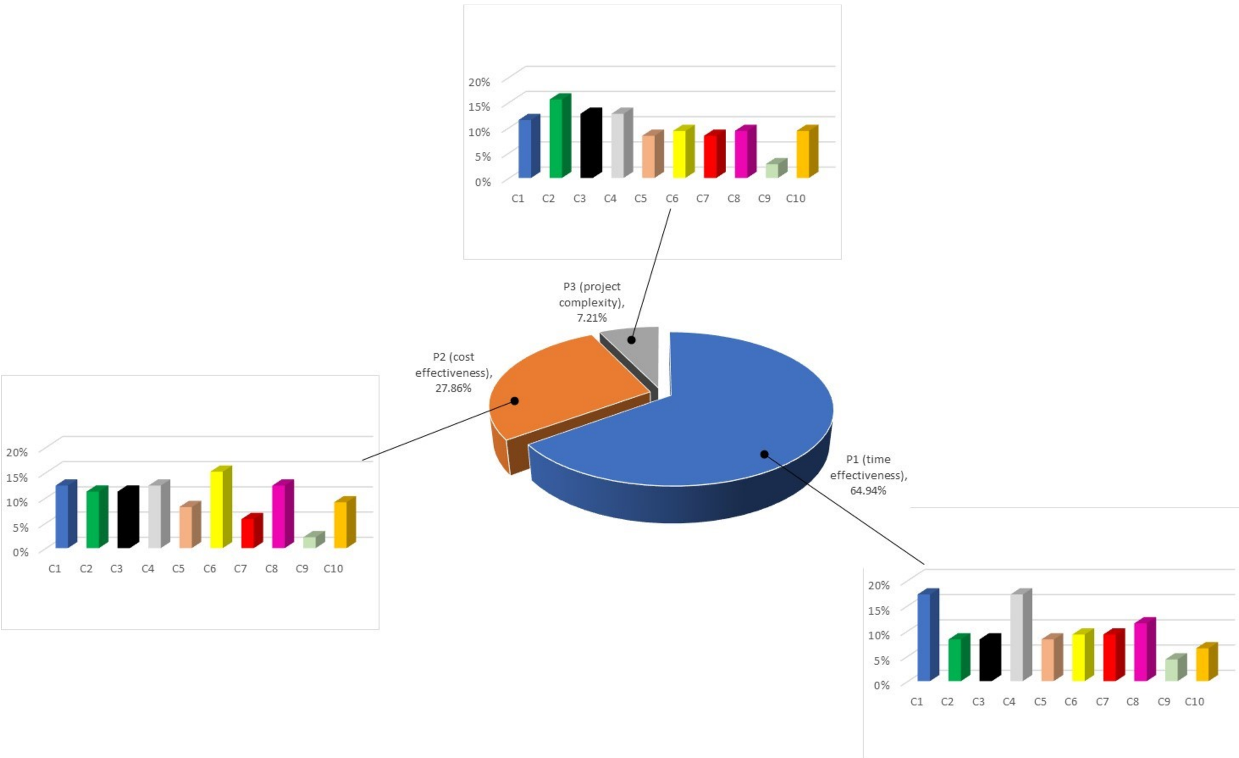


Figure 7.3 Weights-allocation diagram for infrastructure project selection and prioritisation problem

7.5.5 Determination of the Results

The last step in the NSFDSS-II procedure is to determine the overall contribution of each element to the infrastructure project selection and prioritisation process. The calculation method and result are presented in Table 7.17 and Table 7.18 respectively.

Table 7.17 Calculation of element contribution

Ci/Pi	P1 = 64.94%	P2 = 27.86%	P3 = 7.21%
C1	17.20% x 64.94%	12.41% x 27.86%	11.50% x 7.21%
C2	8.27% x 64.94%	11.21% x 27.86%	15.56% x 7.21%
C3	8.27% x 64.94%	11.21% x 27.86%	12.73% x 7.21%
C4	17.20% x 64.94%	12.41% x 27.86%	12.73% x 7.21%
C5	8.27% x 64.94%	8.16% x 27.86%	8.37% x 7.21%
C6	9.25% x 64.94%	15.17% x 27.86%	9.34% x 7.21%
C7	9.25% x 64.94%	5.75% x 27.86%	8.37% x 7.21%
C8	11.47% x 64.94%	12.41% x 27.86%	9.34% x 7.21%
C9	4.30% x 64.94%	2.17% x 27.86%	2.74% x 7.21%
C10	6.52% x 64.94%	9.10% x 27.86%	9.34% x 7.21%

Table 7.18 Contribution of elements

Ci/Pi	P1 = 64.94%	P2 = 27.86%	P3 = 7.21%	sum
C1	11.17%	3.46%	0.83%	15.45%
C2	5.37%	3.12%	1.12%	9.62%
C3	5.37%	3.12%	0.92%	9.41%
C4	11.17%	3.46%	0.92%	15.54%
C5	5.37%	2.27%	0.60%	8.25%
C6	6.01%	4.23%	0.67%	10.91%
C7	6.01%	1.60%	0.60%	8.21%
C8	7.45%	3.46%	0.67%	11.58%
C9	2.79%	0.60%	0.20%	3.59%
C10	4.23%	2.54%	0.67%	7.44%
sum	64.94%	27.86%	7.21%	100.00%

The contributions of each element are then subjected to the final priority ordering as presented in Table 7.19.

Table 7.19 Priority of criteria for the infrastructure project selection and prioritisation problem

Priority Order	Criteria	Weight
1	Risks & politics (C4)	15.54%
2	Strategic fit (C1)	15.45%
3	Private sector & public involvement (C8)	11.58%
4	Funding & financing (C6)	10.91%
5	Readiness criteria (C2)	9.62%
6	Innovative planning (C3)	9.41%
7	Contracts & governance issues (C5)	8.25%
8	Team member & stakeholder coordination (C7)	8.21%
9	Sustainability & env issues (C10)	7.44%
10	Local gov issues (C9)	3.59%
	Total	100.00%

7.6 Chapter Summary

Using a systematic and comprehensive approach, this chapter described the weights of determination for each key selection criteria in the infrastructure project selection and prioritisation process in the Indonesian context. The results of the analysis show the priority order of selection criteria arranged based on the weight of each criterion with higher weights reflecting the higher contribution levels of the criteria in the infrastructure project selection and prioritisation process. Risks and politics (C4) and strategic fit (C1) are in the top two in the priority order while local government issues (C9) received the lowest rank. The results of this analysis will be integrated into the development of a DMT for infrastructure project selection and prioritisation, which will be discussed in the next chapter.

CHAPTER 8. DECISION-MAKING FRAMEWORK FOR INFRASTRUCTURE PROJECT SELECTION AND PRIORITISATION

8.1 Introduction

Based on the conceptual Decision-Making Framework (Chapter 4) and the findings obtained from the interview analysis (Chapter 5), survey analysis (Chapter 6) and NSFDSS-II analysis (Chapter 7), this chapter describes the details of the proposed DMF for infrastructure project selection and prioritisation in the Indonesian context. In doing so, this chapter tries to synthesise all the findings of the entire research study to develop the final DMF. The final DMF consists of two major aspects that complement each other, i.e. the framework process and the Decision-Making Tool (DMT).

8.2 Decision-Making Framework for Infrastructure Project Selection and Prioritisation

The purpose of this research is to develop a DMF for infrastructure project selection and prioritisation that integrates multiple decision criteria. The development of this DMF is based on the conceptual DMF that was outlined in Chapter 4 and the findings from various approaches as explained in Chapters 5, 6 and 7. In general, the development of this DMF follows the pattern of the hierarchy structure depicted in Figure 8.1.

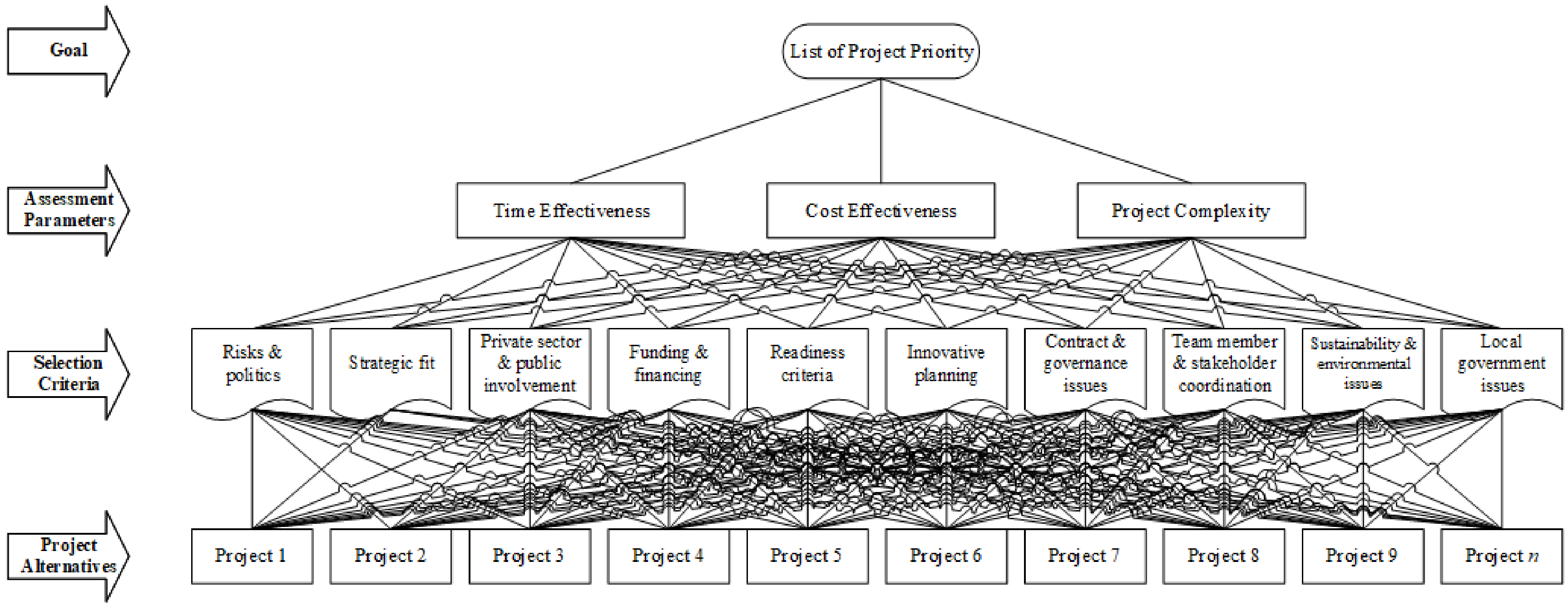


Figure 8.1 Hierarchy structure of DMF development

The above hierarchy structure illustrates the development of the DMF for infrastructure project selection applied in this study. The DMT development aims to provide an alternative decision support system in the decision-making process related to infrastructure project selection and prioritisation. To that end, various infrastructure project proposals that constitute input data in this process (with *n* representing the number of proposals) will be assessed and selected based on multiple selection criteria in accordance with the three assessment parameters of time effectiveness, cost effectiveness and project complexity. In other words, the top level describes the goal of this research, the second level considers the assessment parameters, the third level includes all of the selection criteria necessary for the evaluation process and the bottom level provides the possible infrastructure project alternatives.

Furthermore, there are five elements of an integrated DMF as described by Davidson and Venning (2011). These five elements are also found in the conceptual DMF as illustrated in Figure 4.3 (refer to Chapter 4). In the development of the final DMF, these five elements are as described in Table 8.1.

Table 8.1 Integrated DMF elements

Framework elements	Characteristics as observed in the proposed DMF
Context or environment	• Adopt a systematic assessment with holistic perspective • Adopt a rational decision-making process • Involve a network level of decision makers • Create a simple and effective framework
Goals or objectives	• To develop a model of a DMF for infrastructure project selection that integrates multiple decision criteria
Inputs	• Identify infrastructure project selection criteria • Identify infrastructure project proposals or alternatives
Processes	• Determine the key selection criteria • Determine the criteria weightings using NSFDSS-II • Provide judgments for each project alternatives by decision makers • Undertake calculation for the final scores of each project alternative
Outputs	• Efficient and effective indicators • Project priority list • Criteria performance measures • Provide validation and verification

In view of the preceding findings, a DMF for infrastructure project selection and prioritisation is proposed, as shown in Figure 8.2. The DMF was developed based on a comprehensive and systematic approach that combined the results from the previous data collection stages, i.e. stage 1 (literature studies), stage 2 (interview analysis), stage 3 (questionnaire survey examination) and stage 4 (pairwise comparisons with the Delphi method). Culminating from this process, key determinants are identified and addressed in the proposed DMF. A similar systematic approach in developing a study framework was adopted by Thunberg (2016), who developed a construction supply chain planning framework and Hansen, Rostiyanti and Rif'at (2020), who proposed a CEM framework that illustrates the causes, effects and recommended mitigating actions for CCO events.

The DMF occurs over four stages, i.e. the data input, the data analysis, the project assessment and the final results. It commences with the identification of input data, which consists of infrastructure project proposals and project selection criteria. In this research context, infrastructure project proposals are derived from the input of infrastructure project proposals in relevant ministries or agencies such as MPWH or KPPIP. The infrastructure project selection criteria included in the DMF are derived from a multi-sequencing approach including literature studies, interviews and questionnaire surveys. As a result, ten key infrastructure project selection criteria are established.

The second stage is data analysis, which follows the fuzzy logic-based system. It employs NSFDSS-II principles and has two phases, namely: design and implementation. In the design phase, problem decomposition is the focus with the problem being decomposed into a hierarchical structure, as shown in Figure 7.1 (refer to Chapter 7). Next, the key criteria for infrastructure project selection and prioritisation are identified. This is followed by expert criteria determination. Experts who met the expertise criteria are asked to conduct pairwise comparisons in the implementation phase. This involves comparative judgment with experts providing their judgment on each key selection criterion in pairs. After consistency checking, the weights of selection criteria are determined and evaluated to obtain the final priority scale.

In stage 3, project assessment is carried out by decision makers who utilise this framework by providing their judgment for each project alternative. The DMT that was developed as an inseparable part of this framework automatically calculates the final scores of each project proposal. In stage 4, the result is a list of infrastructure project priority, where proposals with higher scores are deemed more important than those with lower scores.

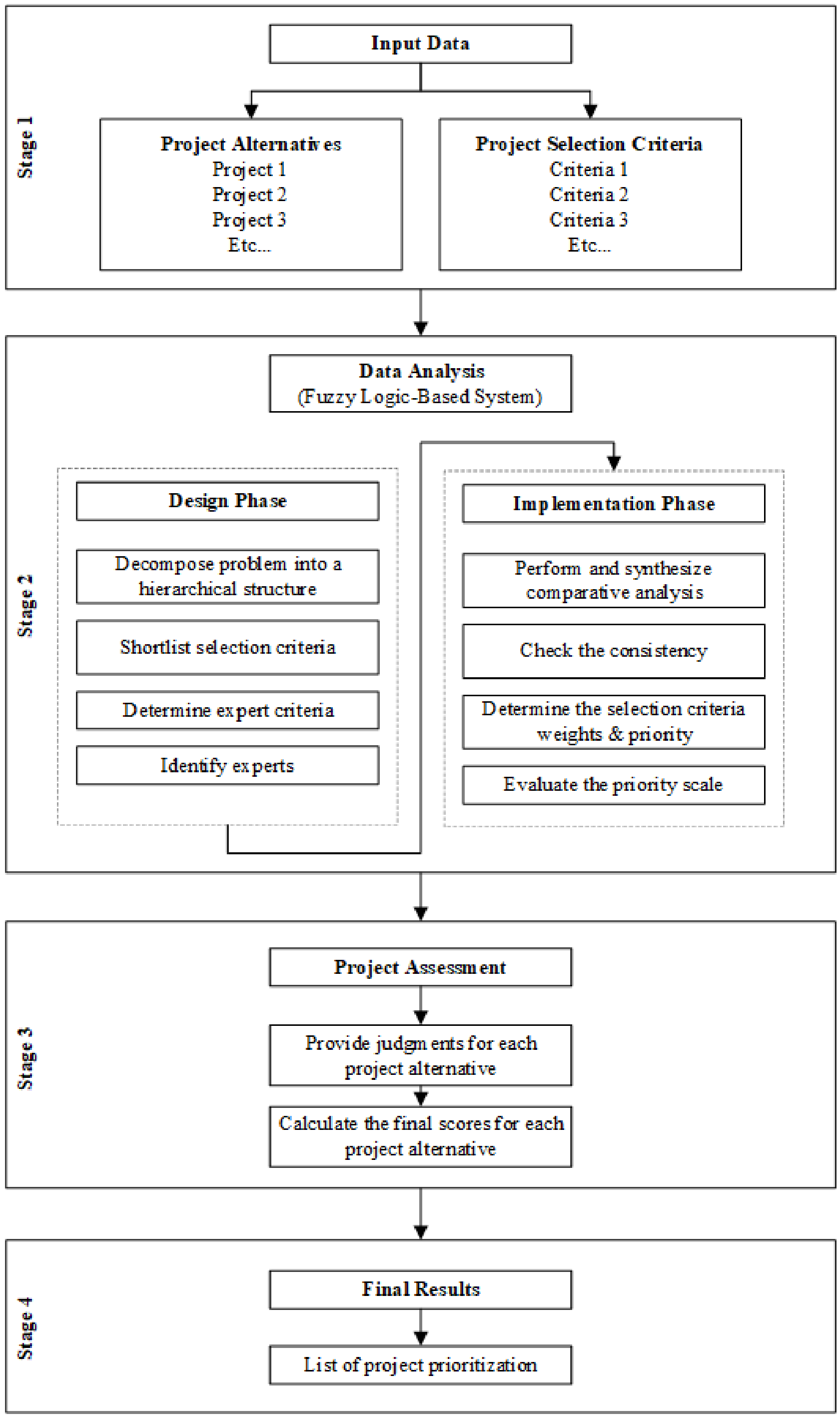


Figure 8.2 The DMF for infrastructure project selection and prioritisation

As presented in Figure 8.2, the developed DMF is simple and easily applicable. It offers a systematic model for improving the decision-making practice in infrastructure project selection and prioritisation. While it is developed based on Indonesian context, it is flexible and adaptive, which may allow others to modify this framework for use in other situations and contexts.

8.3 Decision-Making Tool

Apart from the framework process, another aspect of the developed DMF in this study is the Decision-Making Tool (DMT). There are two benefits of this DMT: (1) to facilitate decision makers in providing their judgments and (2) to facilitate decision makers in evaluating the performance of each project proposal. In this study, Ms. Excel was used as a platform to develop the DMT for infrastructure project selection and prioritisation.

The DMT consists of six parts:

(1) ***instruction***, provides instructions for using DMT for decision makers. There are seven instruction points delivered in Bahasa Indonesia and English (Appendix 10).
(2) ***project profiles***, contains the description of infrastructure project proposals that will be assessed in this DMT.
(3) ***simulation***, contains an input data table where decision makers can provide their judgments on each project proposal against each selection criterion.
(4) ***analysis***, contains an analysis table that automatically calculates input judgment with the weight of each selection criterion. The weight of selection criteria is determined through the NSFDSS-II analysis (as described in Chapter 7).
(5) ***result***, presents the final result of the analysis in the form of a project priority list. Priority ranking is sorted from higher to lower scores.
(6) ***graph***, presents visualisations related to the performance criteria of each project proposal.

The DMT templates are shown in Figure 8.3 to 8.6. In Figure 8.3, decision makers are required to provide their judgment on a scale of 1 to 10 for each project proposal against each selection criterion. To minimise potential biases, these selection criteria are presented in alphabetical order and do not display their weightages.

DATA INPUT

Criteria*	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
Contracts & governance issues								
Funding & financing								
Innovative planning								
Local gov issues								
Private sector & public involvement								
Readiness criteria								
Risks & politics								
Strategic fit								
Sustainability & env issues								
Team member & stakeholder coordination								

Note:
** these criteria are in an alphabetical order and do not reflect the scale of importance (weightage)*

Figure 8.3 Template of data input in DMT

Next, judgments will automatically be calculated by multiplying them with the weight of each selection criterion. This will produce performance scores as shown in Figure 8.4. The total performance scores for each project proposal are ranked from highest to lowest in order to obtain the priority ranking of infrastructure project proposals as shown in Figure 8.5. Meanwhile, Figure 8.6 displays an operational graph in which performance scores of the selection criteria were shown graphically as the DMT ran.

DATA ANALYSIS

Criteria*	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
Contracts & governance issues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Funding & financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Innovative planning	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Local gov issues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Private sector & public involvement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Readiness criteria	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Risks & politics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strategic fit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sustainability & env issues	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Team member & stakeholder coordination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Note:
** these criteria are in an alphabetical order and do not reflect the scale of importance (weightage)*

Figure 8.4 Template of data analysis in DMT

Result: Priority List

Project Name		Score	Priority Rank
Project 1		0.00	
Project 2		0.00	
Project 3		0.00	
Project 4		0.00	
Project 5		0.00	
Project 6		0.00	
Project 7		0.00	
Project 8		0.00	

Figure 8.5 Template of project priority list in DMT

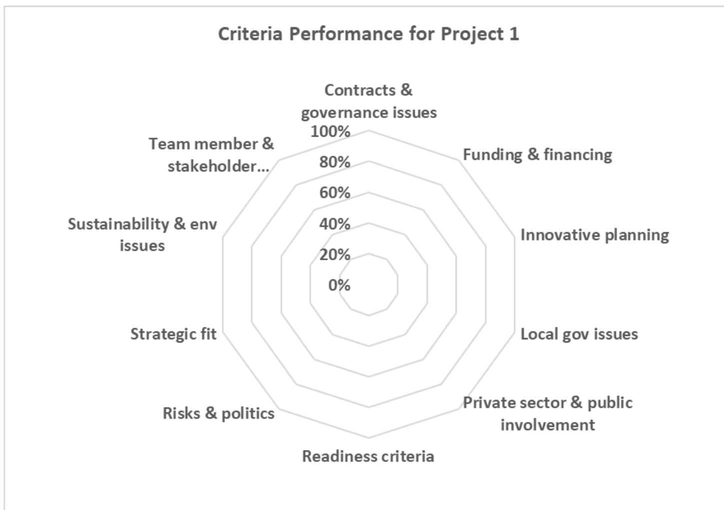


Figure 8.6 Template of radar graph in DMT

8.4 Dimensions, Characteristics and Features of the Decision-Making Framework

Referring to the conceptual development of the DMF model, which was discussed in Chapter 4, there are five dimensions of the DMF that can be used to describe the concepts and characteristics of the proposed DMF. The five dimensions are: (1) theories and concepts, (2) characteristics, (3) contexts, (4) usability and suitability, and (5) benefits and pitfalls. The evaluation of these five dimensions of the developed DMF is described as follows.

1. Theories and concepts

   The underlying approach of the developed DMF is a systematic process to select and prioritise infrastructure project proposals. The assessment is carried out objectively by the decision makers or the FEP team by considering the various key selection criteria that have been identified. According to its type, the developed DMF applies a rational selection technique which is indicated by the existence of a clear procedure and a quantitative decision-making process with a scoring method.

2. Characteristics

   The developed DMF employs a network type of decision makers characterised by a heterogeneous mix of decision makers or the FEP team members during the decision-making process. It does not distinguish between infrastructure project proposals based on their development stages; instead, it proposes four stages of assessment as shown in the framework process. To select and prioritise the project proposals, it has developed a DMT consisting of ten key selection criteria.

3. Contexts

   The developed DMF includes six major contexts in infrastructure project selection and prioritisation, i.e. political context (acknowledging the political influence in the selection process), economical context (placing great emphasis on the economic aspects in the selection process), stakeholders context (identifying the key stakeholders and their respective roles), decision-making process context (providing a scientific and systematic decision-making process), socio-environmental context (taking into account the socio-environmental consideration in the selection process) and technological context (considering technological aspects in the selection process).

4. Usability and suitability

   In general, the developed DMF is useful to assist decision makers in making high quality decisions. It is a vital managerial tool that is suitable for use by the relevant ministries in Indonesia to select infrastructure project proposals.

5. Benefits and pitfalls

   The developed DMF has several benefits including: the comprehensiveness of the DMF's development, the clarity and simplicity in the framework process, the inclusion of a practical tool to assist decision makers in assessing the project proposals and as a proof-based framework that has been tested through several implementation and evaluation strategies. On the other hand, it also has several limitations including: the requirement for training the usage of the DMF and the lack of a detailed rubric assessment to assist the decision makers in making judgments with the DMT.

In addition, the developed DMF has also been developed to meet the expected DMF characteristics and features identified through interview analysis as mentioned in Chapter 5, Figure 5.23. These traits and features of the developed DMF are presented in Table 8.2.

Table 8.2 DMF traits and features

DMF issues	As observed in the developed DMF
Expected characteristics	
Accountability	The developed DMF provides an accountable decision-making process that can help decision makers in arriving at quality decision outputs. The objective and systematic assessment process strengthens answerability and enforcement of the decisions.
User-friendly	The developed DMF has three attributes of user-friendly trait. First, it offers a straightforward and clear procedure as seen in the framework process (Figure 8.2). Second, it provides a detailed explanation which includes key points of the assessment process. Third, it consists of ten key selection criteria that can be considered as a simple and small set of indicators.
Transparency	The use of this DMF provides transparency in the decision-making process of infrastructure project selection and prioritisation by decision makers or the FEP team.
Technology based	The DMF is a proof-based DMT based on MCDM technique that can further be developed as a DSS in the form of software application.
Expected features	
Introductory features	The developed DMF includes several introductory features such as definition of DMF, importance of DMF and the stakeholders involved.
Selection features	The DMF has described in detail the selection stages and provided a DMT to assist the selection process of infrastructure project proposals.
Complementary features	The use of DMF supports the audit process, establishes clear coordination and communication, and provides visualisation with graphical displays.

8.5 Chapter Summary

This chapter described the synthesis of all the findings in this study to develop a DMF for infrastructure project selection and prioritisation in Indonesia. Based on the conceptual DMF and the findings of the multi-sequences approach, the DMF development was completed by focusing on two complementary aspects of DMF, namely: the framework process and the DMT. The developed DMF can serve as an alternative decision support system for decision makers involved in the process of planning and selecting infrastructure project proposals. The next chapter will focus on the validating the effectiveness of this DMF through several evaluation strategies.

CHAPTER 9. DECISION-MAKING FRAMEWORK IMPLEMENTATION AND EVALUATION

9.1 Introduction

This chapter presents the implementation and evaluation processes of the developed DMF. It is important since the effectiveness of a proposed framework must always be verified and validated. While there is no agreement on how to determine the quality of a decision-making framework or the reliability of the resulting decision output (Muñoz, Romana & Ordóñez 2016), this study seeks to evaluate and validate the developed DMF through the following strategies:

(1) **1st implementation**: to implement the developed DMF to see how it would be carried out within an organisation trying to make decisions related to infrastructure project selection and prioritisation. This is done by assessing and selecting several prospective infrastructure project proposals.
(2) **2nd implementation**: to investigate the performance of the developed DMF in selecting several past infrastructure project proposals. This is done by evaluating the level of consistency of DMF decision output with the actual conditions.
(3) **Parallel-forms reliability tests**: to conduct method comparison tests where the results of DMF output developed based on NSFDSS-II are compared with the output results when DMF is developed with other methods such as NSFDSS-I, Fuzzy SAW and AHP OS.
(4) **Sensitivity analysis**: to conduct sensitivity analysis to evaluate the reliability of the developed DMF under different scenarios.
(5) **Dissemination**: to disseminate the DMF at a specific conference and obtain feedback from the reviewers and participants.

The following section gives a summary of the case studies followed by the two case study implementations. It continues with the evaluation of the DMF performance and feedbacks. Reliability tests are conducted through parallel-forms reliability tests and sensitivity analysis. This chapter ends with an overview of the dissemination of the developed DMF at a relevant conference.

9.2 Overview of Case Study (MPWH)

To implement the developed DMF, this research adopts a case study approach where, in the implementation and testing of the effectiveness of this DMF, the researcher has little or no control during the implementation process (Yin 2013). According to Cheaitou, Larbi and Al Housani (2019), case study implementation can be one of the validation techniques of a proposed DMF without limiting its scope. Some previous studies have also applied case study implementation as a way to demonstrate their proposed DMF (Arif, Bayraktar & Chowdhury 2016; Kalutara 2013; Masoumi 2015).

In this study, the DMF implementation is demonstrated using data from two different perspectives: data of prospective infrastructure project proposals and data of past infrastructure project proposals. Hence, there are two case study implementations undertaken to demonstrate the DMF. The first case study implementation was carried out to assess and select prospective infrastructure project proposals (proposed projects 2019/2020 onwards), while the second case study implementation was carried out to assess and select the infrastructure project proposals that had been undertaken prior to 2020 (proposed projects 2019).

Since selection of cases is a crucial aspect in the case study approach (Pham 2016), in this research this aspect was carried out purposefully to maximise variation of cases. While there is no consensus on how many cases should be included in such research, Yin (2013) suggests a minimum of two cases while Miles and Huberman (1994) argue that the maximum number of cases should be no more than 15. Table 9.1 presents the considerations in selecting the cases for both implementations.

Table 9.1 Considerations for case study selection

Considerations	Explanation
Funding schemes	Projects have different funding schemes such as APBN, PPPs and overseas loans
Range of sectors	Projects represent different infrastructure sectors such as toll roads, SPAM, PLTU, etc.
Diverse location	Projects represent a variety of project locations
Number of cases	Between 7-8 cases for each implementation
Ability to access project documents	Documents relating to project profiles and progress are available by relevant authorities and can be easily accessed online

In total, there are seven infrastructure project proposals for the 1st implementation and eight proposals for the 2nd implementation. The data related to infrastructure project proposals are taken from the KPPIP Report Semester 1/2019 and the KPPIP Report Semester 2/2019, which lists the strategic infrastructure project plans in Indonesia.

The case study implementations were carried out on two expert respondents (R1 and R3) from the MPWH as relevant parties in the process of planning and selecting proposals for infrastructure projects in Indonesia. In addition, one expert respondent (R2), a professional academic, was also involved to ensure research transferability through shared experience. The expertise criteria that had to be fulfilled by the expert respondents are shown in Table 9.2, where Y indicates 'Yes' or fulfilled and N indicates 'No' or not fulfilled.

Table 9.2 Expert criteria for case study implementations

Expert Criteria	Descriptions	R1	R2	R3
Practical experience	• Professionals/academics working in construction-related sectors at least 15 years of working experience	Y	Y	Y
Educational background	• Have a construction-related educational background with master degree level	Y	Y	Y
Certification/ accreditation	• Have a professional certification	Y	Y	Y
Other competencies/ personal skills	• Have awareness of infrastructure project development in Indonesia	Y	Y	Y
Trainings and activities	• Have been involved in a construction-related training/ activity	Y	Y	Y
Membership	• Member of a construction-related professional organisation	Y	Y	Y
Perceived knowledge	• Have been involved in infrastructure project planning and/or execution	Y	Y	Y
Position within organisation	• Have a manager/above position	Y	Y	Y
Ability to communicate knowledge	• Have access and willing to share their opinions/knowledge about the topic	Y	Y	Y

9.3 Case Study Implementations

There are two case study implementations applied to MPWH as an organisation involved in the planning and selection of infrastructure project proposals in Indonesia. The 1st implementation aims to demonstrate the application of DMF in selecting and prioritising several prospective infrastructure project proposals. The 2nd implementation is useful for witnessing the application of the DMF in selecting and prioritising some past infrastructure project proposals, so that a comparison can be made between the results of the decision output and the actual conditions.

In general, there are three stages of implementation that must be completed by the three expert respondents as decision makers:

(1) understand and review the DMF process
(2) understand and provide judgment in the DMT
(3) provide feedback and evaluations of the framework process and DMT

9.3.1 First Implementation

The 1st DMF implementation was carried out on two expert respondents (R1 and R2). First of all, they were asked to view and understand the proposed DMF process, as illustrated in Figure 8.2 (refer to Chapter 8). Furthermore, they were asked to conduct a case study implementation of the seven infrastructure project proposals that had been provided. The DMT implementation process is:

Step 1 read and understand the instructions that have been provided in the DMT.
Step 2 read the project profile descriptions for the seven existing infrastructure project proposals.
Step 3 provide judgment on each project proposal against each selection criterion on a scale of 1 to 10.
Step 4 review the results of the input judgment analysis that has been done automatically.
Step 5 review the final project priority list.
Step 6 review operational graphs that show the performance criteria of each project proposal.

Table 9.3 provides project descriptions for seven infrastructure project proposals. The complete document explaining the detailed status of the project proposal is given to the experts for them to understand and read before conducting the assessment. After reading and understanding the status of each project, the two expert respondents were asked to provide their judgments on a scale of 1 to 10 for each project proposal against the ten key selection criteria. Figure 9.1 presents the data input where experts provide their judgment scores, while Figure 9.2 shows the analysis table that automatically calculates the input judgment with the weight of each selection criterion.

DATA INPUT

Criteria	Weight	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
Risks & politics	15.54%	9	6	6	8	8	6.5	7
Strategic fit	15.45%	8.5	6.5	6.5	6.5	6.5	8	5.5
Private sector & public involvement	11.58%	7.5	6	7	9.5	7	8.5	5
Funding & financing	10.91%	9.5	7.5	8	9	5.5	9	6.5
Readiness criteria	9.62%	9.5	7.5	8	8.5	9	8.5	6.5
Innovative planning	9.41%	7.5	5	6	6	3.5	5	6.5
Contracts & governance issues	8.25%	7	4.5	4.5	6.5	6	5.5	3.5
Team member & stakeholder coordination	8.21%	6.5	6.5	5.5	7	10	5.5	5.5
Sustainability & env issues	7.44%	6	4	9	5.5	9	4	4
Local gov issues	3.59%	5.5	4.5	4.5	5.5	5	5	3.5

Figure 9.1 Data input for the first implementation

DATA ANALYSIS

Criteria	Weight	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
Risks & politics	15.54%	1.40	0.93	0.93	1.24	1.24	1.01	1.09
Strategic fit	15.45%	1.31	1.00	1.00	1.00	1.00	1.24	0.85
Private sector & public involvement	11.58%	0.87	0.69	0.81	1.10	0.81	0.98	0.58
Funding & financing	10.91%	1.04	0.82	0.87	0.98	0.60	0.98	0.71
Readiness criteria	9.62%	0.91	0.72	0.77	0.82	0.87	0.82	0.63
Innovative planning	9.41%	0.71	0.47	0.56	0.56	0.33	0.47	0.61
Contracts & governance issues	8.25%	0.58	0.37	0.37	0.54	0.49	0.45	0.29
Team member & stakeholder coordination	8.21%	0.53	0.53	0.45	0.57	0.82	0.45	0.45
Sustainability & env issues	7.44%	0.45	0.30	0.67	0.41	0.67	0.30	0.30
Local gov issues	3.59%	0.20	0.16	0.16	0.20	0.18	0.18	0.13
Total	**100.00%**	**7.99**	**6.01**	**6.61**	**7.43**	**7.02**	**6.88**	**5.63**

Figure 9.2 Data analysis for the first implementation

Table 9.3 Project profiles for the first implementation

Description	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
Project name	Jakarta Sewerage System (Zona 8)	Palembang - Tanjung Api-Api Toll Road	Yogyakarta - Bawen Toll Road	MRT Jakarta (Phase II)	Indramayu Steam Power Plant	Jatiluhur Water Supply System	Bontang Oil Refinery
Amount	Rp 70 T	Rp 14.2 T	Rp 12.14 T	Rp 22.5 T	Rp 27 T	Rp 1,670 B	Rp 197.58 T
Funding scheme	PPP	Assignment to SOE	PPP	National State Budget & Jakarta Budget with overseas loan	National State Budget with overseas loan	PPP	Assignment to Pertamina/ SOE with private sector
Location	Jakarta	South Sumatera	Yogyakarta & Central Java	Jakarta	West Java	West Java & Jakarta	East Kalimantan
Responsibility	Jakarta Provincial Government	Toll Road Governing Body, MPWH	Toll Road Governing Body, MPWH	PT. MRT Jakarta	PT. PLN	Perum Jasa Tirta II	PT. Pertamina
Start of construction	2021	2020	2020	2019	2022	2020	2021
Operational Target	2023	2022	2022	2024	2026	2022	2027

The analysis produces a list of projects prioritisation as shown in Figure 9.3. Here, priorities are sorted by total performance scores from highest to lowest. Meanwhile, the performance criteria for each project proposal can be seen in the form of the radar graph in Figure 9.4.

Result: Priority List			
Project Name		Score	Priority Rank
Project 1	Jakarta Sewerage System (Zona 8)	7.99	1
Project 4	MRT Jakarta (Phase II)	7.43	2
Project 5	Indramayu Steam Power Plant	7.02	3
Project 6	Jatiluhur Water Supply System	6.88	4
Project 3	Yogyakarta-Bawen Toll Road	6.61	5
Project 2	Palembang-Tanjung Api-Api Toll Road	6.01	6
Project 7	Bontang Oil Refinery	5.63	7

Figure 9.3 Priority list for the first implementation

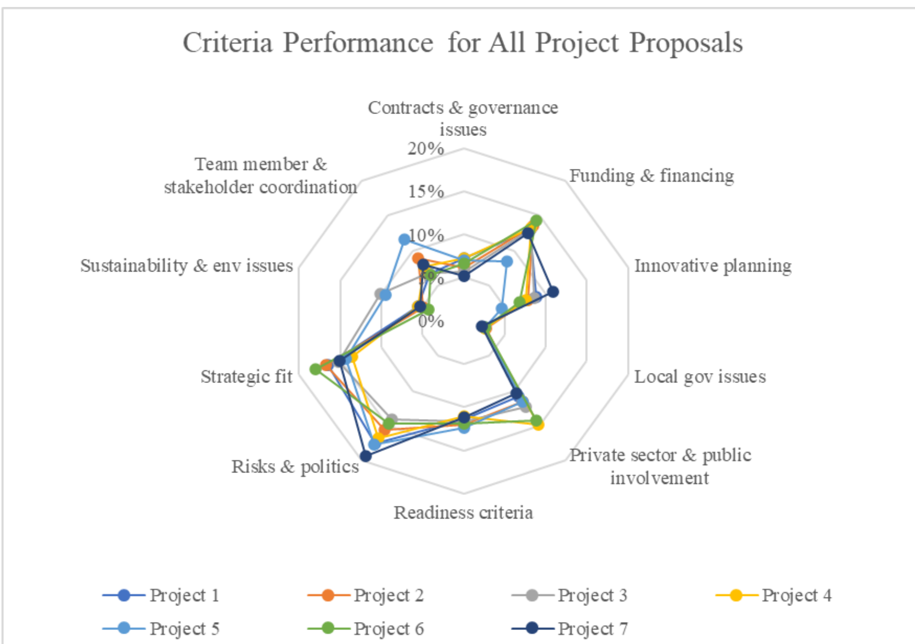


Figure 9.4 Radar graph for the first implementation

9.3.2 Second Case Study Implementation: Past Projects

The 2nd DMF implementation is carried out to test the consistency of decision outputs from the DMF against the actual conditions in the field. For this reason, an expert respondent (R3) from MPWH was asked to provide an assessment of eight past infrastructure project proposals. These eight proposals were submitted for the 2019 fiscal year. The process is the same as in the first implementation.

Brief descriptions of these eight project proposals are presented in Table 9.4. In addition, expert respondents were also provided documents relating to the detailed status of these eight projects. Then the expert respondent was asked to give his judgment scores within a scale of 1 to 10, as shown in Figure 9.5. Meanwhile, Figure 9.6 presents the analysis table that automatically calculates the judgment.

DATA INPUT

Criteria*	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
Contracts & governance issues	5	3	8	8	5	3	8	3
Funding & financing	7	3	8	8	7	3	8	3
Innovative planning	7	8	4	3	8	3	3	5
Local gov issues	9	7	7	7	8	7	7	7
Private sector & public involvement	8	7	9	6	6	6	7	8
Readiness criteria	3	3	5	3	3	7	5	3
Risks & politics	8	6	8	5	7	7	8	8
Strategic fit	8	7	6	4	6	6	5	5
Sustainability & env issues	5	8	3	6	8	8	6	6
Team member & stakeholder coordination	8	8	8	8	8	8	8	8

Note:
** these criteria are in an alphabetical order and do not reflect the scale of importance (weightage)*

Figure 9.5 Data input for the second implementation

DATA ANALYSIS

Criteria*	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
Contracts & governance issues	0.40	0.24	0.64	0.64	0.40	0.24	0.64	0.24
Funding & financing	0.77	0.33	0.88	0.88	0.77	0.33	0.88	0.33
Innovative planning	0.63	0.72	0.36	0.27	0.72	0.27	0.27	0.45
Local gov issues	0.36	0.28	0.28	0.28	0.32	0.28	0.28	0.28
Private sector & public involvement	0.96	0.84	1.08	0.72	0.72	0.72	0.84	0.96
Readiness criteria	0.30	0.30	0.50	0.30	0.30	0.70	0.50	0.30
Risks & politics	1.28	0.96	1.28	0.80	1.12	1.12	1.28	1.28
Strategic fit	1.20	1.05	0.90	0.60	0.90	0.90	0.75	0.75
Sustainability & env issues	0.35	0.56	0.21	0.42	0.56	0.56	0.42	0.42
Team member & stakeholder coordination	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Total	**6.89**	**5.92**	**6.77**	**5.55**	**6.45**	**5.76**	**6.50**	**5.65**

Note:
** these criteria are in an alphabetical order and do not reflect the scale of importance (weightage)*

Figure 9.6 Data analysis for the second implementation

Table 9.4 Project profiles for the second implementation

Description	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
Project name	MRT (Phase 2)	Inland Waterways Cikarang - Bekasi	Existing Refinery Revitalisation	Palembang - Tanjung Api-Api Toll Road	Jakarta Sewerage System (Zona 1 & 6)	West Semarang Water Supply System	Kisaran - Tebing Tinggi Roll Road	Yogyakarta - Bawen Toll Road
Amount	Rp 22.5 T	Rp 3.4 T	Rp 246.22 T	Rp 14.2 T	Rp 70 T	Rp 1,191 B	Rp 13.4 T	Rp 12.14 T
Funding scheme	National State Budget & Jakarta Budget with overseas loan	PPP	Assignment to SOE	Assignment to SOE	National State Budget with overseas loan	PPP	Assignment to SOE	PPP
Location	Jakarta	West Java	East Java, West Java & East Kalimantan	South Sumatera	Jakarta	East Java	North Sumatera	Yogyakarta & East Java
Responsibility	PT. MRT	PT. Pelindo II	PT. Pertamina	Toll Road Governing Body, MPWH	Jakarta Provincial Government	PDAM Kota Semarang	Toll Road Governing Body, MPWH	Toll Road Governing Body, MPWH
Planned start of construction	2019	2019	2019	2019	2019	2019	2019	2019
Planned operational Target	2024	2021	2021	2021	2022	2021	2021	2021

The analysis produces a list of project priority as shown in Figure 9.7. Meanwhile, the relative magnitude of the project proposals compared with the involved selection criteria can be seen in the radar graph presented in Figure 9.8.

Result: Priority List

Project Name		Score	Priority Rank
Project 1	MRT (Phase 2)	6.89	1
Project 3	Existing Refinery Revitalization	6.77	2
Project 7	Kisaran - Tebing Tinggi Roll Road	6.50	3
Project 5	Jakarta Sewerage System (Zona 1 & 6)	6.45	4
Project 2	Inland Waterways Cikarang - Bekasi	5.92	5
Project 6	West Semarang Water Supply System	5.76	6
Project 8	Yogyakarta - Bawen Toll Road	5.65	7
Project 4	Palembang - Tanjung Api-Api Toll Road	5.55	8

Figure 9.7 Priority list for the second implementation

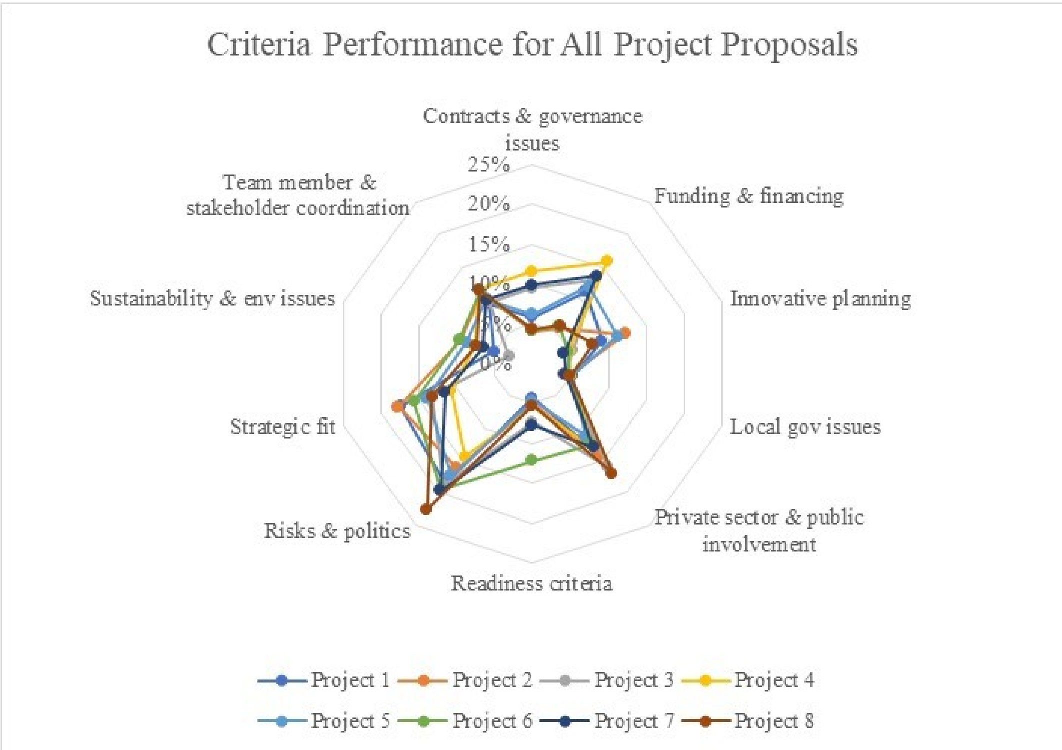


Figure 9.8 Radar graph for the second implementation

As explained previously, the 2nd implementation aims to verify the consistency of the decision outputs of the DMF implementation results compared to the actual status of the project proposal that has been carried out. Table 9.5 shows the comparison between the actual status of past projects and the results of the DMF implementation. It is evident that, although it cannot be known with certainty the priority order of the actual conditions, the decision output from the

DMF indicated that the two least prioritised projects are also the projects that are postponed for the 2019 fiscal year. This implies the advantages of the developed DMF, which results in similar or consistent results for infrastructure projects selection problems.

Table 9.5 Consistency check of the DMF decision output with the actual condition

VERIFICATION

Past Project Proposals	Actual status	Result from the 2nd implementation	
MRT (Phase 2)	selected for implementation	1	MRT (Phase 2)
Inland Waterways Cikarang - Bekasi	selected for implementation	2	Existing Refinery Revitalization
Existing Refinery Revitalization	selected for implementation	3	Kisaran - Tebing Tinggi Roll Road
West Semarang Water Supply System	selected for implementation	4	Jakarta Sewerage System (Zona 1 & 6)
Jakarta Sewerage System (Zona 1 & 6)	selected for implementation	5	Inland Waterways Cikarang - Bekasi
Kisaran - Tebing Tinggi Roll Road	selected for implementation	6	West Semarang Water Supply System
Yogyakarta - Bawen Toll Road	postponed	7	Yogyakarta - Bawen Toll Road
Palembang - Tanjung Api-Api Toll Road	postponed	8	Palembang - Tanjung Api-Api Toll Road

9.4 Feedback from the Experts

To investigate the effectiveness of this framework, an interview survey was developed and implemented to gather the experts' opinions. The interview questions were made based on the research of Ravanshadnia, Abbasian and Rajaie (2010) who developed a structured questionnaire for evaluating the applicability and effectiveness of a decision-making model that included four elements of questions: comprehensiveness, applicability, user-friendliness and practitioner's support. In the context of this study, one element was added to these four elements, namely practitioner's feedback, which is useful for the development and continuous improvement of developed DMF. Table 9.6 provides the interview question development matrix with its association with the five elements applied in this study.

Table 9.6 Interview questions development matrix for DMF evaluation

No	Interview Question	Description/Purpose	Element
1	Do the selection criteria capture the main factors in deciding infrastructure project selection?	Investigating the selection criteria in infrastructure project selection from expert's perspective	comprehensiveness
2	Are the definitions of each criteria clear?	Exploring expert's understanding on the definition of selection criteria in prioritising infrastructure project proposals	comprehensiveness
3	What do you think about the selection criteria priority ordering?	Exploring expert's opinion on the selection criteria priority ordering	comprehensiveness

4	What do you think about the DMF & DMT used to select and prioritise infrastructure project proposals after you have used it?	Exploring expert's opinion on their experience in using the DMF & DMT	applicability
5	Do you think that these DMF & DMT are useful for you in deciding infrastructure project selection? Are they applicable, effective and efficient?	Understanding expert's opinion about the usefulness of the proposed DMF & DMT	applicability
6	Do you think that these DMF & DMT appropriately address the requirements and considerations in making decision for infrastructure project selection?	Investigating the effectiveness of the proposed DMF & DMT for infrastructure project selection	comprehensiveness
7	Do you think that these DMF & DMT are user friendly and easy to understand?	Understanding expert's opinion about the practicality of the proposed DMF & DMT	user-friendliness
8	Do you have some suggestions for future additions to these DMF & DMT?	Exploring expert's suggestion that may improve the DMF & DMT	practitioner's feedback
9	Do you recommend the use of these DMF & DMT?	Exploring expert’s support in using the developed DMF & DMT within his/her organisation	practitioner's support

After the case study implementations, experts were asked to provide their opinions regarding the DMF and DMT. Remarks from their opinions are presented in Table 9.7 for the first implementation and Table 9.8 for the second implementation.

Table 9.7 Remarks from the first implementation

No	Questions	Comments/Feedbacks
1	What do you think about the selection criteria priority ordering?	R1: The order of these selection criteria is match with the current Indonesian situation. That is indeed the most important thing in my opinion is political risks.
		R2: My opinion is these criteria priority orders are different between one project to other project depend on type of the project and many things, however some criteria priority is match for one particular projects.
2	Do the selection criteria capture the main factors in deciding infrastructure project selection?	R1: I think so. These criteria have captured all the critical factors in infrastructure project selection.
		R2: Most of them are the main factors in deciding infrastructure project selection such as readiness criteria, funding and financing and risk and politics

3	Are the definitions of each criteria clear?	R1: Yes, I can understand.
		R2: Yes, clear enough.
4	What do you think about the DMF & DMT used to select and prioritise infrastructure project proposals after you have used it?	R1: It is capable and I agree. I think it is a good tool.
		R2: I think DMF and DMT will help decision makers to prioritise which infrastructural project to be constructed first.
5	Do you think that these DMF & DMT are useful for you in deciding infrastructure project selection? Are they applicable, effective and efficient?	R1: In my opinion it is useful because there are many projects right now but the government might be confused, which projects should be prioritised first while the funds are limited. With this tool, people will know which priorities should they do first.
		R2: Yes, very useful.
6	Do you think that these DMF & DMT appropriately address the requirements and considerations in making decision for infrastructure project selection?	R1: Yes, correct. In my opinion it's already efficient and effective. In a sense, there must be criteria in making decisions. And these criteria are very clear and we can know how they are weighted. In my opinion it is applicable, can be used to make justified decisions.
		R2: I think even though these criteria mostly address all the requirements and considerations, but it will not guarantee the quality and progress of the project. But at least it can minimise the inefficiency and ineffectiveness of all planned projects by decision makers such as government or BUMN as the owner of the projects.
7	Do you think that these DMF & DMT are user friendly and easy to understand?	R1: Yes, I think it is simple.
		R2: Yes, very easy to be understood.
8	Do you have some suggestions for future additions to these DMF & DMT?	R1: I think from practicality, if you want to make project selection, it's easy. I think these framework & tool are good. They provide more rational decisions, compared with intuitive judgment, this is more accountable. These framework and tool are adaptable and applicable in my opinion.
		R2: I think the criteria might different between project to another projects, therefore in my opinion it might add other criteria that it would be appropriate for different infrastructure projects.

Table 9.8 Remarks from the second implementation

No	Questions	Comments/Feedbacks

1	Do the selection criteria capture the main factors in deciding infrastructure project selection?	Yes, they are key selection criteria but the weights of each criteria may be different. Based on my experience, the most important criteria are strategic national projects, urgency and readiness criteria.
2	Are the definitions of each criteria clear?	Clear enough.
3	What do you think about the DMF & DMT used to select and prioritise infrastructure project proposals after you have used it?	With the budget limitation for infrastructure development, there is a need for DMF and DMT to prioritise which project proposals to be funded first.
4	Do you think that these DMF & DMT are useful for you in deciding infrastructure project selection? Are they applicable, effective and efficient?	DMF and DMT will help in selecting projects but it must be simulated with the large number of project proposals at the MPWH, will it be in accordance with the required number during implementation.
5	Do you think that these DMF & DMT appropriately address the requirements and considerations in making decision for infrastructure project selection?	The selection criteria are quite comprehensive but it should be implemented with real (future) cases.
6	Do you think that these DMF & DMT are user friendly and easy to understand?	Yes, they are.
7	Do you have some suggestions for future additions to these DMF & DMT?	It needs to be implemented and simulated with the actual project numbers at the MPWH.
8	Do you recommend the use of these DMF & DMT?	Yes.

9.5 Parallel-Forms Reliability Tests

To investigate the reliability of decision outputs from the developed DMF, one of the tests conducted in this study is the parallel-forms reliability test. Parallel-forms (or alternate-forms) reliability refers to the consistency of different but related measurement tools when applied to the same sample (Lucko & Rojas 2010). It is used to test the stability attribute of a research reliability (Heale & Twycross 2015). To see the success rate of the parallel-forms reliability tests, Glinger, Morgan and Harmon (2001) suggest that the correlation coefficient between the two sets of scores should be at least 80%.

In this study, parallel-forms reliability tests are performed by comparing the decision outputs of a model that is developed based on a particular MCDM technique with another model developed based on another MCDM technique. In total there are four different measurement analysis approaches that are applied to determine the weight and priority scale of the key criteria for infrastructure project selection problems, namely:

(1) **NSFDSS-II**: an MCDM technique adopted in this study.

(2) **NSFDSS-I**: the MCDM technique developed by Chen (1998) is the predecessor technique of NSFDSS-II. Several studies utilising this technique include Lau et al. (2018), Tam et al. (2002b), Wang, Zhang and Gao (2011), and Yau and Chan (2008).
(3) **Fuzzy SAW**: an MCDM technique that combines aspects of fuzzy into a simple additive weighting (SAW) method. Some studies include: Modarres and Sadi-Nezhad (2005), and Sembiring et al. (2018).
(4) **AHP OS**: an MCDM technique based on Saaty's AHP-based online system.

NSFDSS-II is a technique used as a basis for developing DMF for infrastructure project selection and prioritisation in this study. Therefore, this technique becomes the baseline for comparing decision outputs against three other techniques. The following sections explain the determination of weighting criteria based on NSFDSS-I, Fuzzy SAW and AHP OS which are then used as the basis for comparing the results of decision output with the same sample (i.e. expert judgment score from the first implementation).

9.5.1 NSFDSS-II and NSFDSS-I

NSFDSS-II and NSFDSS-I are interrelated techniques in which NSFDSS-II is the result of the evolution of NSFDSS-I. Despite its advantages, NSFDSS-I is still more popularly used in solving decision-making problems than NSFDSS-II. Similar to NSFDSS-II, there are five analysis steps in NSFDSS-I. The first three steps are identical to NSFDSS-II, while the fourth and fifth steps have a slight difference as shown in Table 9.9.

Table 9.9 Differences between NSFDSS-I and NSFDSS-II analysis procedure

Step	NSFDSS-I	NSFDSS-II
4	• Normalisation of decision criteria priority scores and calculation of weight for each decision criterion	• Normalisation of decision criteria priority scores and calculation of weight for each decision criterion • Normalisation of elements priority scores and calculation of weight for each element
5	• Calculation of Euclidean Distance • Calculation of Hamming Distance • Average of both distances to obtain the priority vector • Final priority order	• Calculation of the contribution of each element • Final priority order of elements

Thus, the first three steps of NSFDSS-I are identical to the steps explained in Chapter 7. The next explanation focuses on derivation of weights (step 4) and results determination (step 5). In NSFDSS-I, in order to measure the magnitude of the pairwise comparisons, the normalisation process is carried out. Table 9.10 presents the results of normalisation on decision criteria (in this case is the assessment parameters).

Table 9.10 Normalisation of priority scores into weights

Pi	Priority scores	Normalisation	Weight (w)	w (%)
P1	1	1.000/1.540	0.649	64.94%
P2	0.429	0.429/1.540	0.279	27.86%
P3	0.111	0.111/1.540	0.072	7.21%
sum	1.540			100.00%

After the weights of Pi have been obtained, Equation 5 is used to calculate the priority vector u. The parameter of p in the equation is defined by applying the Hamming Distance for $p = 1$ and Euclidean Distance for $p = 2$ (Chen 1998).

Equation 5: Priority Vector

$$u_j = \frac{1}{1+\left\{\frac{\sum_{i=1}^{m}\left[w_i\left(r_{ij}-1\right)\right]^p}{\sum_{i=1}^{m}\left(w_i r_{ij}\right)^p}\right\}^{\frac{2}{p}}}$$

where $p = 1, 2$ and $u = (u_1, u_2, \ldots, u_j, \ldots, u_n)$

The final priority vector u of the final judgment on each element is obtained by taking the average of the two distances which is presented in Table 9.11. Finally, the priority vector is rearranged in descending order and the final results is obtained and presented in Table 9.12.

Table 9.11 Calculation of Hamming and Euclidean Distances

Decision Criteria	**For P=1 U(j)**	**For P=2 U(j)**	**Average U(j)**
C1	0.9945	0.9939	0.9942
C2	0.6749	0.5497	0.6123
C3	0.6507	0.5464	0.5986
C4	0.9954	0.9943	0.9948
C5	0.5020	0.4808	0.4914
C6	0.8064	0.6893	0.7479
C7	0.4874	0.5267	0.5071
C8	0.8501	0.8280	0.8390
C9	0.0697	0.0863	0.0780
C10	0.4136	0.3395	0.3766

Table 9.12 Priority of selection criteria using NSFDSS-I technique

Rank Order	Calculated weight of each decision	Weight (%)	Decision Criteria
1	0.9948	15.94%	C4
2	0.9942	15.93%	C1
3	0.8390	13.45%	C8
4	0.7479	11.99%	C6
5	0.6123	9.81%	C2
6	0.5986	9.59%	C3
7	0.5071	8.13%	C7
8	0.4914	7.87%	C5
9	0.3766	6.03%	C10
10	0.0780	1.25%	C9
	6.2397	100.00%	

The comparison of decision outputs between the two techniques is shown in Figure 9.9. It appears that there is a slight difference in order for ranking priorities 3 and 4, which have a reversed order. In comparing the consistency of decision output between the two techniques, it was found that the Pearson's R correlation coefficient is 0.96, which is well above the required value of 0.8. Thus, there is a very strong positive relationship between the decision outputs of the two techniques.

Result: Priority List

NSFDSS-I		Priority Rank	NSFDSS-II	
Project	Score		Project	Score
Project 1	8.10	1	Project 1	7.99
Project 4	7.56	2	Project 4	7.43
Project 6	7.03	3	Project 5	7.02
Project 5	7.02	4	Project 6	6.88
Project 3	6.65	5	Project 3	6.61
Project 2	6.09	6	Project 2	6.01
Project 7	5.71	7	Project 7	5.63

Figure 9.9 Decision outputs comparison between NSFDSS-I and NSFDSS-II

9.5.2 NSFDSS-II and Fuzzy SAW

As previously, this section discusses the weighting of selection criteria and decision output based on the SAW fuzzy technique for comparison with the decision output of NSFDSS-II. Simple Additive Weighting (SAW), also known as scoring methods, is a simple MADM technique that is most often used (Afshari, Mohajed & Yusuff 2010; Sembiring et al. 2018). In general, there are three analysis procedures, namely: pairwise comparison, normalisation of decision matrix and determination of weights. The input matrices for infrastructure project selection problems are identical to the input matrices on NSFDSS-II obtained from pairwise comparisons. Following the inputs, the output matrices are generated, which show the normalisation process of each selection criteria under each assessment parameters. They are presented in Table 9.13.

Table 9.13 Fuzzy SAW decision matrices

For P1 - Time Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10	sum hor	weight
1	0.167	0.091	0.182	0.333	0.091	0.100	0.200	0.111	0.143	0.083	1.501	0.150
2	0.167	0.091	0.091	0.000	0.091	0.100	0.100	0.111	0.071	0.083	0.905	0.091
3	0.000	0.091	0.091	0.000	0.091	0.100	0.100	0.111	0.143	0.083	0.810	0.081
4	0.000	0.182	0.182	0.167	0.091	0.100	0.200	0.111	0.143	0.167	1.342	0.134
5	0.167	0.091	0.091	0.167	0.091	0.100	0.100	0.111	0.000	0.083	1.001	0.100
6	0.167	0.091	0.091	0.167	0.091	0.100	0.100	0.111	0.071	0.083	1.072	0.107
7	0.000	0.091	0.091	0.000	0.091	0.100	0.100	0.111	0.143	0.167	0.893	0.089
8	0.167	0.091	0.091	0.167	0.091	0.100	0.100	0.111	0.143	0.083	1.143	0.114
9	0.000	0.091	0.000	0.000	0.182	0.100	0.000	0.000	0.071	0.083	0.527	0.053
10	0.167	0.091	0.091	0.000	0.091	0.100	0.000	0.111	0.071	0.083	0.805	0.081
sum ver	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000

For P2 - Cost Effectiveness

Ci	1	2	3	4	5	6	7	8	9	10	sum hor	weight
1	0.125	0.111	0.111	0.125	0.091	0.143	0.154	0.250	0.059	0.100	1.269	0.127
2	0.125	0.111	0.111	0.250	0.091	0.143	0.077	0.125	0.059	0.100	1.192	0.119
3	0.125	0.111	0.111	0.125	0.091	0.143	0.077	0.125	0.118	0.100	1.126	0.113
4	0.125	0.000	0.111	0.125	0.182	0.143	0.154	0.125	0.118	0.100	1.182	0.118
5	0.125	0.111	0.111	0.000	0.091	0.143	0.077	0.000	0.118	0.100	0.876	0.088
6	0.125	0.111	0.111	0.125	0.091	0.143	0.154	0.125	0.118	0.200	1.302	0.130
7	0.000	0.111	0.111	0.000	0.091	0.000	0.077	0.000	0.118	0.100	0.608	0.061
8	0.000	0.111	0.111	0.125	0.182	0.143	0.154	0.125	0.118	0.100	1.168	0.117
9	0.125	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.000	0.295	0.029
10	0.125	0.111	0.111	0.125	0.091	0.000	0.077	0.125	0.118	0.100	0.983	0.098
sum ver	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000

For P3 - Project Complexity

Ci	1	2	3	4	5	6	7	8	9	10	sum hor	weight
1	0.111	0.143	0.125	0.125	0.182	0.100	0.091	0.100	0.063	0.100	1.139	0.114
2	0.111	0.143	0.125	0.250	0.182	0.100	0.091	0.100	0.125	0.100	1.327	0.133
3	0.111	0.143	0.125	0.125	0.182	0.100	0.091	0.100	0.125	0.100	1.202	0.120
4	0.111	0.000	0.125	0.125	0.091	0.200	0.182	0.100	0.125	0.100	1.159	0.116
5	0.000	0.000	0.000	0.125	0.091	0.100	0.182	0.100	0.125	0.100	0.823	0.082
6	0.111	0.143	0.125	0.000	0.091	0.100	0.091	0.100	0.125	0.100	0.986	0.099
7	0.111	0.143	0.125	0.000	0.000	0.100	0.091	0.100	0.125	0.100	0.895	0.089
8	0.111	0.143	0.125	0.125	0.091	0.100	0.091	0.100	0.063	0.100	1.048	0.105
9	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.063	0.100	0.374	0.037
10	0.111	0.143	0.125	0.125	0.091	0.100	0.091	0.100	0.063	0.100	1.048	0.105
sum ver	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000

For Assessment Parameters

Pi	P1	P2	P3	Sum hor	weight
P1	1.000	0.667	0.400	2.067	0.689
P2	0.000	0.333	0.400	0.733	0.244
P3	0.000	0.000	0.200	0.200	0.067
sum ver	1.000	1.000	1.000		1.000

Table 9.14 summarises the results of the calculation of selection criteria weights based on existing assessment parameters. Then, the final weight is determined by multiplying the criteria weight (Ci) by the parameter weights (Pi) as shown in Table 9.15.

Table 9.14 Recap of decision matrices output

Ci/Pi	**P1**	**P2**	**P3**
	0.689	**0.244**	**0.067**
C1	0.150	0.127	0.114
C2	0.091	0.119	0.133
C3	0.081	0.113	0.120
C4	0.134	0.118	0.116
C5	0.100	0.088	0.082
C6	0.107	0.130	0.099
C7	0.089	0.061	0.089
C8	0.114	0.117	0.105
C9	0.053	0.029	0.037
C10	0.081	0.098	0.105

Table 9.15 Determination of final weights

Ci/Pi	P1	P2	P3	Sum	weight (%)
C1	0.103	0.031	0.008	0.142	14.20%
C2	0.062	0.029	0.009	0.100	10.03%
C3	0.056	0.028	0.008	0.091	9.13%
C4	0.092	0.029	0.008	0.129	12.91%
C5	0.069	0.021	0.005	0.096	9.58%
C6	0.074	0.032	0.007	0.112	11.23%
C7	0.062	0.015	0.006	0.082	8.24%
C8	0.079	0.029	0.007	0.114	11.43%
C9	0.036	0.007	0.002	0.046	4.60%
C10	0.055	0.024	0.007	0.086	8.65%
sum	**0.689**	**0.244**	**0.067**	**1.000**	**100.00%**

The comparison of decision output between the two techniques is shown in Figure 9.10. It appears that both techniques produce the same decision output, even with different performance scores. Likewise, the Pearson's R correlation coefficient results indicate the value of 1, which shows a perfect positive relationship between the decision outputs of the two techniques.

Result: Priority List

Fuzzy SAW		Priority Rank	NSFDSS-II	
Project	Score		Project	Score
Project 1	7.91	1	Project 1	7.99
Project 4	7.38	2	Project 4	7.43
Project 5	7.00	3	Project 5	7.02
Project 6	6.82	4	Project 6	6.88
Project 3	6.62	5	Project 3	6.61
Project 2	5.95	6	Project 2	6.01
Project 7	5.53	7	Project 7	5.63

Figure 9.10 Decision outputs comparison between Fuzzy SAW and NSFDSS-II

9.5.3 NSFDSS-II and AHP OS

The last MCDM method compared to NSFDSS-II is AHP OS. AHP is one of the most commonly used techniques for solving decision-making problems. It is defined by Nydick and Hill (1992) as 'a methodology to rank alternative courses of action based on the decision maker's judgment concerning the importance of the criteria and the extent to which they are met by each alternative'. There are four steps in operating AHP: pairwise comparison, determination of consistency ratio, determination of weights of alternatives and decision criteria and calculation of final comparison scores (Tam, Tong & Zhang 2007). In this study, AHP Online System (AHP OS), which is a free web-based AHP solution, is used as an analysis tool to determine the selection criteria for infrastructure project proposals. Because there are semantic scale differences between AHP and NSFDSS-II, it is necessary to make input judgment adjustments according to Table 9.16.

Table 9.16 Adjustment of semantic scale for AHP and NSFDSS-II adopted in this study

NSFDSS-II	Implications	AHP
0	Worse than	-5
0.5	Equal importance	1
1	Better than	5

By entering pairwise comparison results in the AHP OS, the analysis is done automatically and gives the results as shown in Figure 9.11 to 9.14. These figures display the weight of the selection criteria for each of the assessment parameters and the weight of the assessment parameters themselves.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Strategic fit	21.3%	1	22.5%	22.5%
2	Readiness criteria	7.1%	7	4.1%	4.1%
3	Innovative planning	7.1%	8	3.8%	3.8%
4	Risks & politics	18.3%	2	12.2%	12.2%
5	Contracts & governance issues	8.4%	5	4.6%	4.6%
6	Funding & financing	8.4%	5	4.6%	4.6%
7	Team member & stakeholder coordination	9.2%	4	7.4%	7.4%
8	Private sector & public involvement	9.7%	3	4.9%	4.9%
9	Local gov issues	4.0%	10	2.2%	2.2%
10	Sustainability & env issues	6.5%	9	4.5%	4.5%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8	9	10
1	1	1.00	5.00	5.00	1.00	1.00	5.00	1.00	5.00	1.00
2	1.00	1	1.00	0.20	1.00	1.00	1.00	1.00	1.00	1.00
3	0.20	1.00	1	0.20	1.00	1.00	1.00	1.00	5.00	1.00
4	0.20	5.00	5.00	1	1.00	1.00	5.00	1.00	5.00	5.00
5	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00
7	0.20	1.00	1.00	0.20	1.00	1.00	1	1.00	5.00	5.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1	5.00	1.00
9	0.20	1.00	0.20	0.20	1.00	1.00	0.20	0.20	1	1.00
10	1.00	1.00	1.00	0.20	1.00	1.00	0.20	1.00	1.00	1

Figure 9.11 Weight of selection criteria for assessment parameter 1 (time effectiveness)

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Strategic fit	14.1%	1	14.1%	14.1%
2	Readiness criteria	12.2%	5	14.1%	14.1%
3	Innovative planning	9.2%	6	2.9%	2.9%
4	Risks & politics	12.8%	3	8.4%	8.4%
5	Contracts & governance issues	7.6%	8	4.1%	4.1%
6	Funding & financing	13.8%	2	8.4%	8.4%
7	Team member & stakeholder coordination	5.8%	9	4.1%	4.1%
8	Private sector & public involvement	12.7%	4	8.4%	8.4%
9	Local gov issues	3.5%	10	3.8%	3.8%
10	Sustainability & env issues	8.3%	7	3.6%	3.6%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8	9	10
1	1	1.00	1.00	1.00	1.00	1.00	5.00	5.00	1.00	1.00
2	1.00	1	1.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	5.00	1.00
4	1.00	0.20	1.00	1	5.00	1.00	5.00	1.00	5.00	1.00
5	1.00	1.00	1.00	0.20	1	1.00	1.00	0.20	5.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1	5.00	1.00	5.00	5.00
7	0.20	1.00	1.00	0.20	1.00	0.20	1	0.20	5.00	1.00
8	0.20	1.00	1.00	1.00	5.00	1.00	5.00	1	5.00	1.00
9	1.00	1.00	0.20	0.20	0.20	0.20	0.20	0.20	1	0.20
10	1.00	1.00	1.00	1.00	1.00	0.20	1.00	1.00	5.00	1

Figure 9.12 Weight of selection criteria for assessment parameter 2 (cost effectiveness)

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Strategic fit	11.2%	4	9.9%	9.9%
2	Readiness criteria	16.9%	1	16.7%	16.7%
3	Innovative planning	12.4%	3	9.5%	9.5%
4	Risks & politics	13.7%	2	11.0%	11.0%
5	Contracts & governance issues	9.3%	5	9.1%	9.1%
6	Funding & financing	8.5%	6	3.8%	3.8%
7	Team member & stakeholder coordination	7.9%	9	4.4%	4.4%
8	Private sector & public involvement	8.2%	7	3.0%	3.0%
9	Local gov issues	3.7%	10	2.8%	2.8%
10	Sustainability & env issues	8.2%	7	3.0%	3.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8	9	10
1	1	1.00	1.00	1.00	5.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1	1.00	5.00	5.00	1.00	1.00	1.00	5.00	1.00
3	1.00	1.00	1	1.00	5.00	1.00	1.00	1.00	5.00	1.00
4	1.00	0.20	1.00	1	1.00	5.00	5.00	1.00	5.00	1.00
5	0.20	0.20	0.20	1.00	1	1.00	5.00	1.00	5.00	1.00
6	1.00	1.00	1.00	0.20	1.00	1	1.00	1.00	5.00	1.00
7	1.00	1.00	1.00	0.20	0.20	1.00	1	1.00	5.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00
9	1.00	0.20	0.20	0.20	0.20	0.20	0.20	1.00	1	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1

Figure 9.13 Weight of selection criteria for assessment parameter 3 (project complexity)

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Time effectiveness	68.5%	1	35.5%	35.5%
2	Cost effectiveness	23.4%	2	12.1%	12.1%
3	Project complexity	8.0%	3	4.2%	4.2%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3
1	1	5.00	5.00
2	0.20	1	5.00
3	0.20	0.20	1

Figure 9.14 Weight of assessment parameters

Next, determining the weight of the final selection criteria is done by multiplying the criteria weight (Ci) by the weighting parameters (Pi) as shown in Table 9.17.

Table 9.17 Determination of final contributions for each selection criteria

Ci/Pi	Weights		
	P1 (time eff.)	**P2 (cost eff.)**	**P3 (proj comp.)**
	68.5%	**23.5%**	**8.0%**
Strategic fit	21.3%	14.1%	11.2%
Readiness criteria	7.1%	12.2%	16.9%
Innovative planning	7.1%	9.2%	12.4%
Risks & politics	18.3%	12.8%	13.7%
Contracts & governance issues	8.4%	7.6%	9.3%
Funding & financing	8.4%	13.8%	8.5%
Team member & stakeholder coordination	9.2%	5.8%	7.9%
Private sector & public involvement	9.7%	12.7%	8.2%
Local gov issues	4.0%	3.5%	3.7%
Sustainability & env issues	6.5%	8.3%	8.2%
Total	**100.0%**	**100.0%**	**100.0%**

Ci/Pi	P1	P2	P3	Sum	Rank Order
Strategic fit	14.59%	3.31%	0.90%	18.80%	1
Readiness criteria	4.86%	2.87%	1.35%	9.08%	5
Innovative planning	4.86%	2.16%	0.99%	8.02%	8
Risks & politics	12.54%	3.01%	1.10%	16.64%	2
Contracts & governance issues	5.75%	1.79%	0.74%	8.28%	7
Funding & financing	5.75%	3.24%	0.68%	9.68%	4
Team member & stakeholder coordination	6.30%	1.36%	0.63%	8.30%	6
Private sector & public involvement	6.64%	2.98%	0.66%	10.29%	3
Local gov issues	2.74%	0.82%	0.30%	3.86%	10
Sustainability & env issues	4.45%	1.95%	0.66%	7.06%	9
Total	**68.50%**	**23.50%**	**8.00%**	**100.00%**	

The comparison of decision outputs between the two techniques is shown in Figure 9.15. It appears that both techniques produce the same decision output, even with different performance scores. Likewise, the Pearson's R correlation coefficient results indicate the value of 1 which shows a perfect positive relationship between the decision outputs of the two techniques.

Result: Priority List

AHP OS		Priority Rank	NSFDSS-II	
Project	Score		Project	Score
Project 1	8.01	1	Project 1	7.99
Project 4	7.37	2	Project 4	7.43
Project 5	7.06	3	Project 5	7.02
Project 6	6.89	4	Project 6	6.88
Project 3	6.56	5	Project 3	6.61
Project 2	6.01	6	Project 2	6.01
Project 7	5.62	7	Project 7	5.63

Figure 9.15 Decision outputs comparison between AHP OS and NSFDSS-II

Based on the findings of the parallel-forms reliability tests, it can be concluded that the decision outputs (project priority list) produced by the developed DMF provides consistency when tested in comparison to DMFs based on other MCDM techniques. These findings also indicate that there is no significant difference in decision outputs between DMFs developed with one MCDM technique and those developed with other techniques.

9.6 Sensitivity Analysis

Another strategy for validating the developed DMF applied in this study is sensitivity analysis. According to Muñoz, Romana and Ordóñez (2016), sensitivity analysis can be used to verify the stability of the solution and to validate the proposed model. Similarly, Encheva (2009) and Syamsuddin (2013) also argue that the consistency of decision outputs is often tested using a sensitivity analysis technique. It is done by applying the "what-if" scenarios approach to observe the impact of changes in input on the final decision output.

In the context of this study, sensitivity analysis is carried out with two types of variation of changes:

(1) **Weight variation** – because the selection criteria weights are obtained from input judgment by experts based on their experience which may be subjective, sensitivity analysis can be used to find the effect of the variation of criteria weights on decision output.

(2) **Measurement Scale Independence (MSI) variation** – this is a condition in which the value scale changes in a model must not change the final decision output since the different measurement units are reciprocally connected by a linear or positive affine transformation (Pamučar, Božanić & Ranđelović 2017)

To measure the consistency of outputs from sensitivity analysis, Pearson's R correlation coefficient is measured for these two different scenarios.

9.6.1 Criteria Weight Variation

In this study, sensitivity analysis was conducted to assess how changes in the selection criteria would have changed the ranking of project proposals. It is done through ten scenarios as presented in Table 9.18, which shows sensitivity analysis by eliminating weight in one of the selection criteria.

Table 9.18 Scenarios with selection criteria weight variation

Criteria	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Risks & politics (C4)	0	1	1	1	1	1	1	1	1	1
Strategic fit (C1)	1	0	1	1	1	1	1	1	1	1
Private sector & public involvement (C8)	1	1	0	1	1	1	1	1	1	1
Funding & financing (C6)	1	1	1	0	1	1	1	1	1	1
Readiness criteria (C2)	1	1	1	1	0	1	1	1	1	1
Innovative planning (C3)	1	1	1	1	1	0	1	1	1	1
Contracts & governance issues (C5)	1	1	1	1	1	1	0	1	1	1
Team member & stakeholder coord. (C7)	1	1	1	1	1	1	1	0	1	1
Sustainability & env issues (C10)	1	1	1	1	1	1	1	1	0	1
Local gov issues (C9)	1	1	1	1	1	1	1	1	1	0

Scenario 1. Comparison of decision outputs was conducted when weight of C4 is eliminated while weights of the remaining criteria are unchanged.

Scenario 2. Comparison of decision outputs was conducted when weight of C1 is eliminated while weights of the remaining criteria are unchanged.

Scenario 3. Comparison of decision outputs was conducted when weight of C8 is eliminated while weights of the remaining criteria are unchanged.

Scenario 4. Comparison of decision outputs was conducted when weight of C6 is eliminated while weights of the remaining criteria are unchanged.

Scenario 5. Comparison of decision outputs was conducted when weight of C2 is eliminated while weights of the remaining criteria are unchanged.

Scenario 6. Comparison of decision outputs was conducted when weight of C3 is eliminated while weights of the remaining criteria are unchanged.

Scenario 7. Comparison of decision outputs was conducted when weight of C5 is eliminated while weights of the remaining criteria are unchanged.

Scenario 8. Comparison of decision outputs was conducted when weight of C7 is eliminated while weights of the remaining criteria are unchanged.

Scenario 9. Comparison of decision outputs was conducted when weight of C10 is eliminated while weights of the remaining criteria are unchanged.

Scenario 10. Comparison of decision outputs was conducted when weight of C9 is eliminated while weights of the remaining criteria are unchanged.

An example of an analysis of changes in criteria weights is shown in Figure 9.16. To calculate performance scores under different scenarios, normalisation of selection criteria weights is carried out so that the total weight of selection criteria remains at 100%.

Criteria	Weight	Normalized	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
Risks & politics	0.00%	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strategic fit	15.45%	18.30%	1.56	1.19	1.19	1.19	1.19	1.46	1.01
Private sector & public involvement	11.58%	13.71%	1.03	0.82	0.96	1.30	0.96	1.17	0.69
Funding & financing	10.91%	12.91%	1.23	0.97	1.03	1.16	0.71	1.16	0.84
Readiness criteria	9.62%	11.39%	1.08	0.85	0.91	0.97	1.02	0.97	0.74
Innovative planning	9.41%	11.14%	0.84	0.56	0.67	0.67	0.39	0.56	0.72
Contracts & governance issues	8.25%	9.77%	0.68	0.44	0.44	0.63	0.59	0.54	0.34
Team member & stakeholder coordination	8.21%	9.72%	0.63	0.63	0.53	0.68	0.97	0.53	0.53
Sustainability & env issues	7.44%	8.81%	0.53	0.35	0.79	0.48	0.79	0.35	0.35
Local gov issues	3.59%	4.25%	0.23	0.19	0.19	0.23	0.21	0.21	0.15
Total	**84.46%**	**100.00%**	**7.81**	**6.01**	**6.72**	**7.32**	**6.84**	**6.95**	**5.37**

Figure 9.16 Example of weight variation for scenario 1

Alternative decision outputs by scenarios is presented in Table 9.19 and Figure 9.17. By comparing the results in ten scenarios, it was found that:

- Out of ten scenarios, only three scenarios provide a small difference in priority ranking.
- All project proposal rankings are unchanged, except for P5 and P6 that have reversal order in S1, S8 and S9.
- In ten scenarios, P1 and P4 are still ranked as the top two priority. This confirms domination of both projects.
- The sensitivity analysis shows that decision outputs were sensitive to changes in weight, however it keeps the majority of priority orders as shown in the table.
- All scenarios show high consistency of decision outputs against original decision output produced in the first implementation.

Table 9.19 Project proposal ranking for different criteria weight scenarios

Project		Alternatives ranking by scenarios										
		Ori	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
P1	Jakarta Sewerage	1	1	1	1	1	1	1	1	1	1	1
P2	Palembang Toll Road	6	6	6	6	6	6	6	6	6	6	6
P3	Yogya-Bawen Toll Road	5	5	5	5	5	5	5	5	5	5	5
P4	MRT	2	2	2	2	2	2	2	2	2	2	2
P5	Indramayu Steam PP	3	4	3	3	3	3	3	3	4	4	3
P6	Jatiluhur Water Supply	4	3	4	4	4	4	4	4	3	3	4
P7	Bontang Oil Refinery	7	7	7	7	7	7	7	7	7	7	7
Pearson's R correlation coefficient			0.96	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.96	1.00

In conclusion, the set of solutions is stable and consistent to changes in the weighting of the selection criteria for infrastructure project proposals. The optimal solution fluctuates little from the original decision output as shown in S1, S8 and S9.

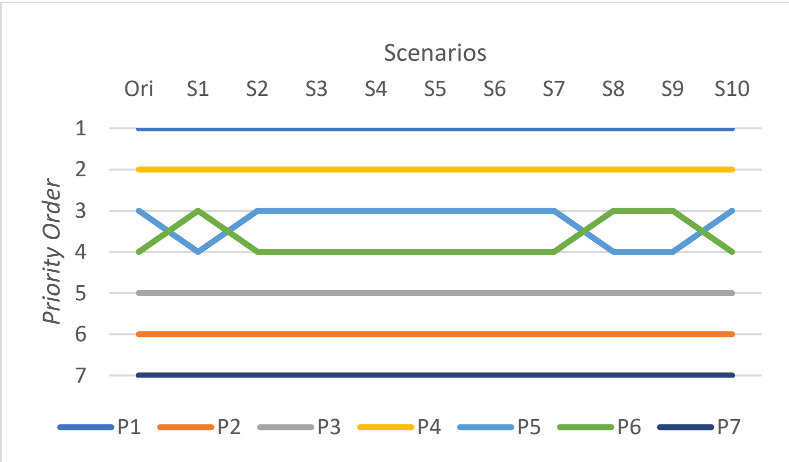


Figure 9.17 Sensitivity analysis simulation

9.6.2 MSI Variation

The MSI condition indicates that results obtained through the use of MCDM do not depend on the measurement unit that we use to express the value of any criterion under the condition that different units of measurement of the observed criterion are mutually interconnected by a linear or a positive affine transformation (Bach & Bridy 2013 as cited in Pamučar, Božanić & Ranđelović 2017). In other words, whether or not the qualitative criterion is changed, the final ranking list of alternatives must not change. In this research, the MSI variation uses positive affine transformation of y = 2x-1. Table 9.20 presents the initial scale (S1) which was then changed to the modified scale (S2).

Table 9.20 Scales S1 and S2

No	Linguistic terms	Scale S1	Scale S2
1	Most important	(9.5, 10)	(18, 19)
2		(8.5, 9)	(16, 17)
3		(7.5, 8)	(14, 15)
4		(6.5, 7)	(12, 13)
5		(5.5, 6)	(10, 11)
6		(4.5, 5)	(8, 9)
7		(3.5, 4)	(6, 7)
8		(2.5, 3)	(4, 5)
9		(1.5, 2)	(2, 3)
10	Least important	(1, 1)	(1, 1)

Figure 9.18 provides the data input for MSI variation with transformed scale S2 as input data, while total performance scores are obtained and displayed in Figure 9.19. As predicted, consistency of rankings to MSI variation shows a perfect positive relationship. In other words, the DMF gives consistent solutions, i.e. changes in measurement scale do not affect the final ranking of alternatives as presented in Figure 9.20. This test is useful to ensure that the data analysis has been run correctly within the DMT.

DATA INPUT

		Transformed Scale of Measurement (S2)						
Criteria	Weight	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
Risks & politics	15.54%	17	11	11	15	15	12	13
Strategic fit	15.45%	16	12	12	12	12	15	10
Private sector & public involvement	11.58%	14	11	13	18	13	16	9
Funding & financing	10.91%	18	14	15	17	10	17	12
Readiness criteria	9.62%	18	14	15	16	17	16	12
Innovative planning	9.41%	14	9	11	11	6	9	12
Contracts & governance issues	8.25%	13	8	8	12	11	10	6
Team member & stakeholder coordination	8.21%	12	12	10	13	19	10	10
Sustainability & env issues	7.44%	11	7	17	10	17	7	7
Local gov issues	3.59%	10	8	8	10	9	9	6

Figure 9.18 Data input for MSI variation

DATA ANALYSIS

		Transformed Scale of Measurement (S2)						
Criteria	**Weight**	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Project 6**	**Project 7**
Risks & politics	15.54%	2.64	1.71	1.71	2.33	2.33	1.86	2.02
Strategic fit	15.45%	2.47	1.85	1.85	1.85	1.85	2.32	1.55
Private sector & public involvement	11.58%	1.62	1.27	1.51	2.08	1.51	1.85	1.04
Funding & financing	10.91%	1.96	1.53	1.64	1.85	1.09	1.85	1.31
Readiness criteria	9.62%	1.73	1.35	1.44	1.54	1.63	1.54	1.15
Innovative planning	9.41%	1.32	0.85	1.04	1.04	0.56	0.85	1.13
Contracts & governance issues	8.25%	1.07	0.66	0.66	0.99	0.91	0.82	0.49
Team member & stakeholder coordination	8.21%	0.99	0.99	0.82	1.07	1.56	0.82	0.82
Sustainability & env issues	7.44%	0.82	0.52	1.26	0.74	1.26	0.52	0.52
Local gov issues	3.59%	0.36	0.29	0.29	0.36	0.32	0.32	0.22
Total	**100.00%**	**14.98**	**11.01**	**12.22**	**13.86**	**13.04**	**12.77**	**10.25**

Figure 9.19 Data analysis for MSI variation

Result: Priority List

Priority	S1		S2	
Rank	Project	Score	Project	Score
1	Project 1	7.99	Project 1	14.98
2	Project 4	7.43	Project 4	13.86
3	Project 5	7.02	Project 5	13.04
4	Project 6	6.88	Project 6	12.77
5	Project 3	6.61	Project 3	12.22
6	Project 2	6.01	Project 2	11.01
7	Project 7	5.63	Project 7	10.25
Pearson's R correlation coefficient				1.00

Figure 9.20 Project proposal ranking for different MSI scenarios

9.7 Dissemination of the Decision-Making Framework

The last strategy to evaluate the effectiveness of DMF is to disseminate the developed DMF at a relevant international conference. Presenting the developed DMF at an appropriate forum will help evaluate DMF through feedback from panellists or discussants involved. Therefore, the selection of the conference as a forum for disseminating the developed DMF had to be done carefully.

In this study, the developed DMF has been presented at the KIPI 2020 Digital Conference. KIPI (Indonesian Scholars International Conference/Indonesian Scholars International Conference) is a biennial academic conference hosted by the Indonesian Student Association in Australia (PPIA). It has provided Indonesian researchers from all countries around the world with a platform to share their research and discuss challenging issues regarding the Indonesian context. Thus, the reasons to disseminate the developed DMF at this conference are:

(1) participation comes from across sectors and represents government, researchers/academics and professionals as discussants and reviewers.
(2) the purpose of KIPI is to provide researchers with the opportunity to pitch their research to the policymakers in Indonesia, which is an ideal setting to introduce the developed DMF to policymakers.
(3) the research is presented in a policy paper format which will be sent to the Office of the Indonesian President.

With over 170 submissions, only 14 policy papers were selected and will be included in the policy book. The DMF dissemination at this conference occurred on 18 April 2020, where the researcher received the opportunity to be the second speaker at the second panel session. The input from panellists and discussants included the following comments:

- There is no literature review section in the ppt.
- The presentation is well-structured. However, there are too many approaches with very limited presentation time.
- There is a need to elaborate on how did you get the data and how did you get these scores from.

In response to the above feedback, the researcher provides the following answers:

- It needs to be underlined that this research presentation is made in the form of a policy paper, not an academic paper, the literature review section was not considered an important part that must be presented in a policy paper.
- It is indeed a comprehensive piece of research that intends to investigate the current challenges in the infrastructure project selection problems faced by related ministries, particularly MPWH. Thus, this research employs a mixed method approach with multi-sequence techniques including interviews, questionnaire survey, pairwise comparisons and NSFDSS-II analysis to obtain the key selection criteria and their weights.
- Data collection was conducted in three main phases, i.e. interviews with 20 experts, chiefly from three different ministries (MPWH, MT and MNDP), a questionnaire survey distribution to a larger number of respondents with more than 300 responses over a five-month period and pairwise comparisons using the Delphi method with eight experts as input data for NSFDSS-II analysis. These scores are the criteria weights for infrastructure project selection and prioritisation. They are obtained through NSFDSS-II analysis based on the result of the pairwise comparisons.

In general, the dissemination of DMF in this conference was useful in introducing DMF to a broader forum and at the same time obtaining some input to evaluate the proposed DMF.

9.8 Chapter Summary

This chapter presented the implementation of the developed DMF to real infrastructure problems. Positive feedback from experts showed the advantages of this DMF as an innovative tool for assessing and prioritising infrastructure project proposals in Indonesia. In addition, this chapter also described other strategies for evaluating the effectiveness of the developed DMF by comparing it to other methods, conducting sensitivity analysis and disseminating it to a conference forum. Table 9.21 summarises the strategies adopted to evaluate the developed DMF.

Table 9.21 Strategies for DMF evaluation adopted in this study

Strategies	Summaries	Results
Implementations to real infrastructure problems	Implementations were carried out in two stages: the 1st implementation to look how the DMF would be carried out within an organisation and the 2nd implementation to evaluate the consistency of decision output with past actual cases	Both implementations show the benefits of DMF as an alternative and innovative tool in selecting and prioritising infrastructure project proposals. In the second implementation, the resulting decision output is consistent with actual conditions. In general, experts using the DMF stated that it is a useful tool.
Parallel-forms reliability tests	To evaluate the reliability by comparing the results to results of other valid methods, i.e. NSFDSS-I, Fuzzy SAW and AHP OS	The comparison between decision outputs based on NSFDSS-II shows a very strong positive relationship (if compared to NSFDSS-I) and a perfect positive relationship (if compared to Fuzzy SAW and AHP OS).
Sensitivity analysis	To conduct sensitivity analysis to evaluate the reliability of the developed DMF under different scenarios (weight variation and MSI variation)	The overall outputs were consistent with the original scenario with the exception of small differences for S1, S8 and S9 (weight variation). However, these outputs still provide a very strong relationship with the original output.
Dissemination	To disseminate the DMF at a specific conference and obtain feedback from the reviewers and participants	Overall, the dissemination of the DMF at this conference was useful in introducing DMF to a broader forum and at the same time obtaining some input to evaluate the proposed DMF.

CHAPTER 10. DISCUSSION

10.1 Introduction

This chapter provides discussion of and reflections on the research process including linking theory to practice; highlighting the connections between this research objectives, its findings and the literature; evaluating what has been found; and explaining the relevance of this study. The aim of this research is to develop a DMF model for infrastructure project selection and prioritisation. To achieve this goal, this research takes a comprehensive approach by investigating current practices and issues that influence strategic decision-making on the selection and prioritisation of infrastructure projects in Indonesia. Thus, contextually this research focuses on strategic decision-making that is complex, dynamic and plural, involving the interaction of various parties in the process. An understanding of this phenomenon is needed to develop a DMF that is effective and efficient to be implemented at the front-end of project policies.

10.2 The Current Practices, Issues and Challenges in the Infrastructure Project Selection and Prioritisation in Indonesia

This section discusses the current practices, issues and challenges in the infrastructure project selection and prioritisation process that have been investigated through semi-structured interviews with three relevant ministries in Indonesia. While the findings were presented in Chapter 5, this section explains these findings in connection with the research objectives and literature review, as well as providing arguments to support the relevance of this study.

10.2.1 The Current Practices of Infrastructure Project Selection and Prioritisation in Indonesia

To understand the phenomena and problems that exist in infrastructure project planning, particularly during the selection and prioritisation process, this research conducted an in-depth case study of three relevant ministries in Indonesia, namely: the Ministry of National Development Planning (MNDP), the Ministry of Public Works & Housing (MPWH) and the Ministry of Transportation (MT). These three ministries are closely related to the process of planning and executing infrastructure projects in Indonesia. In general, the infrastructure project planning process begins with the national level planning conducted by MNDP. As a think-tank institution, MNDP is in charge of developing short-term, medium-term and long-term development plans. Furthermore, the results of national level planning are forwarded to each ministry that will carry out ministerial level planning. Here, planning becomes more detailed and integrated. Next, the results of this ministerial level planning are carried out by the ministries through their respective organisation units. Table 10.1 describes the key characteristics of the decision-making process for infrastructure project selection from these three ministries.

Table 10.1 Key characteristics of the three case studies

Characteristics	MNDP	MPWH	MT
Authority	Think-tank (planning)	Planning and implementation	Planning and implementation
Type of project	General strategic projects across sectors	Construction and infrastructure projects	Transportation projects
Decision approach	Six approaches observed	Six approaches observed	Six approaches observed
Process	Rational	Rational	Rational
Hierarchy	National level	Ministerial level	Ministerial level
Output	National long-term, medium-term and short-term development plans	Ministry's strategic/master plan & work plans	Ministry's strategic/master plan & work plans
Planning responsibility	Planning officers	BPIW (main function) with the assistance of planning bureau of each directorate	Planning bureau of each directorate

While previous planning practices tended to apply the top-down approach, there is now a change in approach by the three ministries, indicating they are now applying a combination of decision approaches. The governance system has shifted from a directive (autocracy) approach to a more participative (democracy) one. An example is the *musrenbang* (planning development forums), which seek to combine participatory, deliberative, top-down and bottom-up approaches. In practice, the ministry (MNDP) will hold several *musrenbang* as a means to get input from grassroots level officials at the district and regional levels. Such forums invite various stakeholders, not only from relevant ministries, but also local governments, communities, professional groups and non-governmental organisations. This mechanism is regulated in Law No. 25 of 2004 concerning the National Development Planning System, while the detailed procedures for its preparation are further regulated in Government Regulation No.

40 of 2006 concerning the Procedures for Developing the National Development Plan. Nevertheless, the implementation of each *musrenbang* is very dependent on the ministry that holds it. According to Datta et al. (2011), *musrenbang* are mainly ceremonial and not optimal as a tool to obtain input regarding development planning. This is because planning processes carried out by MNDP still tend to be top-down.

Conversely, the investigation carried out in this study also reinforces the opinion of Datta et al. (2011) that the ministries in Indonesia in the planning process have grown a culture of more rational decision-making processes. Attempts have been made to develop a structured and logical process of problem solving for the selecting and prioritising of infrastructure projects as part of government decision making (Blomkamp et al. 2017). In the context of this study, this can occur when parties have tried to develop technical standards in the processes of selecting and prioritising infrastructure projects.

Efforts to develop a selection procedure that helps the FEP team or decision makers to select infrastructure project proposals have also been made by BPIW as the planning agency for MPWH. The absence of standard procedures, frameworks or tools in previous practices is considered to be a barrier in the selection process. For this reason, in 2019, BPIW tried to develop a project selection system based on AHP. However, there was a lack of support from other organisational units in MPWH. In addition, the system developed by BPIW has not yet been tested, so it is not yet known how much benefit will be gained from implementing this system.

In relation to the overall decision-making process, a paradigm shift has occurred with the previous judgmental (subjective) approach becoming more rational (objective). This is indicated by the tendency of respondents to rely on logic, objectivity, data and formal techniques in making decisions. At present, the availability of an integrated and mutually agreed master plan is crucial so that the planning and programming of infrastructure projects can refer to it easily. Table 10.2 presents several elements in which a paradigm shift has occurred regarding the selection and prioritisation process of infrastructure projects.

Table 10.2 Changing paradigms in the infrastructure project selection and prioritisation process

Elements	Old paradigms	New paradigms
Governance	Directive (autocracy)	Participative (democracy)
Decision approach	Top-down	Combination
Administrative rule	Centralisation	Decentralisation
Funding sources	State budget	Efforts to encourage private sector investment
Budgetary mindset	Spending focus	Planning focus
Role of government	Provider	Enabler
Planning approach	Sectoral	Integration
Project preparation	Based on short-term planning	Based on master plan
Planning process	Unstandardised	Standardised

10.2.2 The Challenges in Infrastructure Project Selection and Prioritisation in Indonesia

While there has been a paradigm shift in the infrastructure planning process, this research found several internal and external challenges faced by the ministries. The interview analysis has succeeded in identifying six categories of challenges, with 'political influences' being the top challenges in the infrastructure project selection process. This is because politics still plays a crucial role in the Indonesian development planning process. According to Abonyi (2005), the Indonesian political system has undergone a transformation from a highly centralised political and policy decision-making system to a more pluralistic, diffused and evolving system. While the president is still the most powerful political actor, the DPR has gained more power in budgeting processes (Datta et al. 2011). Infrastructure projects, which are mainly funded through the state budget, must obtain DPR approval. This presents new challenges as DPR members can submit new project proposals that have not gone through the technocratic selection process during the previous ministerial level planning. In addition, DPR members do not necessarily understand the selection process that has been carried out. Sherlock (2010) argues that the DPR's lack of rules of procedure has caused parliamentary members to be imprudent in the way they work. This will lead to inappropriate budget allocation and project selection.

The lack of rules of procedure can also be seen in the absence of standard frameworks or tools for infrastructure project selection and prioritisation. Although BPIW's efforts to standardise the planning process have been demonstrated, it is still lacking because standardisation should have started from MNDP's national level planning. If MNDP were to develop a framework for infrastructure project selection, this framework would be applied to the ministerial and regional level planning conducted by all relevant ministries and government agencies. Unfortunately, MNDP has not issued a standard framework or tool for infrastructure project selection.

Further, a crucial challenge that might not be properly acknowledged is decision makers having the wrong mindset in their approach to infrastructure development planning in Indonesia. For a long time, the Indonesian national planning processes focused on setting targets regardless of how the targets would be achieved (Booth 2005). The ministry's performance is measured through budget absorption (spending focus), rather than budget efficiency (planning focus), causing inappropriate planning and budget allocation.

This is compounded by the problem of coordination and integration, which covers many aspects. First, there is a sectoral ego in each department and ministry so that planning is sectoral without regard for planning integration. Here, sectoral ego means that each organisational unit has its own interest in accordance with its vision and mission (Theiss, Ullman & Moinet 2016). This has been identified as a barrier to coordination in Indonesia (Firdini 2014), where planning integration is greatly needed. With the increasingly complex challenges of infrastructure development in Indonesia, precise solutions are required to overcome problems ranging from fragmentation and decentralisation, to international interdependence. These solutions cannot be formulated by individual ministries but instead require inter-ministerial coordination (Kraak 2011). Therefore, it is important that these competing sectors are harmonised so that they can work together to achieve greater strategic goals.

The second aspect is related to behavioural problems, namely: coercive actions and cultural influences. Coercion is the practice of forcing others to behave as desired by using threats, intimidation or other forms of force. It aims to convince the adversary's decision makers to change their view or behaviour by manipulating their considerations (Ehlers 2002). Meanwhile, culture is defined as "the collective programming of the mind that distinguishes the members of one group or category of people from another" (Hofstede 2011). Both of these have become challenges in the process of selecting and prioritising infrastructure projects where those who have higher positions tend to exercise power to influence the selection decisions.

Another unique challenge relates to the problem of land acquisition. Infrastructure projects, especially transportation, requires extensive land acquisition. However, due to lack of clear regulations on land acquisition for public use and provision of land compensation, delays and conflicts regarding infrastructure project execution often occur in Indonesia (KPMG 2015). This must be addressed as early as possible before the project is approved for execution.

Therefore, since 2015, Bappenas has initiated land acquisition regulatory reform to accelerate the development of strategic infrastructure projects in Indonesia (through Presidential Decree No. 148 of 2015). This is reinforced by the Regulation of Ministry of Finance No. 21 of 2017 on Procedures for Land Acquisition for National Strategic Projects and Asset Management of Land Acquisition by State Asset Management Agency. However, in practice, the land acquisition problem still often occurs, especially due to the long history of informal land ownership in Indonesia, which has caused many individuals to claim land rights during the land acquisition process (KPMG 2015).

10.2.3 The Effects and Solutions to the Perceived Challenges

After identifying various challenges in the selection and prioritisation process of infrastructure projects in Indonesia, this research also presents several effects and solutions to the perceived challenges. The interview analysis has identified ten effects and 13 solutions. Most of these effects and solutions are 'planning related', considering that the project selection process is included in the planning phase (specifically at the FEP phase). Besides that, the 'behaviour and coordination related' and 'political related' effects and solutions are also often mentioned since the project planning and selection process involves multiple stakeholders who have diverse human resources capability.

One of the effects of these challenges is a lack of planning integration. Although there have been many studies on the effect of increasing infrastructure development on economic growth in Indonesia (Aini 2018; Maryaningsih, Hermansyah & Savitri 2014; Sumadiasa, Tisnawati & Wirathi 2016), the potential for growth is still constrained due to the lack of integration of development planning. The infrastructure deficit is evident in rural and remote areas where insufficient infrastructure affects people's quality of life. For example, rural and remote areas are characterised by non-paved road access. In addition, connectivity and poor maintenance of built physical assets (due to the lack commitment of the local government) can also cause losses in terms of time and costs (increased travel time and extra costs).

These ten effects that have been identified are also evident in terms of their dependent relationship. Nine effects that arise as a result of perceived challenges can be grouped into primary effects, i.e. those effects that directly arise as a result of a challenge or problem, while the project failures effect can be identified as a secondary effect because it appears subsequently to the primary effects. For example, 'poor identification of needs' and 'unavailability of frameworks' problems can lead to 'inappropriate budget allocation' (primary effect) that will lead to potential 'project failures' (secondary effect).

In attempting to overcome these challenges and their effects, this study has also succeeded in identifying several solutions. The solutions most often promoted are related to planning and programming. These include the availability of standard frameworks for infrastructure project selection, focus on planning integration and developing certain planning flexibilities. Some of these solutions have been implemented even though they may not yet have had a maximum impact. For example, efforts to develop a selection system based on the AHP technique has been carried out by BPIW. By implementing an AHP-based selection system, it is hoped that the decision-making process can improve, resulting in more appropriate project selection.

10.2.4 The Identified Criteria for Infrastructure Project Selection and Prioritisation

The interview analysis has also succeeded in identifying several criteria for infrastructure project selection and prioritisation according to the respondents' insights. The identification of selection criteria is crucial because it is a major component in the development of a DMF. The results of the analysis present 16 established selection criteria with 'funding and financing' as the most frequently mentioned criterion by respondents. These two terms are interdependent, where a funding source must be present to support finance (CfM, n.d.). On the other hand, in Indonesia, funding for infrastructure projects is mainly sourced from the state budget. This state budget comes from the community through taxes and charges. For that reason, the use of the state budget as a public fund must be transparent and accountable.

On the other hand, the Indonesian government has realised that the state budget for financing infrastructure development is limited. They acknowledge that they cannot always be a provider for infrastructure development but must become an enabler so that the growth of infrastructure development can be sustainable. Efforts to overcome this limited infrastructure funding have been made mainly by encouraging the involvement of the private sector. One such initiative is the use of the Public-Private Partnership (PPP) model. A PPP is a form of government and private sector cooperation in financing infrastructure development. PPPs began to be implemented during SBY's government (2004-2014) under the name of *Kerjasama Pemerintah-Swasta* (KPS). Through Presidential Decree No. 38 of 2015, KPS was replaced by *Kerjasama Pemerintah-Badan Usaha* (KPBU). A number of facilities are also provided in the KPBU/PPP scheme, such as the Viability Gap Fund (VGF) and Project Preparation Facilities (PPF). The purpose of the VGF is to overcome project financial inability caused by the cost of infrastructure development being so expensive that it cannot be fully returned through the infrastructure service tariff. PPF is provided to assist the private sector in preparing and conducting project funding transactions.

Another source of funding is *Pembiayaan Investasi Non-Anggaran Pemerintah* (PINA) or the Non-Government Budget Investment Financing scheme, which relies entirely on the private sector to finance infrastructure project development. This scheme was launched in 2017. It is different from KPBU/PPP, which still get partial funding from the state (through APBN/APBD and/or the VGF and PPF). Because it depends entirely on the private sector, projects within the PINA scheme must be able to provide high returns to attract private sector investment. In other words, it must be financially feasible. Table 10.3 provides a comparison between the three types of funding sources for infrastructure projects in Indonesia.

Table 10.3 Comparison of the three infrastructure project funding sources in Indonesia

Sources	State Budget	Combination	Private sector funded
Description	Use the annual government budget	Involve the role of private sector in financing infrastructure development	Fully use private sector financing for infrastructure development
Scheme	APBN/APBD	KPBU (PPP)	PINA
Characteristic	• Fully depends on state budget capacity • Still the biggest source of infrastructure funding	Still get partial funding from the state and/or the VGF and PPF facilities	• Fully depends on the financial capacity of the private sector • Must be able to attract investment (financially feasible)
Project cases	• Trans-Papua Highway • MRT Jakarta • Jatigede Dam • Raknamo Dam • Cikawung Irrigation	• Umbulan Water Supply System • LRT Jakarta • LRT South Sumatera • Jakarta Sewerage System	• Kertajati Airport (by BIJB) • 15 toll roads (by Waskita Toll Road) • PLTU Batubara Meulaboh (by PP Energi)

Other identified criteria include the needs, urgency, risk, conformity, local authority, policy, politics, technology readiness, land acquisition readiness, design readiness, preliminary studies, innovation, planning integration, existing utilities and sustainability. These criteria can be used as parameters in evaluating project proposals. The selection process for project proposals based on multiple criteria is usually done in the form of a scoring assessment. A scoring model is a method that most people use for project selection (Kipper et al. 2014). Here, each criterion receives a specific weighting. Determining the weight of each of these criteria can be done qualitatively and/or quantitatively. However, Hu et al. (2008) argue that decision making without quantitative analysis has significant risks. For this reason, this study employs quantitative techniques to develop the DMF for infrastructure project selection.

10.2.5 The Influencing Factors in Infrastructure Project Selection and Prioritisation

The interview analysis has also succeeded in identifying factors influencing the decision makers when selecting and prioritising infrastructure projects. The selection and prioritisation of infrastructure projects as part of the decision-making process is a cognitive process experienced by the decision makers or the FEP team. There are several factors that influence them in making decisions with 'experience' being the main factor highlighted by the respondents. Experience can guide a person to make future decisions (Juliusson, Karlsson & Gärling 2005). Furthermore, people tend to avoid repeating bad experiences (Sagi & Friedland 2007). However, experience is not the only factor that determines the best selection decision. Besides experience, one’s knowledge and personal attributes can also influence the selection and prioritisation process to arrive at the best decisions.

The analysis shows that the knowledge a person received from their education also affects the quality of the decisions produced. With an appropriate educational background, a person can easily make an appropriate decision. For instance, someone with a civil engineering and infrastructure management background will find it easier to understand the situation, make judgments and arrive at decisions regarding infrastructure development planning than those with other educational backgrounds. A similar argument was also presented by Kim et al. (2018).

Personal attributes refer to a decision maker’s characteristics which include gender, age, commitment, and habits and attitudes (Hansen, Too & Le 2020b). Regarding gender, this study found no significant difference in terms of cognition between men and women. Meanwhile, based on the age factor, this study found that most of the strategic planning positions were filled by older decision makers. Although they are more experienced in the planning process, they may become overconfident (de Bruin, Parker & Fischhoff 2007) and thus, their decision judgment may decline as well (Finucane et al. 2005). On the other hand, decision makers must be aware of escalation of commitments that can lead them to take risky decisions based on irrational judgment (Juliusson, Karlsson & Gärling 2005; Hansen, Too & Le 2020b).

Meanwhile, habits and attitudes are related to the way of thinking and practical habits of decision makers. It is a complex factor because it is directly related to a person's personality (Haris 2012).

Understanding these influencing factors is important to comprehending how decision makers make decisions and ultimately, what decisions are made. In other words, these factors may influence the decision-making process, which in the end, will impact the quality of decisions and outcomes (Hansen, Too & Le 2020b).

10.2.6 Issues in the Development of a DMF for Infrastructure Project Selection and Prioritisation

The last finding from the interview analysis focuses on three issues in the development of a DMF for infrastructure project selection and prioritisation, namely: DMF characteristics, DMF features and future planning considerations. DMF characteristics are related to expected characteristics or traits within the DMF to be developed. The respondents mentioned four main characteristics, namely: user-friendly, transparency, accountability and technology-based. These characteristics can also be found in other DMF developments (Arain & Pheng 2006; Arif, Bayraktar & Chowdhury 2016; Masoumi 2015; Tripathi 2011).

The DMF features refer to important aspects that must be available in the DMF for infrastructure project selection. From the analysis, perhaps the most important features are the selection features, which consist of selection stages and procedures, the DMT and funding schemes. The selection process itself is a lengthy and complex process, as it involves a series of systematic steps (Kumar, Antony & Cho 2009; Santos & Araújo 2016). These steps can be further developed into several selection stages. It may vary from one organisation to another. For example, the CDIA (2010) framework has three stages, i.e. financial capacity analysis, project prioritisation and project programming for investment. Meanwhile, the DMT as an important part of the DMF is used as a means to select and prioritise infrastructure projects. Utilising the DMT shows that decision makers implement a rational selection technique rather than a judgmental one. Using a scoring method based on multiple weighted criteria is one way of assessing DMT (Hansen, Too & Le 2020c).

Furthermore, this study also succeeded in identifying several future planning considerations in the Indonesian context, which were classified into two groups, namely: concepts and approaches. ‘Concepts’ refers to the fundamental theories in the infrastructure planning process and includes asset management, connectivity, sustainability and thematic development. While

'Approaches' refers to the five approaches to be considered in the future infrastructure planning, namely: adaptability, community-focused, continuation program, technology-based and cross sector involvement. Egeland and Perkins (2017) emphasises the importance of flexibility, cross-sectoral planning, stakeholder engagement and integration in the government infrastructure investment planning process. Meanwhile, the concept of sustainability is closely related to the life cycle of infrastructure planning, which is defined as a comprehensive system covering the entire range of infrastructure planning, development and operations (Neuman 2011). These considerations have been widely discussed and applied in several developed countries such as UK, Australia, France, Denmark and Japan (Egeland & Perkins 2017) but have not yet been considered in the Indonesian infrastructure development planning process.

10.3 A Decision-Making Framework for Infrastructure Project Selection and Prioritisation

An in-depth investigation of various challenges and issues in Indonesian infrastructure development planning has highlighted the need for a DMF model for infrastructure project selection and prioritisation. This DMF will assist decision makers in aligning organisational objectives with project strategy. Poor selection of infrastructure project proposals leads to project failure and ultimately, missed organisational objectives. A good project selection and prioritisation process will allow organisations to strategically align their resources allocation, identify which projects are beneficial, and balance the number of projects with resource capability to invest in those projects.

10.3.1 A Theoretical Framework for Infrastructure Decision-Making Process

A theoretical framework is a set of interrelated concepts used to direct a research. It is developed based on an existing theory in a field of inquiry (Adom, Hussein & Agyem 2018) and serves as the blueprint of a study (Grant & Osanloo 2014). A theoretical framework for research is described by Ravitch and Carl (2016) as an important tool to guide researchers in situating formal theories within their studies.

The selection of a theory for use in a study must reflect the understanding of the researcher regarding research phenomena (Simon & Goes 2011) and help researchers to achieve the purpose of the study (Grant & Osanloo 2014). After a thorough understanding of the research objectives has been acquired and a comprehensive literature review has been completed, this research provides a theoretical framework consisting of three major elements, as proposed by Bakht and El-Diraby (2015), namely: decision makers, selection techniques and decision tools. Decision makers are those with the power to influence and make strategic decisions. Selection technique refers to the strategies and techniques that form the basis for reaching the final conclusion, while a decision tool refers to any means used to evaluate the consequences of an alternative (Bakht & El-Diraby 2015).

This theoretical framework (as presented in Figure 2.8) illustrates the relationship between these three major elements in a decision-making problem. In the context of this research, decision makers involved in the process of infrastructure project selection and prioritisation tend to be of a network type that apply a rational selection technique. Since this research involves dealing with multiple criteria, it applies NSFDSS-II as the basis in its development of a Decision-Making Tool (DMT) for the infrastructure project selection and prioritisation process in Indonesia.

10.3.2 A DMF Model for Infrastructure Project Selection and Prioritisation

In developing a DMF for infrastructure project selection and prioritisation, this research takes a comprehensive and systematic approach. First, it establishes a conceptual DMF model used to identify the concepts and variables needed in a study related to infrastructure project selection and prioritisation. Using a systematic procedure consisting of (1) problem identification, (2) information gathering, (3) screening, (4) concepts identification and classification, (5) analysis, synthesis and design and (6) framework validation and modification, this study has successfully developed a conceptual DMF model as presented in Figure 4.3. This conceptual DMF model possesses several positive characteristics, including being straightforward, flexible and modifiable.

The goal of this study is to develop an effective DMF model that better mimics the actual decision-making process to assist decision makers in selecting and prioritising infrastructure projects with adequate consideration for decision makers' inputs, thereby facilitating better project selection and prioritisation. Thus, it is necessary to choose a specific decision-making context in which the experiences of decision makers in making decisions on specific problems can be better understood. This research uses three relevant ministries as case studies to observe the decision-making process regarding infrastructure project selection and prioritisation as carried out in the Indonesian context.

The next step is to identify the appropriate selection criteria. According to Purnus and Bodea (2014), it is essential to establish a list of project selection criteria before various project options can be evaluated. In this study, this process was carried out comprehensively and systematically over three stages: integrative literature review, expert interview and questionnaire survey. Through an integrative literature review of previous publications, this study has identified 34 criteria for the infrastructure project selection and prioritisation problem. Contextualisation followed by conducting expert interviews. The findings were synthesised based on their similarities and scope to establish a set of 23 preliminary selection criteria as used in the Indonesian context. Finally, a questionnaire survey was used to validate and refine the identified selection criteria based on a large number of respondents. Considering the practicability and creditability of the weighting exercise, ten selection criteria were established to be used as a final set of selection criteria.

In multi-criteria decision making, it is crucial that the weight of each criterion is determined correctly. This study utilises NSFDSS-II, an MCDM technique developed by Tam et al. (2002a, 2002b) based on Chen's NSFDSS (1998), to determine the criteria weights for infrastructure project selection and prioritisation problems. The use of this technique for infrastructure project selection problems has not been previously studied, including in the context of infrastructure planning in Indonesia.

In this research, NSFDSS-II analysis has been carried out to determine the weight of ten key selection criteria for infrastructure project selection and prioritisation. The result is a priority ordering of the selection criteria based on the weight of each. As presented in Table 7.19, the selection criteria were sorted with higher weights indicating that criterion's higher contribution levels in the infrastructure project selection and prioritisation process. The criteria with greater weights are also those deemed worthy to be investigated and improved. Thus, the result provides a solid foundation on which decision makers can allocate suitable resources to these criteria, as they can more effectively improve the overall infrastructure project performance.

Based on the NSFDSS-II analysis, there are four criteria that have weights above 10%, representing 53.48% of the total effect in selecting infrastructure project proposals. It appears that C4 (risks & politics) is the most important criterion in infrastructure project selection and prioritisation in Indonesia. This is mainly because infrastructure projects are commonly large and complex projects characterised by high degrees of risks and uncertainties, including political risks, legal risks, permitting risks and market risks. These risks are common challenges in the development environment in Indonesia. Similarly, political conditions are also one of the main factors in the success of infrastructure development in Indonesia. Political uncertainty can disrupt project development and result in project cancellations (Mostaan & Ashuri 2017), as seen in the Jakarta Monorail project. This political uncertainty is partly due to the lack of understanding of political actors in infrastructure project selection, change of government officials, interventions and expropriation (Shrestha et al. 2017).

With only a slightly lesser weight at 0.09%, C1 (strategic fit) is the second most important selection criteria. It deals with the assessment of an infrastructure project proposal that provides a strategic fit to the socio-economic development of a nation. It consists of four aspects, namely: the needs, urgency, conformity and policies. This assessment involves many variables such as geo-demography, GDP growth, economic background, existing laws and regulations, and social variables (da Cruz & Marques 2014).

Private sector and public involvement (C8) are two external forces that may influence the project success. Hence, both of these are the major considerations in selecting infrastructure project proposals in Indonesia. Recently, the Indonesian government has encouraged private sector involvement in infrastructure project development, especially in relation to private sector investment. Various policies and procedures have been devised to bolster the interest of the private sector to invest in infrastructure development, including the establishment of investment guarantee business entities. On the other hand, public involvement also contributes to the selection of project proposals, especially considering that infrastructure development in Indonesia must obtain public approval. In line with that, Mostafavi et al. (2012) state that public perception assessment is a vital consideration in the implementation of infrastructure financing policies. In Indonesia, public rejection of controversial projects such as the Solok Geothermal Power Plant (Hadi & Putra 2019) and Lambo Reservoir project (Leda 2018) has become a primary challenge in project planning and development.

Funding and financing (C6) are important in ensuring capital to fund infrastructure projects. These include national and local government budgets, private sector investments, bank loans, equity contributions, etc. Readiness criteria (C2) are also critical for project success (Mostaan & Ashuri 2017). These can be assessed according to four technical criteria: land acquisition, design readiness, OM readiness and technology readiness. Innovative planning (C3) contributed 9.41% in the process of selecting and prioritising infrastructure projects. In this research, innovative planning is defined as a process that (1) applies a new approach to project planning by providing more resources during the FEP phase, (2) is concerned with creativity manifestation, conceptualisation and strategy and (3) promotes planning integration between all aspects and entities.

Contract and governance issues (C5) contributed 8.25%. This deals with contract arrangements and governance structures during the planning and implementation of infrastructure projects. Team member and stakeholder coordination (C7) weighs 8.21% and should be considered in the selection of infrastructure project proposals since many problems can be resolved if the team members and stakeholders are actively engaged in the FEP phase (Jergeas & der Put 2001). Sustainability and environmental issues (C10) have a sizeable weight of 7.44%. This is understandable considering that, in recent years, there has been an increased concern regarding these aspects in Indonesia. Finally, local government issues (C9) are the last key selection criteria, with a weight of 3.59%. This shows that, in the process of planning and selecting infrastructure project proposals in Indonesia, the role of the central government is still large compared to that of local governments.

Based on the above findings, this study develops a DMF model that consists of two inseparable parts, namely: the framework process and the DMT. The framework process offers a systematic model for improving the decision-making practice in infrastructure project selection and prioritisation that occurs over four stages, i.e. the data input, the data analysis, the project assessment and the final results. Meanwhile, the DMT is a technical tool used to facilitate decision makers in providing their judgments and evaluating the performance of each alternative.

10.3.3 The DMF Implementation and Evaluation

While there is no agreement on how to determine the quality of a decision-making framework or the reliability of the resulting decision output (Muñoz, Romana & Ordóñez 2016), this research seeks to evaluate and validate the developed DMF through several strategies including real case study implementations, parallel-forms reliability tests and sensitivity analysis.

According to Cheaitou, Larbi and Al Housani (2019), case study implementation can be one of the validation techniques of a proposed DMF. In this study, the DMF implementation is demonstrated using data from two different perspectives: data of prospective infrastructure project proposals and data of past infrastructure project proposals. Hence, there are two case study implementations undertaken to demonstrate the DMF. After each implementation, an interview survey was conducted to gather the experts' opinions on the effectiveness of the developed DMF. The results of the investigation show that experts who have tried the application of the DMF through actual case studies stated that it was very useful in supporting the selection and prioritisation process of infrastructure projects. They also agreed that this DMF was easy to understand and applicable, and recommended its use in the related work units.

Next, parallel-forms reliability tests were conducted to investigate the consistency of different but related measurement tools when applied to the same sample (Lucko & Rojas 2010). In this study, parallel-forms reliability tests were performed by comparing the decision outputs of a model that is developed based on a particular MCDM technique with another model developed based on another MCDM technique. In total, there are four different measurement analysis approaches that are applied to determine the weight and priority scale of the key criteria for infrastructure project selection problems, namely: NSFDSS-II, NSFDSS-I, Fuzzy SAW and AHP OS. NSFDSS-II is used as a basis for developing DMF for infrastructure project selection and prioritisation in this study. Therefore, this technique becomes the baseline for comparing decision outputs against three other techniques. Based on the findings of the parallel-forms reliability tests, it can be concluded that the decision outputs (i.e. the project priority list) produced by the developed DMF provides consistency when tested in comparison to DMFs based on other MCDM techniques.

Finally, sensitivity analysis was used to verify the stability of the solution and to validate the proposed model (Muñoz, Romana and Ordóñez 2016). It is done by applying the "what-if" scenarios approach to observe the impact of changes in input on the final decision output. In this study, sensitivity analysis was carried out with two types of variation of changes, namely: weight variation and MSI variation. The sensitivity analysis with weight variation shows that the decision outputs were sensitive to changes in weight; however, it retains the majority of the priority orders. It also shows high consistency of decision outputs against original decision output. Similarly, the MSI variation shows a perfect positive relationship—meaning that the DMF provides consistent solutions.

10.4 The Decision-Making Framework and the Identified Challenges in the Current Practice of Infrastructure Project Selection and Prioritisation Process

The current practices and challenges were identified in Chapter 5. These are the common problems in infrastructure project planning and decision making in the Indonesian context. With the development of the DMF for infrastructure project selection, which is the aim of this study, it is expected that these current challenges can be overcome. To facilitate understanding, these challenges are reproduced in Table 10.4 with a description of how the developed DMF can address each problem.

Table 10.4 The DMF vs. the identified challenges

Challenges		How the DMF can address the identified challenges?
Planning related challenges	Poor identification of strategic needs	Provides appropriate decisions for decision makers in identifying strategic needs related to infrastructure project planning and selection.
	Planning inflexibility	Offers space for decision makers to consider various aspects in the process of selecting infrastructure project proposals.
	Lack of information	Presents an opportunity for decision makers to broaden the main information needed / necessary in the selection and prioritisation process
	Wrong mindset	Changes the mindset of decision makers with a focus on good planning aspects
Programming related challenges	No standard selection framework or tool	Delivers a standard technical DMF that helps the process of selecting and prioritising infrastructure project proposals. In addition, a tool was also developed to help facilitate the decision-making process.
	No synchronisation & continuation	Affords opportunities for program synchronisation and continuation where proposals that have not / are not selected as priorities are still recorded in the database.
	Unclear budget distribution	Helps provide sound decisions related to infrastructure project priority so that budget distribution is more targeted, transparent and accountable.
	Unclear time frames	Makes measuring time frames easier as a standard framework has been set. DMT also facilitates rational decision-making processes, thus saving time.
Behaviour & coordination related challenges	Coordination problems	Identifies the main goal of the infrastructure project selection process so that all stakeholders involved have a common interest and facilitate coordination.
	Cultural challenges	Provides rational decisions without having to be supported by cultural dilemmas

	Coercive actions	Inhibits the practice of coercive actions in the infrastructure project planning and selection process.
Resources related challenges	Human resource issues	Increases the capability of the decision makers involved. In addition, the socialisation and training of the DMF also helped to equalise human resources between the central and local governments.
	Financial problems	Allows a limited budget allocation to be maximally utilised to carry out appropriate infrastructure projects.
	Geodemographic challenges	-
Policy & political related challenges	Decentralisation trap	Helps the local governments to improve their planning capacity and human resource capabilities.
	Political influences	Includes political influences as a key selection criterion in infrastructure project selection and prioritisation.
	Global issue challenges	-
Regulatory related challenges	Poor regulatory framework	Strengthens the existing regulations by providing details procedures and mechanisms for infrastructure project selection and prioritisation based on the multi-criteria decision-making technique.
	Land acquisition problems	Includes land acquisition as one aspect in the readiness criteria in infrastructure project selection and prioritisation.

10.4.1 Addressed challenges

Of the 19 identified challenges, the DMF can address 17 challenges in the infrastructure project planning and selection processes in the Indonesian context. First, in terms of planning-related challenges, there are four challenges related to aspects of infrastructure project planning, namely: poor identification of strategic needs, planning inflexibility, lack of information and wrong mindset. With the DMF for infrastructure project selection, decision makers can identify strategic infrastructure needs so as to provide appropriate decisions. In addition, the DMF is designed to provide space for decision makers to consider various aspects of infrastructure project planning, including the ease of improving assessment and the ability to update the selection criteria and priority scale in line with the needs and / or developments in conditions in Indonesia. Related to the lack of information challenge, DMF can be utilised by decision makers to find out what key information should be sought and deepened in relation to the interests of the process of selection and prioritisation of infrastructure projects. Thus, the information obtained is better directed and appropriately used as material for analysis. Furthermore, utilising this DMF can help change the mindset of decision makers today who tend to focus on budget spending instead of budget planning.

For programming-related challenges, this DMF is designed as an effective and efficient technical DMF to be applied by related parties in the infrastructure project selection process. As such, the DMF is expected to become a standard framework that can synchronise various programs and provide space for continuity for project proposals that have not been prioritised. Using this DMF will assist decision makers to produce an appropriate decision regarding which project should be invested in, so that the budget distribution becomes more targeted, transparent and accountable. Additionally, this DMF also facilitates decision makers in selecting and evaluating infrastructure project proposals in a rational and time-saving manner, thus providing time efficiency in the decision-making process. Having this DMF opens the possibility for decision makers to measure the required time frames for other activities such as the duration of the selection process and the deadline for announcing the selection results.

Regarding behaviour and coordination-related challenges, this DMF can help overcome coordination problems by identifying the main goal of the infrastructure project selection process so that all parties involved can have a common vision. The DMF also facilitates the coordination process by providing standard flow and selection tools that can be understood and operated together. In addition, this DMF can also minimise the existing cultural challenges as all infrastructure project proposals must be assessed and selected through a standardised DMF and DMT. Coercive practices that occur can be reduced or even eliminated by ensuring transparency of the decision-making process through an audit of the application of this DMF.

DMF development is also intended to address challenges related to resources. By utilising this DMF, decision makers can increase their capabilities in producing rational decisions instead of non-rational ones. In addition, this DMF needs to be accompanied by socialisation efforts and training of potential decision makers to make the distribution of human resource capabilities between the central and local governments more even. Regarding financial problems, the application of DMF can assist in the budgeting process to decide precisely where limited investment resources can be maximised to carry out appropriate infrastructure projects.

In terms of the policy and political-related challenges, this DMF can help local governments who have been limited by capacity inequality and capability in planning infrastructure projects in their respective regions. In this case, DMF can increase local governments' planning capacity and their human resource capabilities that will carry out project planning. Further, the DMF accounts for the fact that political influences undeniably play an important role in the process of planning and selecting infrastructure projects in Indonesia. This can be seen in projects instructed by the president and the ministers, as well as DPR proposed projects. Therefore, this DMF has accommodated political influences as one of the key selection criteria in the DMT for infrastructure project selection and prioritisation.

Finally, regarding regulatory-related challenges, this DMF can strengthen existing regulations related to infrastructure project planning in Indonesia by providing detailed procedures and mechanisms for infrastructure project selection and prioritisation based on an MCDM technique. Thus, the DMF serves as a complement that fills the void in the relevant existing regulations. The DMF also recognises land acquisition as an important aspect in the selection process for infrastructure projects in Indonesia. For this reason, land acquisition is included in the aspect of readiness criteria in the DMT.

This explanation illustrates how the developed DMF addresses either fully or partially the identified challenges. As almost all identified challenges in current practices in Indonesia have been addressed through the application of the developed DMF, the purpose of this study to develop an effective and efficient DMF for infrastructure project selection has been achieved.

10.4.2 Unaddressed challenges

As seen in Table 10.4, there are two challenges that cannot be countered by the developed DMF for infrastructure project selection and prioritisation. These are geodemographic challenges and global issue challenges. Geodemographic challenges relate to the issue of population and the geographic area of the vast Indonesian state. It poses a unique challenge for Indonesia in developing the land infrastructure, as the nation is an archipelago with many disconnected land masses. In addition, its large population demands growth in infrastructure development, which is also increasingly large and uneven. The DMF can assist in the selection and prioritisation of infrastructure projects, but due to limited investment resources, it is not possible for all project proposals to be carried out for the welfare of all the people of Indonesia.

Meanwhile, global issue challenges are related to international adverse factors that affect not only worldwide communities but also the growth of infrastructure in Indonesia. For example, the US-China Trade war since 2018, as exacerbated by the outbreak of the COVID-19 pandemic, has become a challenge for the construction industry in Indonesia including hampered infrastructure growth. Thus, this DMF cannot address these challenges due to aspects of external influences that cannot be measured and controlled by decision makers through the use of this DMF. In other words, it is out of the scope of this DMF to address these challenges.

10.5 Implications for Practice

This study aims to address the absence of a comprehensive DMF for infrastructure project selection and prioritisation in Indonesia. It increases understanding of the infrastructure project selection and prioritisation problems by providing an in-depth analysis of the current practices of infrastructure project selection and prioritisation in Indonesia, establishing the essential selection criteria used to assess infrastructure project proposals, integrating a new MCDM method to support the decision-making process, and developing a practical DMF using a broad and in-depth understanding of the real problems. Throughout the exploration of the real-life practices within the infrastructure management agencies, this research contributes to the existing knowledge of infrastructure project planning and decision-making practices.

Understanding the status quo

The first major practical contribution of this study is to provide much-needed empirical data on the current practices of Indonesian infrastructure project selection in particular, and infrastructure planning in general. This information is crucial given that there are many challenges in the current practices that must be identified, including the lack of capabilities to identify the strategic needs, the highly politicised decision-making process and the absence of a DMF developed specifically for the Indonesian context. It is imperative to identify these issues at the front end of project planning so the best alternatives can be selected and limited investment resources can be optimised. Using this DMF will allow decision makers (particularly the relevant ministries) to optimise the limited investment funds by making high-quality decisions.

In fact, most of the expert respondents indicated a high level of interest in the development of a DMF for infrastructure project selection and prioritisation as carried out in this research. They generally acknowledged that although several existing techniques and procedures are available to address this need, there were some gaps to be filled, including improved capabilities to conduct better and simplified decision-making process; improved techniques to measure the performance scores of infrastructure project proposals; improved capabilities to evaluate project proposals across project types; and improved capabilities to understand factors influencing the decision makers during the decision-making process.

Understanding the strategic decision-making issues

The second important implication of this research derives from the findings on the uniqueness of the knowledge and practices of infrastructure project planning and selection as carried out by the relevant ministries in Indonesia. These findings provide an advanced understanding of strategic decision-making issues both in the Indonesian and global contexts. For example, this research has successfully established the Indonesian development planning hierarchy, which starts at the national level planning and proceeds to the ministerial level planning before ending with regional level planning. It has also identified six decision approaches as observed in the current practices in Indonesia. Comparison of these decision approaches provides a better understanding of how each approach influences the decision-making process.

The qualitative findings have also identified several key characteristics of decision-making process as observed in the three different ministries in Indonesia. Several challenges and recommendations for advancing infrastructure project planning and selection have been identified and explained in detail. This contributes to the development of an appropriate and efficient DMF that can answer these challenges. This research also acknowledges that there are several crucial factors influencing the decision makers in the decision-making process. Prior to this study, there had been no comprehensive research that investigated the influencing factors during the infrastructure project selection and prioritisation process. Understanding these factors is essential to allowing decision makers to identify potential behavioural problems and take precautionary actions to arrive at sound decisions. Finally, the findings present a changing paradigm in the infrastructure project selection and prioritisation process from a directive and top-down approach to a participative and decentralisation approach. All of these findings are useful in understanding the potential problems that exist in the current practices and thus, can significantly minimise biases during the subsequent decision-making process.

Understanding what matters in selecting and prioritising infrastructure projects

The third implication stems from the need to establish appropriate selection criteria. This suggests that each decision-making problem requires a set of decision criteria in accordance with the decision-making context. Therefore, this research provides decision makers with an awareness of the criteria that must be taken into account when selecting and prioritising infrastructure project proposals in the Indonesian context. This is the key issue that this research attempted to address by exploring different approaches to establish and refine the criteria for infrastructure project selection and prioritisation. No robust studies exist in the literature that identify the key infrastructure project selection criteria, particularly in the Indonesian context. This study has successfully identified ten essential criteria in infrastructure project planning and selection for determining the performance scores of a project proposal. These criteria were obtained through a multi-sequence analysis of all specific criteria involved in the infrastructure project planning and selection process. The use of the linguistic variables and NSFDSS-II to assess these selection criteria proved to be a rigorous way of calculating and integrating them in the proposed DMF. Using these comprehensive data for input into the DMF is expected to increase credibility of the DMF parameters.

A model for infrastructure project selection and prioritisation in the Indonesian context

One of the significant challenges of the infrastructure project selection and prioritisation problem is that it may involve more than one evaluation dimensions. Thus, it is important to complement conventional analysis by eliminating the bias of using only one project evaluation dimension, e.g. cost-benefit analysis only considers the economic efficiency. This research contributes by developing a technical DMF and DMT that are able to provide assessment of the multi-dimensional and highly political process of infrastructure project selection and prioritisation. It was achieved through the application of NSFDSS-II in the development of DMF for infrastructure project selection and prioritisation. The application of NSFDSS-II is new and was designed based on other applications of NSFDSS-II identified in the literature review. To obtain accurate input data, the Delphi method was employed as a means for pairwise comparison.

Based on the assessment procedure of this DMF, the performance scores of infrastructure project proposals can be easily evaluated to establish a list of project priority. Due to fuzziness in the infrastructure project selection process, attributes and criteria should be assessed using linguistic terms on a ten-point Likert scale, with 1 representing ‘extremely low’ and 10 standing for ‘extremely high’. A DMT was developed using Microsoft Excel software, which is readily accessible by decision makers. Using this tool, decision makers can input their judgments of the selection criteria of each project alternative taken on these linguistic scales. The DMT will compute and display the performance scores of each project proposal. Thus, decision makers can directly use the DMF and DMT to measure the project proposal performances and improve FEP significance by making appropriate investment decisions.

In its development, the DMF focuses on all types of infrastructure project proposals since, in most organisational practices, various decision makers are dealing with all types of infrastructure projects. Therefore, this study does not focus on developing a DMF for a particular type of infrastructure project—such as building/residential projects (Baba 2013, Kalutara 2013, Wang, Zhang & Gao 2011), urban transport projects (Goh, Goh & Chong 2019, Lee 2012, Liu 2015), hydro-system projects (Su 2013) and maintenance projects (Arif 2013, Yau 2012)—as has been the case in many previous studies. It adapts to the needs of Indonesian agencies to select and prioritise infrastructure project proposals regardless of the project types. However, it is possible to develop a DMF to be used for one particular type of project in accordance with future needs.

In brief, tackling the project selection and prioritisation problem has become challenging for many decision makers since they have to deal with complex and dynamic situations during the decision-making process. Therefore, understanding the reasons for potential problems is useful as it helps decision makers to find ways to mitigate these challenges. This research provides a comprehensive review by addressing several issues related to the infrastructure selection problem. It provides a set of ready-to-use tools that have been validated through several evaluation strategies. This study found that a simple yet efficient tool is needed to assess infrastructure project selection using an accountable and rational decision-making technique. As such, this research has succeeded in developing a DMF that allows decision makers to achieve these objectives. Along with the actual application of this DMF, a database recording infrastructure project planning and selection processes can be further developed. This would not only add to the knowledge but could also function as a practical guide for those engaging in infrastructure project planning and selection in particular, as well as infrastructure asset management in general.

10.6 Chapter Summary

The selection and prioritisation of infrastructure projects is an important part of the strategic decision-making process that aligns organisational objectives with project strategies. Organisations undertaking infrastructure development such as governments or ministries, have to invest extensive resources to ensure the project success. Front End Planning phase is crucial, particularly in relation to the project approval and final investment decision, considering that incorrect approaches in the decision-making process can lead to project failure and the organisation's strategic objectives being missed. Therefore, in situations of complex and uncertain decision-making processes such as strategic infrastructure investments, a DMF model is required to direct the decision-making process. Furthermore, organisations have limited resources so there is a need for infrastructure projects to be selected and prioritised based on a certain set of selection criteria by the decision makers. The selection of these criteria must be done comprehensively by considering the decision-making context to better mimic the decision-making situation and process. This study has succeeded in developing a DMF that can be used by decision makers to assess infrastructure project proposals and make appropriate decisions regarding investment resources allocation.

CHAPTER 11. CONCLUSION

11.1 Research Achievements and Summaries

This research aimed to develop a model of a Decision-Making Framework for infrastructure project selection and prioritisation that integrates multiple decision criteria in the Indonesian context. To achieve this aim, four research questions were posed. A concise summary of the main discovery for each research question is presented as follows.

RQ 1. What are the current practices of FEP, particularly related to the decision-making process for infrastructure project selection?

This research focused on the final stage of the FEP phase, namely the decision-making process of investment decisions. Hence, this research examined a case study of Indonesia as the decision-making context in which in-depth investigation of the current practices related to infrastructure project planning and selection process was conducted. The findings showed that there are many challenges in the current practices, which were further grouped into six categories, namely: planning-related challenges, programming-related challenges, resources-related challenges, behaviour and coordination-related challenges, policy and political-related challenges, and regulatory-related challenges. There are opportunities for improvements that can be made to answer these challenges, one of which is the development of a DMF for infrastructure project selection and prioritisation.

RQ 2. What are the key features of a good DMF for infrastructure project selection?

A set of key features of a good DMF for infrastructure project selection and prioritisation was successfully identified through typology review analysis of the existing DMFs and expert interviews with relevant ministries. Identification of these key features was useful for directing the development of the DMF in this study. These key features include:

1) Introductory features, which consist of four aspects, namely: definition of DMF, importance of DMF, stakeholders involved and beneficiary of the DMF decision outputs.
2) Selection features, which refer to the key features used to select and prioritise infrastructure project proposals. These consist of four aspects, namely: selection stages

and decision points, Decision-Making Tool, timing and procedure, and funding schemes.

3) Complementary features, which refer to features that complement the two prior features in order to improve the performance of DMF decision outputs. These consist of audit process, regulatory compliance, coordination and communication, and visualisation.

RQ 3. What are the appropriate decision criteria in selecting infrastructure projects?

The findings suggest five clusters of criteria for selecting infrastructure project proposals, namely: technical criteria, administrative criteria, strategic fit criteria, risks and political criteria, and innovation criterion. The first cluster consists of six criteria related to the technical aspects of infrastructure project selection, namely: land acquisition, funding and financing, design readiness, team member and stakeholder coordination, contractual conditions and procurement system, and operational and maintenance readiness. The second cluster consists of six criteria related to the administrative aspects of infrastructure project selection, namely: government policies, planning integration, private and public sector involvement, local government issues, good governance and technology transfer. The third cluster relates to the strategic aspects of infrastructure project selection and consists of four criteria, namely: the needs, urgency, conformity and sustainability issues. The fourth cluster has two criteria, namely: project risks and political issues. Finally, the last cluster only has one criterion: innovation. Considering the practicability and creditability of the weighting exercise using NSFDSS-II, these criteria were grouped based on their natures and similarities to provide a final set of key selection criteria used in this research. This final set of key selection criteria are: strategic fit, readiness criteria, innovative planning, risks and politics, contract and governance issues, funding and financing, team member and stakeholder coordination, private and public involvement, local government issues and sustainability issues.

RQ 4. How DMF for infrastructure project selection can be developed and to what extent it can be implemented?

Based on the previous findings, a DMF for infrastructure project selection and prioritisation was developed in the Indonesian context. The DMF fulfils the five elements of integrated framework by providing clear context, goals, inputs, processes and outputs. It consists of two major aspects that complement each other—the framework process and the Decision-Making Tool (DMT). The framework process presents four stages of infrastructure project selection and prioritisation, namely: data input, data analysis, project assessment and result determination. Meanwhile, the DMT allows the decision makers to provide their judgments and evaluate the performance of each project proposal. It was developed based on fuzzy logic system using NSFDSS-II. The DMF was developed to address most identified challenges in the current infrastructure project selection process in Indonesia. Finally, to provide an evidence-based framework, the developed DMF was evaluated and validated through several strategies, including case study implementations, parallel-forms reliability tests and sensitivity analysis. The results show that the use of the developed DMF provides consistent and accountable decision outputs. Overall, the developed DMF has established ten qualities:

1. The DMF is simple yet applicable and provides the flow needed in the process of selecting and prioritising infrastructure project proposals.
2. The selection criteria and DMF features have been identified through a contextualisation process that reflects the real conditions and current situations of infrastructure project investment appraisal in Indonesia. Thus, the proposed DMF has been developed in accordance with the actual needs.
3. It assists decision makers to identify and compare various feasible selection criteria under a multi-dimensional perspective to assess the project proposals.
4. The tool was developed using an MCDM fuzzy-based technique, i.e. NSFDSS-II. The result of NSFDSS-II provides optimal selection criteria weighting that considers each possible criteria rating via pairwise comparisons.
5. The tool provides the outcome of the project priority list that will assist the decision makers to produce decisions based on its performance score.
6. This framework can improve decision-making process by providing stronger arguments and decisions with acceptable levels of accuracy. Thus, the decision output made can be accounted for.
7. As is evident from the decision structure of the system, the developed DMF is a structured system that is characterised by having a stable context and being commonplace, recurrent and programmable, as opposed to unstructured systems that are volatile, atypical, refer to a unique place (not replicable) and are discrete and intuitive.
8. It serves as a strategic managerial tool that assists decision makers dealing with strategic decision-making problems, i.e. the selection and prioritisation of infrastructure project proposals.
9. It is flexible enough to incorporate future knowledge (adaptable to changes).

10. Its effectiveness has been demonstrated through case study implementations. Thus, it provides a proof-based tool. The reliability test results show that the decision output from the DMF offers high consistency.

To summarise the association of findings from all chapters, Table 11.1 presents the matrix of research questions, approaches and achievement status of all aspects of this study.

Table 11.1 Research achievements and summaries

No.	Research Question	Research Objective	Approach	Deliverable	Status
1	What are the current practices of FEP, particularly related to the decision-making process for infrastructure projects selection?	To assess the current FEP practices and extent of FEP significance in infrastructure projects	Integrative literature review, Expert interview	The significance of FEP, the current practices of the decision-making process for infrastructure project selection	*Achieved mainly in Chapter 2 and 5*
2	What are the key features of a good DMF for infrastructure project selection?	To investigate the key features of a good DMF for infrastructure project selection	Typology analysis, Expert interview	The key features of DMF, conceptual DMF development	*Achieved mainly in Chapter 4 and 5*
3	What are the appropriate decision criteria in selecting infrastructure projects?	To examine the appropriate decision criteria in selecting infrastructure project proposals	Integrative literature review, Expert interview, Questionnaire	Selection criteria based on literature review, interview findings & questionnaire analysis	*Achieved mainly in Chapter 5 and 6*
4	What DMF for infrastructure project selection can be developed and to what extent can it be implemented?	To propose a DMF that enhances the decision-making efficacy for infrastructure project selection and to investigate the effectiveness of the proposed framework	MCDM technique (pairwise comparison followed by NSFDSS-II), Case study implementations, Parallel-forms reliability tests, Sensitivity analysis	Conceptual DMF model, proposed DMF model (including DMT), and its implementation and evaluation	*Achieved mainly in Chapter 4, 7, 8 and 9*

11.2 Limitations and Recommendations

A holistic approach emphasising the identification of selection criteria has been applied for the development of this DMF. However, there are several limitations in this study that may potentially weaken its quality. These are mainly related to the data collection methods. This study employs a mixed-method approach with multi-sequence techniques. Although this approach provides a more comprehensive study, it also causes this research to be costly and time consuming since it requires a lot of effort to gather the data.

Another limitation of this study is related to qualitative analysis where only one researcher analyses the interview data. This can result in the emergence of biases in data analysis. The last limitation occurred at the stage of implementation and evaluation of the DMF, which was carried out during the COVID-19 outbreak. This meant that the second implementation had to be done online with only one expert respondent. Nevertheless, several efforts were made to anticipate shortcomings due to these limitations.

For future research, it will be helpful to further develop this framework by considering the level of detail (for example, by considering details of CBA for financial criteria) and a rubric assessment to assist decision makers in making judgments when assessing the project proposals. Also, this DMF has been implemented for multiple types of infrastructure. Thus, it is recommended that similar tools to be developed to select and prioritise certain categories of infrastructure project proposals (for instance, selection of road project proposals, selection of power plant projects proposals, etc.).

The development of a DMF needs to consider the time aspect. Hence, the DMF was developed in view of developments and changes in the situation and mindset of the community related to infrastructure project proposals. For this reason, future research is needed to update the requirements of the DMF and DMT, particularly the selection criteria and weights. Finally, future research may also use the proposed DMF as the basis for a Decision Support System (DSS) software development.

In addition, this research has observed that the process of selecting infrastructure project proposals in Indonesia involves multiple stakeholders, including local governments, relevant ministries and the DPR (House of Representatives). This causes the selection stage to be divided into two, namely: technocratic and post technocratic. This study discusses further issues related to the selection process that can be applied at the technocratic (ministerial level) stage. Thus, future research could focus on the infrastructure project selection process at the post-technocratic stage, particularly the discussion and approval of project proposals in the DPR. This may include the post-technocratic selection process, their incentives and impact on decisions, and potential decision biases due to political influences.

11.3 Closing Remarks

Overall, this study has shed light on the practice of strategic decision-making regarding infrastructure project selection and prioritisation. It has successfully investigated the current practices and challenges of infrastructure project planning and selection in Indonesia, identified several factors influencing the decision makers in making infrastructure investment decisions, and described several potential issues faced by the decision makers in the management of infrastructure projects. To overcome the existing problems and challenges, this study focuses on developing a DMF for infrastructure project selection and prioritisation that can be used to support organisational strategic decision-making. In order to function effectively and efficiently, this study develops a DMF by considering: (1) the context in which the decision problem will be investigated, formulated and analysed, (2) a comprehensive method to identify the appropriate selection criteria and (3) strategies to evaluate the effectiveness of the developed DMF. This research emphasises a contextualisation approach, based on an Indonesian context, to improve the use of decision-making technique in solving infrastructure project selection and prioritisation problem.

This research highlights the importance of effective Front End Planning—particularly related to the project investment decisions—for the successful performance of infrastructure projects. The developed DMF can serve as a strategic management tool for decision makers in selecting and prioritising infrastructure project proposals, thus facilitating a better investment decision-making process and contributing to the achievement of organisational goals. In its development, this research presents sufficient detailed information regarding how to develop the appropriate DMF for selecting and prioritising infrastructure projects. This is particularly relevant in Indonesia where the project environment is often characterised by uncertainty and high political influence.

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APPENDICES

Appendix 1: Interview Protocol

Stage	Protocol	Arrangement
1	Introduce yourself	Refer to introductory script
2	Explanation the content of PISC Form to expert respondent	• Prepare the PISC Form • Ask the expert to sign the form
3	Interview session • Introduction about the research • Background information • Interview questions • Closing questions	• Prepare the script • Prepare the audio recorder • Prepare notes (if necessary) • Ask the key questions • Try to develop probe questions during interview
4	Closing statement	Snowballing

Appendix 2: Semi-Structured Expert Interview Script

Project: **Front-End Planning Decision-Making Framework for Infrastructure Project Selection in Indonesia**

Contact: Seng Hansen

PhD Candidate (Built Environment)

Building 8, Level 7, Room 49

360 Swanston St., Melbourne Victoria 3000, Australia

P:

E: hansen.seng@rmit.edu.au

Introductory script:

Thank you for agreeing to be interviewed as part of the research project that we are doing into the Decision-Making Framework for infrastructure project selection during front-end planning phase. My name is Seng Hansen and currently I am a PhD student at RMIT University. I wish that I could learn much from you about the topic. The aim of this interview is to explore your experience and knowledge on infrastructure project selection in Indonesia. There is no right or wrong, desirable or undesirable answers. You can provide your answers in an honest and direct ways. We just want to confirm that you are okay for us to record you? ____

Also, we just want you to know that the interview is confidential and details like people's and projects' names will be deidentified.

Goal: To seek a comprehensive understanding of the practices, challenges, and effectiveness of decision-making framework for infrastructure projects during front-end planning phase.

PART I – INTRODUCTION

- Reminder of what FEP is
- Reminder of what Decision-Making is
- Researchers' background

PART II – INTERVIEWEE'S & PROJECT'S BACKGROUND

- Interviewee's background
  1. How long have you been working in this field?
     - How about in the Ministry?
  2. What is your educational background?
  3. What is your current job position in your organization?
  4. What are your roles and tasks?
  5. Can you please tell us briefly about your experience with government projects, particularly for the planning and selection of infrastructure projects? What are the project types?

For this interview, please CHOOSE ONE SITUATION/EVENT that you think may be most representative of your experience with infrastructure projects.

Can you tell us brief about the situation/event and your role?

Timeline:

Goals & objectives:

Budget:

Client and other major parties:

Who makes the decision about which project to undertake and prioritize?

PART III – PRACTICES, CHALLENGES AND EFFECTIVENESS OF DMF

Walk us through the process you followed to make your decision in selecting infrastructure project proposals.

1. **How is FEP organized and executed at the organization?**
   Follow up on:

   - Whether there is a procedure/framework/guideline
   - What are the stages/gates
   - Decision points
   - Tools or techniques being used (as simple as a checklist)
   - If there is no formal processes or procedures, ask about de facto processes
2. **Do you have a process/procedure/methodology/model that you use when you are making decisions?**
   Follow up on:

   - Why?
   - Any technique/tool/software/model to support the decision-making?
   - Is there a document/guideline for that?
3. **How decisions are made during and at the end of FEP regarding infrastructure project selection?**
   Elaborate on the decision-making process:

   - Whether there is a framework or guideline
   - Whether there are phase gates

- Formal or informal decision-making; judgmental, rational or emergent
- Who are involved in the decision-making process?
- Known objectives
- Appropriate information
- Set of alternatives
- Assess possible consequences
- The output of this process

4. **<u>What are the criteria</u> in making decision to select and prioritize infrastructure projects?**
   Decision criteria are those criteria used to assess the project proposals. It includes: financial criteria, technical criteria, risk-related criteria, resources-related criteria, contractual conditions criteria, etc.

   Follow up to find out about:

   - How criteria are selected and defined; what they actually mean (elaboration needed as a name can mean different things to different people)
   - Could you please named 3 most important criteria?
   - If there is a methodical approach to using these criteria in making decision (e.g., weighting, qualitative, quantitative/MCDM)

5. **<u>What are the factors</u> influencing decision-making process for infrastructure project selection?**
   Influencing factors are those factors/characteristics that influence decision-making process. It includes: past experience (Juliusson, Karlsson & Garling 2005), cognitive biases (Stanovich & West 2008), age and individual differences (Bruin, Parker & Fischoff 2007), belief in personal relevance (Acevedo & Krueger 2004), personal competencies, attitude, habits, etc.

   Follow up to find out about:

   - What are these factors actually mean?
   - If there are sub-factors?
   - Could you please provide some examples on how these factors influence the decision-making process?

6. **<u>Are there any major challenges</u> in making decisions for infrastructure project selection and prioritization?**
   Follow up on:

   - Where the challenges come from (why, who and how)?
   - How does it happen?
   - How these challenges affect FEP and decision-making process?
   - Do you have some cases/examples? (ask for data if any)
   - What has been done to minimize the challenges?
   - What could be done to overcome these challenges from happening?

7. **<u>How effective is the current</u> decision-making process for infrastructure project selection you involved in?**
   Follow up on:

   - Is it effective/not? Why?
   - Are you satisfied with the process?
   - How the continuity (of people, process, material, etc.) is maintained?
   - Could you provide some examples?

- Could you provide some guidelines/standards/documents on the current process/procedure?

8. **In an ideal world, <u>what do you think decision-making process should be done/improve</u> to make sure effective decisions are achieved which eventually result in project success?**
   Follow up on:

   - The need for decision-making framework (i.e., a structured and systematic approach to decision-making in complex situation that serves as a guide for decision makers in achieving their organizational objectives and goals), the potential benefits and drawbacks of DMF, the key features of DMF, how to develop it
   - Lessons learned from past experiences
   - Learn from other countries
   - Resources, people involved, improved processes, regulations and future considerations
9. **Do you have <u>other ideas/suggestions</u> you would like to add about the given questions in selecting and prioritizing infrastructure projects?**

PART IV – CLOSING

- Snowball: if the interviewee thinks s/he can introduce suitable people, ask for permission to mention their introduction or better yet ask them to make the introduction, however it works best for them.
- Thanks and future follow-up if needed (for clarification and further detail on the project). Ask for their contact number.

Notes:

- If the project is suitable for case study later, we can request them to volunteer the project as a case study/workshop.
- Some questions may require the interviewee to refer to their general experience instead of just the project being discussed; this is okay.

Appendix 3: Interview Key Responses

No	Questions	Respondent 1	Respondent 2	Respondent 3	Respondent 4
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**				
1	How does FEP occur and how is it carried out in your organisation?	• In stages • No guidance	• In stages* • The cycle is not closed • Need to be improved	• In stages* • Translate into strategic planning: long-term, medium-term and short-term	• In stages* • Start from the concept • Long-term, medium-term and short-term planning
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	• Based on needs • Judgment process • Provide alternatives	• Based on needs • WPS (Strategic Development Regions)	• Based on needs • Based on president's vision and mission/policy • WPS • Regional consultations	• Based on needs • Based on government policies, macro national policies • Conduct FGDs • BPIW process
3	Is there any procedure, technique, tool etc. available to help you make decisions / select the project proposals?	• Comparison	• Readiness criteria • Need new tool to integrate all projects	• Prioritisation	• Prioritisation
4	Is the decision-making process more judgmental or rational?	• Rational*	• Rational*	• Rational*	• Rational*
5	How effective is the current decision-making process?	• Getting better	-	-	• It can be effective but we have no tool to measure it yet
6	What are the weaknesses of government decision making?	-	• Too many directive programs	-	-
B	**Criteria in infrastructure project selection and prioritisation**				

7	What are the criteria for selecting and prioritising infrastructure projects?	• Needs • Political • Financial • Land acquisition	• Readiness criteria • Financial	• Budget constraint • Readiness criteria • Continued projects	• Economic • Readiness criteria • Urgency
8	Is there a methodical approach to using these criteria? / How do you assess these criteria?	• Financial criteria are easy • Political criteria are difficult • Weighting	• Prioritisation tool (not yet implemented)	• Prioritisation tool (not yet implemented) • Checklist	• Checklist
C	**Factors influencing infrastructure project selection decision-making process**				
9	What are the factors influencing the decision-making process for infrastructure project selection?	• Experience • Gender • Knowledge exposed (education, job position)	• Politic	-	• Experience
D	**Challenges in infrastructure project planning and selection**				
10	What are the challenges in the decision-making process of infrastructure project selection?	• Community objections • Community interference • Lack of integration	• Readiness criteria is sectoral • No indicators for integrated strategic planning • Human resource • Directive programs • Demand for quick planning • Value for money vs. National Budget approach	• Change of proposals • Not knowing the field • Local authority	• Funding sources • Institution coordination • Sectoral ego • Weak socialisation • Program synchronisation

11	How do these challenges affect the decision-making process? / Can you provide cases?	• Investor withdrawal • High risk investment • Becak Kayu toll road	• Reschedule other programs • Re-planning, re-programming	• Re-planning	• Miss the target, wrong demand • Flat project for civil servants
12	What are the solutions? / How do you deal with the challenges?	• A government entity to attract investment • Provide good legislative framework	• Based on project prioritisation	• Based on project prioritisation	• Ministry Regulation No. 21/2018 • All projects must receive recommendation from BPIW
13	How does the politics influence the selection process? / What is the best way to measure political criteria?	• Politic is important • It is a top criterion in project selection • Look at the regulations	• Political instruction is mandatory	• It may change the planned list of programs	-
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?	-	• BPIW exists to integrate	-	• Coordination between stakeholders not yet integrated well
E	**Considerations of expected Decision-Making Framework (DMF)**				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	• Integration • Provide the tool	• Closed cycle • Agreement that BPIW is the agency to integrate all infrastructure project planning • Based on thematic development	-	• The SDR concept must be strengthened • Determine the integrated indicators of a region

16	Is it important to have a DMF for infrastructure project selection in Indonesia?	• Yes	• Yes*	-	-
17	What are the features that must be available in the DMF?	• Stakeholder • Regulatory	-	-	• The tool • Stakeholder • Funding schemes • Coordination
18	Is an audit process required? / Transparent process?	• Yes, to ensure the framework is well implemented • Provide transparent process	-	-	• Yes, but just with reports
19	What are the consequences of having no DMF?	-	-	-	-
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	-	• Small indicators • Simple tool • Integrated indicators	-	-

Note: (*) inferred from the respondent's response

No	Questions	Respondent 5	Respondent 6	Respondent 7	Respondent 8
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**				
1	How does FEP occur and how is it carried out in your organisation?	• In stages	• In stages* • Long-term, medium-term and short-term planning • Strategic plans	• In stages • Employer's perspective	• In stages* • Long-term, medium-term and short-term planning
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	• Based on needs • By proposals or by directive/instructions • BPIW process • Baseline and stocks	• Based on WPS • BPIW process • Island scale characteristics • Updating • Strategic environment	• Provide alternatives • Use selection criteria	• Based on WPS • BPIW process • Regional consultations
3	Is there any procedure, technique, tool etc. available to help you make decisions / select the project proposals?	• Prioritisation	• Benefit analysis • Prioritisation	• Various methods	• Prioritisation
4	Is the decision-making process more judgmental or rational?	• Rational*	• Rational*	• Rational*	• Rational*
5	How effective is the current decision-making process?	• Technocratic selection is effective but not for post-technocratic process	• Getting better through technology usage	-	• It is a comprehensive process
6	What are the weaknesses of government decision making?	-	-	• Tends to hinder competition • Lack of innovations	• No perfect model • Indonesia is not just WPS
B	**Criteria in infrastructure project selection and prioritisation**				

7	What are the criteria for selecting and prioritising infrastructure projects?	• Urgency • Continued projects • Integrated projects • Readiness criteria	• Strategic area • Resources • Funding • Urgency • Influencing strategic environment • Continued projects	• Funding • Added value/Innovation	• Financing schemes • Political parameters • Integration parameters • Sustainability • Specific parameters
8	Is there a methodical approach to using these criteria? / How do you assess these criteria?	• Checklist	• Checklist	• Expert judgment • Weighting	• Weighting • AHP
C	**Factors influencing infrastructure project selection decision-making process**				
9	What are the factors influencing the decision-making process for infrastructure project selection?	-	-	• Experience	-
D	**Challenges in infrastructure project planning and selection**				
10	What are the challenges in the decision-making process of infrastructure project selection?	• Maintenance issues • Political intervention • Decentralisation trap • Authority • Lack of regulations	• Financial problems • Land acquisition • Local authority • Limited human resources	• Political biases • Human error • Poor regulations	• Resources are limited (funding, human resources) • Demographic factors • Geographical factors • Political factors • Global factors
11	How do these challenges affect the decision-making process? / Can you provide cases?	• Complicated bureaucracy	• Poor planning	-	• Programs are vulnerable to change

12	What are the solutions? / How do you deal with the challenges?	• Flexibility • Anti-corruption commissioner • MNDP could intervene	• Technology	-	• Prepare technocratic strategic plans
13	How does the politics influence the selection process? / What is the best way to measure political criteria?	• Selection by politic	-	• Political biases must be considered. It may change the planning	• It may change the planning
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?	• The enforcement for integrated planning is still difficult	• Integration of programming and evaluation	-	• Integration of monitoring and evaluation
E	**Considerations of expected Decision-Making Framework (DMF)**				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	-	-	• Scientifically proven • Made objectively • Transparent and accountable	• Provide valid • Made into a collective agreement • Real considerations basis
16	Is it important to have a DMF for infrastructure project selection in Indonesia?	-	-	• Yes	-
17	What are the features that must be available in the DMF?	-	-	• Tools • Technology-based • Stakeholders	-
18	Is an audit process required? / Transparent process?	• Evaluation and monitoring	-	• Ensure neutrality	-

				• Ensure transparency and accountability • Internal and third party audits	
19	What are the consequences of having no DMF?	-	-	-	-
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	-	• Use technology	• Use online IT	• Provide evidence based*

Note: (*) inferred from the respondent's response

No	Questions	Respondent 9	Respondent 10	Respondent 11	Respondent 12
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**				
1	How does FEP occur and how is it carried out in your organisation?	• In stages*	• In stages* • Strategic planning	• In stages • Starts from project identification, selection, preparation, funding schemes • Short, medium or long terms	• In stages* • Scope, criteria, output, preparation, elaboration, proposal, delivery, assessment, determination
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	• Based on needs • There are alternatives • Provide justifications • Have time frame • A simple decision is better	• Look at the ministry strategic planning • Based on president's vision and mission/policies • Ministry mechanism thru directorate's planning departments	• Based on the regulations • Ministry mechanism • MNDP programs: national strategic projects	• Level of decisions: strategic decisions, tactical decision, operational decisions • Process: problem identification, alternatives identification, information gathering, decision-making
3	Is there any procedure, technique, tool etc. available to help you make decisions / select the project proposals?	• Prioritisation • Look at procedures and regulations	• Studies • Priority scale	• Masterplans • Regulations • Preliminary studies	• Follow SOP, regulations
4	Is the decision-making process more judgmental or rational?	• Rational	• Rational*	• Rational*	• Rational*
5	How effective is the current decision-making process?	-	-	-	-

6	What are the weaknesses of government decision making?	• Too many directive projects/political pressures • Politically driven projects do not mean bad	• Change the plans easily from the masterplans • Focused on the financing, not the planning	-	-
B	**Criteria in infrastructure project selection and prioritisation**				
7	What are the criteria for selecting and prioritising infrastructure projects?	• Economic feasibility • Financial feasibility • Readiness criteria • Underlying events • Urgency • Local commitment	• Directions of priority policies • Local needs • Funding	• Need analysis • Funding schemes • Economic feasibility • Financial feasibility	• Relevancy • Conformity with the results of previous projects • Conformity with thematic, holistic, integrative and spatial approaches
8	Is there a methodical approach to using these criteria? / How do you assess these criteria?	• Benefit analysis/calculation	• Clear parameters to prioritise	• CBA	• Procedures
C	**Factors influencing infrastructure project selection decision-making process**				
9	What are the factors influencing the decision-making process for infrastructure project selection?	• Technical experience • Personal characteristics/types • Gender • Religious/belief	-	-	-
D	**Challenges in infrastructure project planning and selection**				
10	What are the challenges in the decision-making process of infrastructure project selection?	• Local authority commitment to provide budget for maintenance • Political pressure	• Decentralisation trap • Limited funding • Planning continuation • Geographic challenge	• Limited human resources • Limited budget for hiring expert consultants	• Lack of information • Subjectivity problem • Politics

			• Limited human resources • Politics	• Poor capabilities to do the planning and selection • No standard for project selection (by MNDP) • Lack of knowledge • Job rotation/change of people involved • Lack of incentive	
11	How do these challenges affect the decision-making process? / Can you provide cases?	• It changes the plans • Planning is not based on pure technical justification	• Some projects are outside of the central gov's authority while the local gov has not enough funds • Identify earlier all stakeholders' needs	• Do the selection process differently • Training new staffs always starts from 0 • Unmotivated	• Wrong or lack of information, the plans may deviate from the target • Subjectivity may depend of political will
12	What are the solutions? / How do you deal with the challenges?	• Provide studies • Prioritise based on needs	• Central gov provides special funding allocations	• Establish a special unit • Provide toolkits/checklists for project selection	• Provide enough information • Minimise subjectivity • Provide valid and reasonable arguments for decisions related to project prioritisation
13	How does the politics influence the selection process? / What is the best way to measure political criteria?	• Still many political pressures	• Top-down approach should be combined with bottom-up approach	-	• Human need is very complex. Politics may change the plans

14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?	-	• Trilateral level discussions (between ministries etc.) • Integration between the government, academics and communities	• Should think more comprehensively between stakeholders	-
E	**Considerations of expected Decision-Making Framework (DMF)**				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	• Based on needs • Reduce the political pressures • Provide technical justifications • Evaluate the effectiveness of the built infrastructure projects	• Provide enough time for planning so that it becomes more prepared, comprehensive • Involve academics in the planning and decision-making process • Stick to the masterplan	• The unit to do this should be more independent and have more authority • Have a toolkit to select and prioritise projects	• Strategic environmental changes • Global commitments • Continuation of the projects • Project impacts towards the environment
16	Is it important to have a DMF for infrastructure project selection in Indonesia?	• Yes, to make sure that the proposed projects have been prioritised	• Yes*	• Yes*	• Yes
17	What are the features that must be available in the DMF?	• Visualisation	-	• The tools and criteria • 2 frameworks: to determine economic feasibility and financial feasibility	• Clear process • Clear criteria • Transparency
18	Is an audit process required? / Transparent process?	• Provide accountability to the public	-	-	• Yes

19	What are the consequences of having no DMF?	• Projects will be chaotic • Projects can be stalled • Poor decision-making • Cannot be maintained • Not appropriate projects	• Not appropriate projects	• Poor planning • Project cancellations • No investors due to high risk • Waste of energy and time	• The selection cannot be measured clearly • Risk of project deviations • Poor governance practice • Jealousy from others • No commitment
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	• It should be able to visualise • Provide quick calculation • Flexibility	• Based on regions characteristics • Learned from other countries	• Should also think comprehensively on how the built infrastructure can be operationalised and maintained	• Environmentally friendly technologies

Note: (*) inferred from the respondent's response

No	Questions	Respondent 13	Respondent 14	Respondent 15	Respondent 16
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**				
1	How does FEP occur and how is it carried out in your organisation?	• In stages*	• In stages*	• In stages*	• In stages*
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	• Based on relevancy • Look at the community needs and problems • Provide valid arguments • Process: collect and list all proposals, selection, locations, cost magnitudes and benefits, domestic capacity, preparation	• Based on needs • Provide technical considerations • Look at the impacts	• Consider the possible risks • Look at the urgency • Planning bureau	• Based on regulations • Ministry procedures
3	Is there any procedure, technique, tool etc available to help you make decisions / select the project proposals?	• Meetings • Technical coordination	• Data availability	• Feasibility study	• Feasibility study • Assessment of needs
4	Is the decision-making process more judgmental or rational?	• Rational*	• Rational*	• Rational*	• Rational*
5	How effective is the current decision-making process?	-	-	-	-
6	What are the weaknesses of government decision making?	-	• Too politicised	-	• Use top-down approach • Not consider the community's demands

B	**Criteria in infrastructure project selection and prioritisation**				
7	What are the criteria for selecting and prioritising infrastructure projects?	• The project characteristic • Funding sources • Domestic industry capabilities • Project preparation (land availability)	• Project feasibility • Readiness criteria • Technology • Specification • Existing utility • Policy • Specific criteria	• Urgency • Regulations	• Budget • Funding sources
8	Is there a methodical approach to use these criteria? / How do you assess these criteria?	-	• Checklist	• Benefits analysis	-
C	**Factors influencing infrastructure project selection decision-making process**				
9	What are the factors influencing the decision-making process for infrastructure project selection?	-	• Risk • Competency • Experience	• Competency • Experience • Environment	• Experience • Sharing experience
D	**Challenges in infrastructure project planning and selection**				
10	What are the challenges in the decision-making process of infrastructure project selection?	• Too many stakeholder involvements • Diverse capabilities of human resources	• Technical challenges • Coordination • Demand to be quick • Funding sources • Level of approval	• Politics • Bureaucracy • Lack of consistency • Limited time in planning	• Political decision • Leader interference • Demand to be quick • Limited human resources
11	How do these challenges affect the decision-making process? / Can you provide cases?	• People who are not experts get involve in the process • Difficult to compare fairly the proposals	• Too many parties involved	• When there is a change of leadership, the policies sometimes will change too. The regulations can be changed	• Directive instructions that may not in accordance with the demands • Kertajati airport

		• Inappropriate project formulation		• Double works	
12	What are the solutions? / How do you deal with the challenges?	-	• Flexible process	• Be consistent	• Socialisation to the community
13	How does the politics influence the selection process? / What is the best way to measure political criteria?	• Stakeholders who have the power to intervene while it is actually not their expertise	• Top-down projects are given from the president • The instructions are directed to the ministry • Should be minimised	• Change the leadership, change the policies	• Top-down should be minimised • Bottom-up should be encouraged
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?	-	• Integration between ministries and communities	• Sectoral ego	-
E	**Considerations of expected Decision-Making Framework (DMF)**				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	• Must be known and understood • Refusal and approval must be clear • Provide strong arguments	• The political aspect should be minimised	-	-
16	Is it important to have a DMF for infrastructure project selection in Indonesia?	• Yes	• Yes	• Yes	• Yes
17	What are the features that must be available in the DMF?	• Proposal period • Timing	• Tool • Criteria	• Communication between stakeholders	• Regulations • Stakeholders' roles

		• Beneficiaries • Domestic capabilities • Funding sources • Project readiness	• Explanation of stakeholders involved	• Audit	
18	Is an audit process required? / Transparent process?	-	• Yes, starts from the very beginning • Internal and external audits	• Yes	-
19	What are the consequences of having no DMF?	• Proposals may come at any time • Difficulties in selecting and prioritising proposals • Subjective considerations	• Inappropriate projects • Too politicised • Waste of energy • Waste of money	• Lack of objectivity • Change of plans • No integration • No transparency	• The project will not be maximum • Inappropriate budget allocation • Double efforts
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	• Based on community needs for both short and long terms • Infrastructure development must be timely	• Based on community needs • In line with the gov's vision • Community empowerment	• Look at the benefits, efficiency and connectivity • Look at the existing infrastructure	• Based on community needs • Look at community satisfaction

Note: (*) inferred from the respondent's response

No	Questions	Respondent 17	Respondent 18	Respondent 19	Respondent 20
A	**Current practices of decision-making process for infrastructure project selection and prioritisation**				
1	How does FEP occur and how is it carried out in your organisation?	• In stages*	• In stages*	• In stages*	• In stages*
2	How do you make decisions related to infrastructure project selection? / What is your current practice in making decisions related to infrastructure project selection and prioritisation?	• Look at the objectives • Based on regulations • Establish work units • MPWH strategic plans	• Proposals from the local governments • Selection process with multiple criteria • Ministry directions	• Provide alternatives • Ministry procedures • Involve experts • 2 stages: importance and further studies	• Directorate level planning • Strategic plans
3	Is there any procedure, technique, tool etc available to help you make decisions / select the project proposals?	• Assessments	• Prioritisation	• Reviews: strategic reviews, brief reviews, self-managed reviews • FGDs • Feasibility study	• Consultations/FGDs
4	Is the decision-making process more judgmental or rational?	• Rational*	• Rational*	• Rational*	• Rational*
5	How effective is the current decision-making process?	-	-	-	-
6	What are the weaknesses of government decision making?	• Too politicised*	-	• Lack of responsiveness of the current trends/developments	-
B	**Criteria in infrastructure project selection and prioritisation**				
7	What are the criteria for selecting and prioritising infrastructure projects?	• Strategic plans	• Readiness criteria • Budget • Direction • Commitment letter	• Urgency • Benefits • Local government response	• Strategic plans • Technocratic • Authority • Politic

			• Community	• Technical • Economical	• National priority
8	Is there a methodical approach to use these criteria? / How do you assess these criteria?	• Formulas	• Checklist	• Benefits analysis	• Assessment scoring
C	**Factors influencing infrastructure project selection decision-making process**				
9	What are the factors influencing the decision-making process for infrastructure project selection?	-	• Interest • Experience • Commitment	-	• Supervisor's role
D	**Challenges in infrastructure project planning and selection**				
10	What are the challenges in the decision-making process of infrastructure project selection?	• Cultural dilemma • Organisation • Time frame problem • No framework • Fails in detailing	• Politics • Local capacities • Land acquisition • Community reluctance • No standard framework	• Funding sources • Human resources capacity (esp. at local government)	• Insistence of proposals • Manual selection • Subjectivity
11	How do these challenges affect the decision-making process? / Can you provide cases?	• Change the plans • Propose inappropriate projects	• Rejection from the community • The project may not function properly	• Burden the central government to fund local projects	• Supervisor may change the list of priority according to his preference
12	What are the solutions? / How do you deal with the challenges?	• Have a standard framework	• Balanced both top-down and bottom-up approaches • Program socialisation • Local gov's commitment	• Better coordination • Involvement of all stakeholders since the very beginning of the planning • Comprehensive planning	• Provide standard framework/guidance*

13	How does the politics influence the selection process? / What is the best way to measure political criteria?	• The representatives may propose projects to please their constituencies	• Some projects are rejected by the representatives	• Projects must be executed	-
14	Is there no integration/coordination between stakeholders/sectors? / To what extent does cross sector influence infrastructure project selection?	-	• Need integration from cross-sectors	• Communication between stakeholders • Should encourage more involvement from private sector	• Discussions through regional consultations
E	**Considerations of expected Decision-Making Framework (DMF)**				
15	How should the decision-making process ideally be carried out and improved? / How should the DMF be developed?	• Provide concrete evidence* • Minimise political intervention	• Easy to be understood • Easy to be implemented • User friendly • Cross-sectors	• Clear roles of stakeholders involved in the process • Open and transparent • In accordance with applicable regulations • Easy calculation • Faster process	• Establish in stages with decision points
16	Is it important to have a DMF for infrastructure project selection in Indonesia?	• Yes	• Yes	• Yes	• Yes
17	What are the features that must be available in the DMF?	• Political aspect • Criteria • Tool	• The readiness • The legalisation	• Weighting • Tool • Criteria • Stakeholders	• Tool • System • Weighting • Criteria
18	Is an audit process required? / Transparent process?	• Yes, thru online system	-	• Yes*	• Review through annual reports*

19	What are the consequences of having no DMF?	• Inappropriate budget allocation	• No continuation • No clear roles	-	• Poor planning
20	What should be considered in the infrastructure planning, selection and prioritisation process for the future?	• Environmental aspects* • Backward and forward effects • Based on necessity	• Cross-sectors • Establish the road map • Look at existing conditions • Provide operational and maintenance budgets	• Look at the project characteristics • Easy to access • More open • Involve private sectors and community • Be more responsive with the current conditions/trends and developing technologies • Update the regulations	• Use IT

Note: (*) inferred from the respondent's response

Appendix 4: Questionnaire Survey Template

Default Question Block

INTRODUCTION
This questionnaire aims to explore the potential criteria associated with the infrastructure project selection and prioritization in Indonesia context. The researchers have conducted literature review and semi-structured expert interviews with some professionals working at the Indonesian Ministry of Public Works & Housing, the Indonesian Ministry of Transportation, and the Indonesian Ministry of National Development Planning. The results are 23 potential criteria in selecting and prioritizing infrastructure project proposals.

This questionnaire is part of a PhD research project titled "**A Front-End Planning Decision-Making Framework for Infrastructure Projects in Indonesia**". Your feedback and timely response will greatly assist with the conduct of this research project. Please be assured that participation in this research project is voluntary. Any information obtained from this survey will be kept **strictly confidential** and will only be used for research purposes.

GENERAL INSTRUCTIONS
Please read carefully!

This questionnaire consists of three main parts:
(a) participant's profile
(b) project information
(c) data collection for selection criteria

Block 1

PART A – PARTICIPANT'S PROFILE (CONFIDENTIAL)
Please provide your details according to the following questions.

Name/initial

E-mail address

Do you graduate from construction/infrastructure related disciplines (including Civil Engineering, Architecture, Planology, etc.)?

- ◯ Yes
- ◯ No

What is your latest educational background?

- ◯ Bachelor/Diploma IV
- ◯ Master
- ◯ Doctoral
- ◯ Others

How long have you been working in the construction/infrastructure industry?

- ◯ Less than 5 years

- 5 - 10 years
- 10 - 20 years
- More than 20 years

What is your affiliation?

- Ministry of Public Works & Housing
- Ministry of Transportation
- Ministry of National Development Planning/Bappenas
- Others

What is your current job position?

- Staff
- Junior manager/supervisor
- Senior manager/supervisor
- Head of department/director
- Others

Block 2

PART B – PROJECT INFORMATION
To help the process of filling out Part C below, please CHOOSE ONE PROJECT SITUATION/EVENT that you think may be the most representative of your experience with infrastructure projects. Please provide your responses according to the following questions.

Project name

Project type (e.g. road/airport/tunnel/stadium/irrigation, etc.)

Project location (e.g. Jambi Province/Jakarta, etc.)

Your roles (e.g. project staff/supervisor/manager/PPK, etc.)

Project value size

- < IDR 150 billion
- IDR 50 - 100 billion
- > IDR 100 billion

Project duration

- ◯ < 12 months
- ◯ 12 - 24 months
- ◯ > 24 months

Project status

- ◯ On-going, expected to be completed in:
- ◯ Completed, when it was completed:

Block 3

PART C – DATA COLLECTION FOR SELECTION CRITERIA
Based on the project/event that you have selected in Part B, please indicate your view on the importance of the following criteria in infrastructure project selection and prioritization.
Scale 1 indicates 'the least important' and 10 indicates 'the most important'.

Indicate your view on the importance of the following criteria in infrastructure project selection and prioritization.

	1	2	3	4	5	6	7	8	9	10
The Needs (related to the strategic need and purpose of a proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Conformity (related to the conformity of the proposed project to the National Development Goals and commitments, applicable laws & regulations)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Risk (related to the proposed project's level of risks and uncertainties involved)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Urgency (related to the urgency of the proposed project to be executed immediately)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Private Sector & Community Involvement (related to the level of private sector & public involvement, as well as public attitudes regarding the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Good Governance (related to the level of good governance implementation of the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Local Government Issues (related to the local government issues, including the local gov proposals, local gov commitment, local capabilities, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Policies (related to projects supporting policies taken to solve actual problems that exist in society, including government priority/policies, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Politics (related to the political issues and impacts of a proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Innovation/Added Value (related to the degree of innovation/added value of the proposed project throughout its life cycle, VE implementation)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Design Readiness (related to the readiness of design principles, including life time expectancy, aesthetics requirements, design for safety, functionality, scope of work, constructability, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Funding & Financing (related to the sources of funding, funding schemes, allocation for contingencies, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
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.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Technology Readiness & Transfer (related to the readiness of technology as well as technology transfer of the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Land Acquisition (related to the readiness to acquire land needed for the project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Team Member & Stakeholder Coordination (related to the degree of alliance among all key stakeholders and team members of a proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
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.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Contractual Conditions & Procurement System (related to the contractual conditions and procurement system that will be adopted by the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Project Scheduling & Programming (related to the readiness of project scheduling and programming, including the availability of preliminary master schedule, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Project Resources Management (related to the resources handling and utilization, including work force, materials, equipment, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
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.)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Existing Infrastructure & Utilities (related to considerations of the existing infrastructure and utility impacts on the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Sustainability & Environmental Issues (related to the sustainability issues and impacts of the proposed project)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Appendix 5: Pairwise Comparison Questionnaire Templates (Round 1 and Round 2)

Kuesioner Penelitian (Delphi Technique – Round 1)

Yth. Saudara/i calon responden,

Dengan ini saya memohon kesediaan Saudara/i untuk meluangkan waktu ± 15-20 menit untuk mengisi kuesioner berikut sebagai bagian dari penelitian disertasi saya yang berjudul "***A Front-End Planning Decision-Making Framework for Infrastructure Project Selection in Indonesia***". Sebelumnya saya telah melaksanakan tinjauan literatur, wawancara ahli, dan penyebaran kuisioner tahap 1 kepada lebih kurang 300 responden. Hasilnya adalah 10 kriteria utama untuk menyeleksi proposal proyek infrastruktur di Indonesia. Pada kesempatan ini akan dicari bobot dari kesepuluh kriteria utama melalui perbandingan berpasangan (*pairwise comparisons*) dalam bentuk Delphi Technique. *Delphi Technique* akan dilakukan sebanyak 2 kali hingga konsensus tercapai dimana mayoritas respondent (>50%) setuju pada nilai yang sama.
Seluruh informasi yang terkumpul hanya akan digunakan untuk kepentingan akademik dan dijamin kerahasiaannya. Terima kasih atas partisipasi Anda dalam mengisi kuesioner ini.

INSTRUKSI UMUM
Kuisioner ini terdiri dari dua bagian utama:
(a) profil responden ahli
(b) perbandingan berpasangan

NB: Proyek infrastruktur dalam penelitian ini termasuk semua jenis proyek konstruksi meliputi proyek gedung (kantor, mall, hotel, dll.), proyek sipil basah (bendungan, irigasi, normalisasi kali, dll.), proyek transportasi (jalan, rel, pelabuhan, bandara, dll.), dan proyek infrastruktur fisik lainnya.

BAGIAN A – PROFIL RESPONDEN AHLI (RAHASIA)
Silakan mengisi data diri Anda sesuai dengan pertanyaan berikut ini.

Nama

Nomor telepon / alamat email

Pendidikan yang pernah ditempuh (contoh: S1 Teknik Sipil, S2 Manajemen Strategis)

Nama instansi/afiliasi saat ini

Jabatan dalam instansi/afiliasi saat ini

Kategori instansi/afiliasi

- Pemerintah/Kementerian/BUMN
- Swasta
- Lainnya

Pengalaman bekerja di industri konstruksi (dalam tahun)

Apakah Anda pernah terlibat dalam perencanaan dan/atau pelaksanaan proyek infrastruktur sebelumnya?

- Ya
- Tidak

Apakah Anda pernah mempublikasikan maupun mempresentasikan suatu rancangan / gagasan / jurnal penelitian / buku sebelumnya?

- Ya
- Tidak

Apakah Anda pernah terlibat dalam sebuah organisasi profesi di sektor konstruksi?

- Ya
- Tidak

Block 1

BAGIAN B – PERBANDINGAN BERPASANGAN

Kuesioner ini bertujuan untuk mengetahui pendapat Anda mengenai **kriteria seleksi mana yang lebih penting dalam memilih proposal proyek infrastruktur** yang ada. Dalam melakukan perbandingan berpasangan, terdapat 3 parameter yang menjadi dasar penilaian, yaitu:

(1) Efektifitas Waktu
(2) Efektifitas Biaya
(3) Kompleksitas Proyek

Contoh:

(A) Dilihat dari efektifitas waktu:

	Kurang Penting (KP)	Sama Penting (SP)	Lebih Penting (LP)	
Kebutuhan Strategis	○	○	○	Kesiapan
Kebutuhan Strategis	○	○	○	Perencanaan Inovatif
Kebutuhan Strategis	○	○	○	Risiko & Politik

Pengisian di atas berarti menurut Anda, dalam menyeleksi proposal proyek infrastruktur dilihat dari **efektifitas waktu**-nya:

- kebutuhan strategis terhadap proyek **kurang penting** daripada kriteria kesiapan
- kebutuhan strategis terhadap proyek **lebih penting** daripada perencanaan inovatif
- kebutuhan strategis terhadap proyek **sama penting** dengan tingkat risiko & politik

Untuk membantu Anda memahami penjelasan dari masing-masing kriteria seleksi tersebut, silakan mengacu pada penjelasan berikut ini.

Kode	Kriteria	Deskripsi
C1	Kebutuhan Strategis (*strategic fit*)	Terkait kebutuhan strategis proyek, kesesuaian proyek dengan Rencana Pembangunan Nasional/ komitmen/peraturan, tingkat urgensitas proyek diperlukan, dan dukungan terhadap kebijakan pemerintah
C2	Kesiapan (*readiness criteria*)	Terkait kesiapan aspek teknis termasuk kesiapan desain, kesiapan akuisisi lahan, kesiapan operasional dan pemeliharaan, kesiapan dan transfer teknologi
C3	Perencanaan Inovatif (*innovative planning*)	Terkait dengan aspek integrasi perencanaan dengan program maupun rencana strategis lainnya, dan tingkat inovasi proyek yang memberikan nilai tambah
C4	Risiko & Politik (*risks & politics*)	Terkait dengan tingkat risiko dari proyek dan isu-isu politik serta dampak dari proyek
C5	Isu Kontrak & Tata Kelola (*contracts & governance issues*)	Terkait kondisi-kondisi kontrak yang dipersyaratkan, sistem pengadaan yang diadopsi, dan tingkat tata kelola yang akan diterapkan
C6	Pendanaan & Pembiayaan (*funding & financing*)	Terkait aspek pendanaan dan pembiayaan seperti sumber-sumber pendanaan, skema pembiayaan, alokasi biaya, dll.
C7	Koordinasi Tim & Pemangku Kepentingan (*team member & stakeholder coordination*)	Terkait tingkat aliansi/koordinasi di antara anggota tim proyek maupun para pemangku kepentingan lainnya yang terlibat
C8	Keterlibatan Sektor Swasta & Publik (*private sector & public involvement*)	Terkait tingkat keterlibatan sektor swasta dan komunitas/masyarakat umum, termasuk sikap publik terhadap proyek yang diajukan
C9	Isu Pemerintah Daerah (*local government issues*)	Terkait dengan isu-isu pemerintah daerah antara lain proyek yang diajukan dari pemerintah daerah, komitmen pemerintah daerah, kapabilitas pemerintah daerah, dll.
C10	Isu Lingkungan & Keberlanjutan (*sustainability & environmental issues*)	Terkait isu-isu lingkungan dan keberlanjutan dari proyek yang diajukan

Kode	Parameter Penilaian	Deskripsi
P1	Efektifitas Waktu (*time effectiveness*)	Waktu adalah hal penting dalam proyek konstruksi karena berkaitan langsung dengan biaya. Oleh karena itu, waktu harus menjadi salah satu pertimbangan dalam seleksi dan prioritisasi proyek infrastruktur
P2	Efektifitas Biaya (*cost effectiveness*)	Ini merujuk pada efektifitas keseluruhan biaya konstruksi untuk menyelesaikan sebuah proyek infrastruktur
P3	Kompleksitas Proyek (*project complexity*)	Ini merujuk pada aspek-aspek kompleks lain dari proyek selain efektifitas waktu dan biaya. Kompleksitas proyek infrastruktur dapat dilihat dari aspek teknologi, organisasi, tujuan, lingkungan, sosial-budaya, dan informasi yang tersedia

Block 2

(A) Dilihat dari **efektifitas waktu**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting	Sama Penting	Lebih Penting	
Kebutuhan Strategis	○	○	○	Kesiapan
Kebutuhan Strategis	○	○	○	Perencanaan Inovatif
Kebutuhan Strategis	○	○	○	Risiko & Politik
Kebutuhan Strategis	○	○	○	Isu Kontrak & Tata Kelola
Kebutuhan Strategis	○	○	○	Pendanaan & Pembiayaan
Kebutuhan Strategis	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kebutuhan Strategis	○	○	○	Keterlibatan Sektor Swasta & Publik
Kebutuhan Strategis	○	○	○	Isu Pemerintah Daerah
Kebutuhan Strategis	○	○	○	Isu Lingkungan & Keberlanjutan
Kesiapan	○	○	○	Perencanaan Inovatif
Kesiapan	○	○	○	Risiko & Politik
Kesiapan	○	○	○	Isu Kontrak & Tata Kelola
Kesiapan	○	○	○	Pendanaan & Pembiayaan
Kesiapan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kesiapan	○	○	○	Keterlibatan Sektor Swasta & Publik
Kesiapan	○	○	○	Isu Pemerintah Daerah
Kesiapan	○	○	○	Isu Lingkungan & Keberlanjutan
Perencanaan Inovatif	○	○	○	Risiko & Politik
Perencanaan Inovatif	○	○	○	Isu Kontrak & Tata Kelola
Perencanaan Inovatif	○	○	○	Pendanaan & Pembiayaan
Perencanaan Inovatif	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Perencanaan Inovatif	○	○	○	Keterlibatan Sektor Swasta & Publik
Perencanaan Inovatif	○	○	○	Isu Pemerintah Daerah
Perencanaan Inovatif	○	○	○	Isu Lingkungan & Keberlanjutan
Risiko & Politik	○	○	○	Isu Kontrak & Tata Kelola
Risiko & Politik	○	○	○	Pendanaan & Pembiayaan
Risiko & Politik	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Risiko & Politik	○	○	○	Keterlibatan Sektor Swasta & Publik

Risiko & Politik	○	○	○	Isu Pemerintah Daerah
Risiko & Politik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Kontrak & Tata Kelola	○	○	○	Pendanaan & Pembiayaan
Isu Kontrak & Tata Kelola	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Isu Kontrak & Tata Kelola	○	○	○	Keterlibatan Sektor Swasta & Publik
Isu Kontrak & Tata Kelola	○	○	○	Isu Pemerintah Daerah
Isu Kontrak & Tata Kelola	○	○	○	Isu Lingkungan & Keberlanjutan
Pendanaan & Pembiayaan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Pendanaan & Pembiayaan	○	○	○	Keterlibatan Sektor Swasta & Publik
Pendanaan & Pembiayaan	○	○	○	Isu Pemerintah Daerah
Pendanaan & Pembiayaan	○	○	○	Isu Lingkungan & Keberlanjutan
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Keterlibatan Sektor Swasta & Publik
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Pemerintah Daerah
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Lingkungan & Keberlanjutan
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Pemerintah Daerah
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Pemerintah Daerah	○	○	○	Isu Lingkungan & Keberlanjutan

(B) Dilihat dari **efektifitas biaya**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting	Sama Penting	Lebih Penting	
Kebutuhan Strategis	○	○	○	Kesiapan
Kebutuhan Strategis	○	○	○	Perencanaan Inovatif
Kebutuhan Strategis	○	○	○	Risiko & Politik
Kebutuhan Strategis	○	○	○	Isu Kontrak & Tata Kelola
Kebutuhan Strategis	○	○	○	Pendanaan & Pembiayaan
Kebutuhan Strategis	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kebutuhan Strategis	○	○	○	Keterlibatan Sektor Swasta & Publik
Kebutuhan Strategis	○	○	○	Isu Pemerintah Daerah
Kebutuhan Strategis	○	○	○	Isu Lingkungan & Keberlanjutan
Kesiapan	○	○	○	Perencanaan Inovatif
Kesiapan	○	○	○	Risiko & Politik
Kesiapan	○	○	○	Isu Kontrak & Tata Kelola
Kesiapan	○	○	○	Pendanaan & Pembiayaan
Kesiapan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kesiapan	○	○	○	Keterlibatan Sektor Swasta & Publik
Kesiapan	○	○	○	Isu Pemerintah Daerah
Kesiapan	○	○	○	Isu Lingkungan & Keberlanjutan
Perencanaan Inovatif	○	○	○	Risiko & Politik
Perencanaan Inovatif	○	○	○	Isu Kontrak & Tata Kelola
Perencanaan Inovatif	○	○	○	Pendanaan & Pembiayaan
Perencanaan Inovatif	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Perencanaan Inovatif	○	○	○	Keterlibatan Sektor Swasta & Publik
Perencanaan Inovatif	○	○	○	Isu Pemerintah Daerah
Perencanaan Inovatif	○	○	○	Isu Lingkungan & Keberlanjutan
Risiko & Politik	○	○	○	Isu Kontrak & Tata Kelola
Risiko & Politik	○	○	○	Pendanaan & Pembiayaan

Risiko & Politik	○	○	○	Pendanaan & Pembiayaan
Risiko & Politik	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Risiko & Politik	○	○	○	Keterlibatan Sektor Swasta & Publik
Risiko & Politik	○	○	○	Isu Pemerintah Daerah
Risiko & Politik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Kontrak & Tata Kelola	○	○	○	Pendanaan & Pembiayaan
Isu Kontrak & Tata Kelola	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Isu Kontrak & Tata Kelola	○	○	○	Keterlibatan Sektor Swasta & Publik
Isu Kontrak & Tata Kelola	○	○	○	Isu Pemerintah Daerah
Isu Kontrak & Tata Kelola	○	○	○	Isu Lingkungan & Keberlanjutan
Pendanaan & Pembiayaan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Pendanaan & Pembiayaan	○	○	○	Keterlibatan Sektor Swasta & Publik
Pendanaan & Pembiayaan	○	○	○	Isu Pemerintah Daerah
Pendanaan & Pembiayaan	○	○	○	Isu Lingkungan & Keberlanjutan
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Keterlibatan Sektor Swasta & Publik
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Pemerintah Daerah
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Lingkungan & Keberlanjutan
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Pemerintah Daerah
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Pemerintah Daerah	○	○	○	Isu Lingkungan & Keberlanjutan

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting	Sama Penting	Lebih Penting	
Kebutuhan Strategis	○	○	○	Kesiapan
Kebutuhan Strategis	○	○	○	Perencanaan Inovatif
Kebutuhan Strategis	○	○	○	Risiko & Politik
Kebutuhan Strategis	○	○	○	Isu Kontrak & Tata Kelola
Kebutuhan Strategis	○	○	○	Pendanaan & Pembiayaan
Kebutuhan Strategis	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kebutuhan Strategis	○	○	○	Keterlibatan Sektor Swasta & Publik
Kebutuhan Strategis	○	○	○	Isu Pemerintah Daerah
Kebutuhan Strategis	○	○	○	Isu Lingkungan & Keberlanjutan
Kesiapan	○	○	○	Perencanaan Inovatif
Kesiapan	○	○	○	Risiko & Politik
Kesiapan	○	○	○	Isu Kontrak & Tata Kelola
Kesiapan	○	○	○	Pendanaan & Pembiayaan
Kesiapan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Kesiapan	○	○	○	Keterlibatan Sektor Swasta & Publik
Kesiapan	○	○	○	Isu Pemerintah Daerah
Kesiapan	○	○	○	Isu Lingkungan & Keberlanjutan
Perencanaan Inovatif	○	○	○	Risiko & Politik
Perencanaan Inovatif	○	○	○	Isu Kontrak & Tata Kelola
Perencanaan Inovatif	○	○	○	Pendanaan & Pembiayaan
Perencanaan Inovatif	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Perencanaan Inovatif	○	○	○	Keterlibatan Sektor Swasta & Publik
Perencanaan Inovatif	○	○	○	Isu Pemerintah Daerah

Perencanaan Inovatif	○	○	○	Isu Pemerintah Daerah
Perencanaan Inovatif	○	○	○	Isu Lingkungan & Keberlanjutan
Risiko & Politik	○	○	○	Isu Kontrak & Tata Kelola
Risiko & Politik	○	○	○	Pendanaan & Pembiayaan
Risiko & Politik	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Risiko & Politik	○	○	○	Keterlibatan Sektor Swasta & Publik
Risiko & Politik	○	○	○	Isu Pemerintah Daerah
Risiko & Politik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Kontrak & Tata Kelola	○	○	○	Pendanaan & Pembiayaan
Isu Kontrak & Tata Kelola	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Isu Kontrak & Tata Kelola	○	○	○	Keterlibatan Sektor Swasta & Publik
Isu Kontrak & Tata Kelola	○	○	○	Isu Pemerintah Daerah
Isu Kontrak & Tata Kelola	○	○	○	Isu Lingkungan & Keberlanjutan
Pendanaan & Pembiayaan	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Pendanaan & Pembiayaan	○	○	○	Keterlibatan Sektor Swasta & Publik
Pendanaan & Pembiayaan	○	○	○	Isu Pemerintah Daerah
Pendanaan & Pembiayaan	○	○	○	Isu Lingkungan & Keberlanjutan
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Keterlibatan Sektor Swasta & Publik
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Pemerintah Daerah
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Lingkungan & Keberlanjutan
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Pemerintah Daerah
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Pemerintah Daerah	○	○	○	Isu Lingkungan & Keberlanjutan

(D) Berikan pendapat Anda terhadap **parameter penilaian** berikut ini:

	Kurang Penting	**Sama Penting**	**Lebih Penting**	
Efektifitas Waktu	○	○	○	Efektifitas Biaya
Efektifitas Waktu	○	○	○	Kompleksitas Proyek
Efektifitas Biaya	○	○	○	Kompleksitas Proyek

Default Question Block

Kuesioner Penelitian (Delphi Technique – Round 2)

"Kriteria Seleksi Proposal Proyek Infrastruktur"

Seng Hansen
School of Property, Construction & Project Management, RMIT University
e-mail: hansen.seng@rmit.edu.au

Yth. Saudara/i responden,

Sebelumnya terima kasih banyak telah meluangkan waktu untuk mengisi kuisioner perbandingan berpasangan (pairwise comparisons) dalam Delphi Technique Round 1. Hasil dari Round 1 adalah tercapainya konsensus untuk 101 perbandingan berpasangan dari total 138 perbandingan berpasangan yang ada. ***Pada Round 2 ini, akan dicari nilai untuk 37 perbandingan berpasangan yang belum mencapai konsensus pada Round 1***. Untuk membantu Anda dalam memberikan penilaian, hasil penilaian dari Round 1 disajikan dalam bentuk persentase pada setiap perbandingan yang dicari. Seluruh informasi yang terkumpul hanya akan digunakan untuk kepentingan akademik dan dijamin kerahasiaannya. Terima kasih atas partisipasi Anda dalam mengisi kuesioner ini.

PERBANDINGAN BERPASANGAN

Kuesioner ini bertujuan untuk mengetahui pendapat Anda mengenai **kriteria seleksi mana yang lebih penting dalam memilih proposal proyek infrastruktur** yang ada. Dalam melakukan perbandingan berpasangan, terdapat 3 parameter yang menjadi dasar penilaian, yaitu:

(1) Efektifitas Waktu
(2) Efektifitas Biaya
(3) Kompleksitas Proyek

Berikanlah penilaian yang sejujurnya sesuai pendapat Anda dengan memberi tanda silang (☒) pada skala yang tersedia.

Untuk membantu Anda memahami penjelasan dari masing-masing kriteria seleksi tersebut, silakan mengacu pada penjelasan berikut ini.

Kode	Kriteria	Deskripsi
C1	Kebutuhan Strategis (*strategic fit*)	Terkait kebutuhan strategis proyek, kesesuaian proyek dengan Rencana Pembangunan Nasional/ komitmen/peraturan, tingkat urgensitas proyek diperlukan, dan dukungan terhadap kebijakan pemerintah
C2	Kesiapan (*readiness criteria*)	Terkait kesiapan aspek teknis termasuk kesiapan desain, kesiapan akuisisi lahan, kesiapan operasional dan pemeliharaan, kesiapan dan transfer teknologi
C3	Perencanaan Inovatif (*innovative planning*)	Terkait dengan aspek integrasi perencanaan dengan program maupun rencana strategis lainnya, dan tingkat inovasi proyek yang memberikan nilai tambah
C4	Risiko & Politik (*risks & politics*)	Terkait dengan tingkat risiko dari proyek dan isu-isu politik serta dampak dari proyek
C5	Isu Kontrak & Tata Kelola (*contracts & governance issues*)	Terkait kondisi-kondisi kontrak yang dipersyaratkan, sistem pengadaan yang diadopsi, dan tingkat tata kelola yang akan diterapkan

C6	Pendanaan & Pembiayaan (*funding & financing*)	Terkait aspek pendanaan dan pembiayaan seperti sumber-sumber pendanaan, skema pembiayaan, alokasi biaya, dll.
C7	Koordinasi Tim & Pemangku Kepentingan (*team member & stakeholder coordination*)	Terkait tingkat aliansi/koordinasi di antara anggota tim proyek maupun para pemangku kepentingan lainnya yang terlibat
C8	Keterlibatan Sektor Swasta & Publik (*private sector & public involvement*)	Terkait tingkat keterlibatan sektor swasta dan komunitas/masyarakat umum, termasuk sikap publik terhadap proyek yang diajukan
C9	Isu Pemerintah Daerah (*local government issues*)	Terkait dengan isu-isu pemerintah daerah antara lain proyek yang diajukan dari pemerintah daerah, komitmen pemerintah daerah, kapabilitas pemerintah daerah, dll.
C10	Isu Lingkungan & Keberlanjutan (*sustainability & environmental issues*)	Terkait isu-isu lingkungan dan keberlanjutan dari proyek yang diajukan

Kode	Parameter Penilaian	Deskripsi
P1	Efektifitas Waktu (*time effectiveness*)	Waktu adalah hal penting dalam proyek konstruksi karena berkaitan langsung dengan biaya. Oleh karena itu, waktu harus menjadi salah satu pertimbangan dalam seleksi dan prioritisasi proyek infrastruktur
P2	Efektifitas Biaya (*cost effectiveness*)	Ini merujuk pada efektifitas keseluruhan biaya konstruksi untuk menyelesaikan sebuah proyek infrastruktur
P3	Kompleksitas Proyek (*project complexity*)	Ini merujuk pada aspek-aspek kompleks lain dari proyek selain efektifitas waktu dan biaya. Kompleksitas proyek infrastruktur dapat dilihat dari aspek teknologi, organisasi, tujuan, lingkungan, sosial-budaya, dan informasi yang tersedia

Contoh:
(A) Dilihat dari **efektifitas waktu**,

	Kurang Penting 25%	Sama Penting 37.5%	Lebih Penting 37.5%	
Kesiapan	○	○	○	Isu Lingkungan & Keberlanjutan
Isu Kontrak & Tata Kelola	○	○	○	Isu Pemerintah Daerah

Pernyataan di atas menunjukkan feedback dari Delphi Round 1 dimana dalam menyeleksi proposal proyek infrastruktur dilihat dari efektifitas waktunya:
- sebanyak **25%** responden menjawab kriteria kesiapan **kurang penting** dibandingkan isu lingkungan & keberlanjutan
- sebanyak **37.5%** responden menjawab kriteria kesiapan **sama penting** dengan isu lingkungan & keberlanjutan
- sebanyak **37.5%** responden menjawab kriteria kesiapan **lebih penting** dibandingkan isu lingkungan & keberlanjutan
- sebanyak **25%** responden menjawab isu kontrak & tata kelola **kurang penting** dibandingkan isu pemerintah daerah
- dan seterusnya

Silakan Anda memberikan penilaian baru terhadap 37 kriteria yang belum mencapai konsensus (belum terlihat jawaban dominan).

(A) Dilihat dari **efektifitas waktu**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 0%	Sama Penting 50%	Lebih Penting 50%	
Kesiapan	○	○	○	Koordinasi Tim & Pemangku Kepentingan

(A) Dilihat dari **efektifitas waktu**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 25%	Sama Penting 37.5%	Lebih Penting 37.5%	
Kesiapan	○	○	○	Isu Lingkungan & Keberlanjutan
Risiko & Politik	○	○	○	Keterlibatan Sektor Swasta & Publik
Isu Kontrak & Tata Kelola	○	○	○	Isu Pemerintah Daerah
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Pemerintah Daerah
Isu Pemerintah Daerah	○	○	○	Isu Lingkungan & Keberlanjutan

(A) Dilihat dari **efektifitas waktu**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 25%	Lebih Penting 37.5%	
Kebutuhan Strategis	○	○	○	Risiko & Politik
Risiko & Politik	○	○	○	Isu Pemerintah Daerah
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Pemerintah Daerah
Koordinasi Tim & Pemangku Kepentingan	○	○	○	Isu Lingkungan & Keberlanjutan
Kebutuhan Strategis	○	○	○	Isu Pemerintah Daerah

(A) Dilihat dari **efektifitas waktu**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 37.5%	Lebih Penting 25%	
Risiko & Politik	○	○	○	Isu Lingkungan & Keberlanjutan

(B) Dilihat dari **efektifitas biaya**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 0%	Sama Penting 50%	Lebih Penting 50%	
Kebutuhan Strategis	○	○	○	Koordinasi Tim & Pemangku Kepentingan
Risiko & Politik	○	○	○	Koordinasi Tim & Pemangku Kepentingan

(B) Dilihat dari **efektifitas biaya**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

Kurang Penting | Sama Penting | Lebih Penting

	25%	37.5%	37.5%	
Kebutuhan Strategis				Risiko & Politik
Kesiapan				Pendanaan & Pembiayaan
Risiko & Politik				Isu Lingkungan & Keberlanjutan
Kebutuhan Strategis				Keterlibatan Sektor Swasta & Publik
Kesiapan				Koordinasi Tim & Pemangku Kepentingan
Keterlibatan Sektor Swasta & Publik				Isu Lingkungan & Keberlanjutan

(B) Dilihat dari **efektifitas biaya**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 25%	Lebih Penting 37.5%	
Isu Kontrak & Tata Kelola				Isu Lingkungan & Keberlanjutan

(B) Dilihat dari **efektifitas biaya**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 37.5%	Lebih Penting 25%	
Kebutuhan Strategis				Perencanaan Inovatif
Koordinasi Tim & Pemangku Kepentingan				Keterlibatan Sektor Swasta & Publik
Isu Pemerintah Daerah				Isu Lingkungan & Keberlanjutan

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 0%	Sama Penting 50%	Lebih Penting 50%	
Pendanaan & Pembiayaan				Koordinasi Tim & Pemangku Kepentingan

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 25%	Sama Penting 37.5%	Lebih Penting 37.5%	
Kebutuhan Strategis				Koordinasi Tim & Pemangku Kepentingan
Perencanaan Inovatif				Isu Kontrak & Tata Kelola
Risiko & Politik				Isu Lingkungan & Keberlanjutan
Isu Kontrak & Tata Kelola				Keterlibatan Sektor Swasta & Publik

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 25%	Lebih Penting 37.5%	
Kebutuhan Strategis				Risiko & Politik
Risiko & Politik				Pendanaan & Pembiayaan

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

(C) Dilihat dari **kompleksitas proyek**, berikan pendapat Anda terhadap kriteria-kriteria berikut ini:

	Kurang Penting 37.5%	Sama Penting 37.5%	Lebih Penting 25%	
Kebutuhan Strategis	○	○	○	Kesiapan
Keterlibatan Sektor Swasta & Publik	○	○	○	Isu Lingkungan & Keberlanjutan
Kebutuhan Strategis	○	○	○	Isu Kontrak & Tata Kelola
Isu Pemerintah Daerah	○	○	○	Isu Lingkungan & Keberlanjutan
Kebutuhan Strategis	○	○	○	Pendanaan & Pembiayaan

(D) Berikan pendapat Anda terhadap **parameter penilaian** berikut ini:

	Kurang Penting 37.5%	Sama Penting 37.5%	Lebih Penting 25%	
Efektifitas Waktu	○	○	○	Efektifitas Biaya

Appendix 6: Case Study Protocol

Stages in Case Study Implementation of Decision-Making Framework for Infrastructure Project Selection and Prioritization

Stage	Activity	Description
1	Designing case study	Identify overall purpose and outcomes for the case study workshop
2	Preparing for presentation	Data, procedures and protocols for DMF implementation are being established, including: • Identify the expert respondents • Generate the questions • Develop the script • Select facilitators (if necessary) • Choose the time and locations
3	DMF implementation	Conduct the implementation, including: • Bring materials • Present the DMF and DMT • Present the problems (infrastructure project alternatives) • Simulate the DMF and DMT • Conclude the findings • Ask the evaluation questions
4	Analysing the data	Analyse and interpret the data obtained from the implementation
5	Reporting the results	Write the report

Appendix 7: PISCF Templates

RMIT UNIVERSITY

Participant Information Sheet/Consent Form

Expert Interview Group

Title	Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase
Chief Investigator/Senior Supervisor	Dr. Eric Too
Associate Investigator(s)/Associate Supervisor(s)	Dr. Tiendung Le
Principal Research Student(s)	Seng Hansen

What does my participation involve?

1 Introduction

You are invited to take part in this research project, which is called Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase. You have been invited because you have been identified as a senior manager/officer who has been involved in strategic decision-making of infrastructure projects in Indonesia. Your contact details were obtained from contacts known to the research team.

This Participant Information Sheet/Consent Form tells you about the research project. It explains the processes involved with taking part. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about. Before deciding whether or not to take part, you might want to talk about it with a relative or friend.

Participation in this research is voluntary. If you don't wish to take part, you don't have to.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:
• Understand what you have read
• Consent to take part in the research project

You will be given a copy of this Participant Information and Consent Form to keep.

2 What is the purpose of this research?

This research aims to develop a model of Decision-Making Framework for infrastructure project selection that integrates multiple decision parameters. It can serve as an innovation as oppose to the traditional infrastructure investment decision-making that has been applied in developing countries such as Indonesia. This research will employ a Multi-Criteria Decision-Making technique, i.e. Non-Structural Fuzzy Decision Support System II (NSFDSS-II) to develop the tool to be incorporated in the framework. The use of NSFDSS-II in infrastructure project selection problem has never been studied previously. The implementation of this framework is expected to improve the decision-making process quality for infrastructure project selection and investment. This research can also be used as a basis for further studies such as the development of a Decision Support System software. In practical side, this research proposes a Decision-Making Framework that can be used by the infrastructure management agencies of developing countries (e.g. Ministry of Public Works and Housing, infrastructure consultants, etc.).

The results of this research will be used by the researcher Seng Hansen to obtain a PhD (in Built Environment) degree.

3 What does participation in this research involve?

Participating in this study is completely voluntary. If you agree to participate, you have to sign Consent form prior to further involvement in the research. We will require 60-90 minutes of your time to conduct a face-to-face interview. We would ideally seek an understanding of infrastructure project selection and decision-making process that your organization may have done and that you have intimate knowledge about as a senior manager/officer. The interview will be done at the Ministry of Public Works & Housing Office or at the location you preferred. Please understand that while the information gathered will be stored in confidential, this interview will be audio recorded.

4 Other relevant information about the research project

For expert interview, a total of five participants will be taking part in this research. Since this research employs a mixed method approach, other techniques will also be conducted to gather data, i.e. questionnaire survey and focus groups. This research is mainly focus on the Indonesian Ministry of Public Works & Housing.

5 Do I have to take part in this research project?

Participation in any research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage.

If you do decide to take part, you will be given this Participant Information and Consent Form to sign and you will be given a copy to keep.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect your relationship with the researchers or with RMIT University.

You may stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview.

6 What are the possible benefits of taking part?

Your participation in this study is an opportunity to reflect on your experience on infrastructure evaluation and selection decision and contribute to the academic knowledge and the real-world industrial practises. The findings of this research provide an insight into the multiple decision parameters in infrastructure project selection in developing countries. Possible benefits may include the development of Decision-Making Framework and tool that can be used to improve the effectiveness of decision-making process for infrastructure project selection. The research outcomes will benefit the academic community, industry stakeholders, and the community in general.

You can request for digital copies of the publications resulting from this research, among them are academic journals, conference papers, and research reports. This project calls for voluntary participation and does not provide any remuneration

7 What are the risks and disadvantages of taking part?

This research does not seek any identifiable information from the participants. Any potential risk will be minimized by (1) removing all identifying information before publication (through encoding) and (2) provide participants the opportunity to review the transcriptions before publication.

8 What if I withdraw from this research project?

If you do consent to participate, you may withdraw at any time. If you decide to withdraw from the project, please notify a member of the research team.

You have the right to have any unprocessed data withdrawn and destroyed, providing it can be reliably identified.

9 What happens when the research project ends?

Upon request, individual participants have subsequent access to published reports stemming from the research through academic sources (journals, university repository, etc.). These may be available during the research duration period or after the research has been completed. Please contact the researcher Seng Hansen for further details.

How is the research project being conducted?

10 What will happen to information about me?

By signing the consent form you consent to the research team collecting and using information from you for the research project. Any information obtained in connection with this research project that can identify you will remain confidential. Only the research team members will have access to the information you provided. The identifiable information will be coded. The researcher will minimize identifiers than he needs in this study. All electronic information will be stored in a secure server and will only be accessible to the researchers involved in this study. The research data will be kept securely at RMIT University for 5 years after publication, before being destroyed.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, except with your express permission. The researchers will minimize the use of identifiable information in any publication.

In accordance with relevant Australian and/or Victorian privacy and other relevant laws, you have the right to request access to the information about you that is collected and stored by the research team. You also have the right to request that any information with which you disagree be corrected. Please inform the research team member named at the end of this document if you would like to access your information.

Any information that you provide can be disclosed only if (1) it is protect you or others from harm, (2) if specifically allowed by law, (3) you provide the researchers with written permission. Any information obtained for the purpose of this research project that can identify you will be treated as confidential and securely stored.

11 Who is organising and funding the research?

This research project is being conducted by Seng Hansen for his PhD study with the sponsor of The Indonesian Endowment Fund for Education (Lembaga Pengelola Dana Pendidikan/LPDP).

12 Who has reviewed the research project?

All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). This research project has been approved by the RMIT University HREC.

This project will be carried out according to the *National Statement on Ethical Conduct in Human Research* (2007). This statement has been developed to protect the interests of people who agree to participate in human research studies.

13 Further information and who to contact

If you want any further information concerning this project, you can contact the researcher on [redacted] or any of the following people:

Research contact person

Name	Dr Eric Too
Position	Chief investigator / Senior supervisor
Telephone	[redacted]
Email	eric.too@rmit.edu.au

14 Complaints

Should you have any concerns or questions about this research project, which you do not wish to discuss with the researchers listed in this document, then you may contact:

Reviewing HREC name	RMIT University
HREC Secretary	Peter Burke
Telephone	[redacted]
Email	human.ethics@rmit.edu.au
Mailing address	Research Ethics Co-ordinator Research Integrity Governance and Systems RMIT University GPO Box 2476 MELBOURNE VIC 3001

Consent Form

Title	Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase
Chief Investigator/Senior Supervisor	Dr. Eric Too
Associate Investigator(s)/Associate Supervisors	Dr. Tiendung Le
Research Student(s)	Seng Hansen

Acknowledgement by Participant

I have read and understood the Participant Information Sheet.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my relationship with RMIT.

I understand that I will be given a signed copy of this document to keep.

Name of Participant (please print) ______________________________

Signature ______________________ Date ______________________

Declaration by Researcher†

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher† (please print) ______________________________

Signature ______________________ Date ______________________

† An appropriately qualified member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature.

RMIT UNIVERSITY

Participant Information Sheet/Consent Form

Expert Interview (Project Selection Simulation/Validation)

Title	Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase
Chief Investigator/Senior Supervisor	Dr. Eric Too
Associate Investigator(s)/Associate Supervisor(s)	Dr. Tiendung Le
Principal Research Student(s)	Seng Hansen

What does my participation involve?

1 Introduction

You are invited to take part in this research project, which is called Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase. You have been invited because you have been identified as an expert who has been involved in strategic decision-making of infrastructure projects in Indonesia/has perceived knowledge on the subject matter. Your contact details were obtained from contacts known to the research team.

This Participant Information Sheet/Consent Form tells you about the research project. It explains the processes involved with taking part. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about. Before deciding whether or not to take part, you might want to talk about it with a relative or friend.

Participation in this research is voluntary. If you don't wish to take part, you don't have to.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:
• Understand what you have read
• Consent to take part in the research project

You will be given a copy of this Participant Information and Consent Form to keep.

2 What is the purpose of this research?

This research aims to develop a model of Decision-Making Framework for infrastructure project selection that integrates multiple decision parameters. It can serve as an innovation as oppose to the traditional infrastructure investment decision-making that has been applied in developing countries such as Indonesia. This research will employ a Multi-Criteria Decision-Making technique, i.e. Non-Structural Fuzzy Decision Support System II (NSFDSS-II) to develop the tool to be incorporated in the framework. The use of NSFDSS-II in infrastructure project selection problem has never been studied previously. The implementation of this framework is expected to improve the decision-making process quality for infrastructure project selection and investment. This research can also be used as a basis for further studies such as the development of a Decision Support System software. In practical side, this research proposes a Decision-Making Framework that can be used by the infrastructure management agencies of developing countries (e.g. Ministry of Public Works and Housing, infrastructure consultants, etc.).

The results of this research will be used by the researcher Seng Hansen to obtain a PhD (in Built Environment) degree.

3 What does participation in this research involve?

Participating in this study is completely voluntary. If you agree to participate, you have to sign Consent form prior to further involvement in the research. We will require 60-90 minutes of your time to conduct a face-to-face interview. We would ideally seek an understanding of infrastructure project selection and decision-making process as you will be asked to run the DMF and DMTool simulation. Thus, it serves as a validation or verification of this DMF/DMT. The interview will be done at the location you preferred. Please understand that while the information gathered will be stored in confidential, this interview will be audio recorded.

4 Other relevant information about the research project

For expert interview (4th data collection), only one expert participant will be taking part in this final data collection process. Since this research employs a mixed method approach, other techniques have been conducted to gather data, i.e. interviews, questionnaire survey and delphi technique.

5 Do I have to take part in this research project?

Participation in any research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage.

If you do decide to take part, you will be given this Participant Information and Consent Form to sign and you will be given a copy to keep.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect your relationship with the researchers or with RMIT University.

You may stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview.

6 What are the possible benefits of taking part?

Your participation in this study is an opportunity to reflect on your experience on infrastructure evaluation and selection decision and contribute to the academic knowledge and the real-world industrial practises. The findings of this research provide an insight into the multiple decision parameters in infrastructure project selection in developing countries. Possible benefits may include the development of Decision-Making Framework and tool that can be used to improve the effectiveness of decision-making process for infrastructure project selection. The research outcomes will benefit the academic community, industry stakeholders, and the community in general.

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7 What are the risks and disadvantages of taking part?

This research does not seek any identifiable information from the participants. Any potential risk will be minimized by (1) removing all identifying information before publication (through encoding) and (2) provide participants the opportunity to review the transcriptions before publication (if needed).

8 What if I withdraw from this research project?

If you do consent to participate, you may withdraw at any time. If you decide to withdraw from the project, please notify a member of the research team.

You have the right to have any unprocessed data withdrawn and destroyed, providing it can be reliably identified.

9 What happens when the research project ends?

Upon request, individual participants have subsequent access to published reports stemming from the research through academic sources (journals, university repository, etc.). These may be available during the research duration period or after the research has been completed. Please contact the researcher Seng Hansen for further details.

How is the research project being conducted?

10 What will happen to information about me?

By signing the consent form you consent to the research team collecting and using information from you for the research project. Any information obtained in connection with this research project that can identify you will remain confidential. Only the research team members will have access to the information you provided. The identifiable information will be coded. The researcher will minimize identifiers than he needs in this study. All electronic information will be stored in a secure server and will only be accessible to the researchers involved in this study. The research data will be kept securely at RMIT University for 5 years after publication, before being destroyed.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, except with your express permission. The researchers will minimize the use of identifiable information in any publication.

In accordance with relevant Australian and/or Victorian privacy and other relevant laws, you have the right to request access to the information about you that is collected and stored by the research team. You also have the right to request that any information with which you disagree be corrected. Please inform the research team member named at the end of this document if you would like to access your information.

Any information that you provide can be disclosed only if (1) it is protect you or others from harm, (2) if specifically allowed by law, (3) you provide the researchers with written permission.

Any information obtained for the purpose of this research project that can identify you will be treated as confidential and securely stored.

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This research project is being conducted by Seng Hansen for his PhD study with the sponsor of The Indonesian Endowment Fund for Education (Lembaga Pengelola Dana Pendidikan/LPDP).

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This project will be carried out according to the *National Statement on Ethical Conduct in Human Research* (2007). This statement has been developed to protect the interests of people who agree to participate in human research studies.

13 Further information and who to contact

If you want any further information concerning this project, you can contact the researcher on [redacted] or any of the following people:

Research contact person

Name	Dr Eric Too
Position	Chief investigator / Senior supervisor
Telephone	[redacted]
Email	eric.too@rmit.edu.au

14 Complaints

Should you have any concerns or questions about this research project, which you do not wish to discuss with the researchers listed in this document, then you may contact:

Reviewing HREC name	RMIT University
HREC Secretary	Peter Burke
Telephone	[redacted]
Email	human.ethics@rmit.edu.au
Mailing address	Research Ethics Co-ordinator Research Integrity Governance and Systems RMIT University GPO Box 2476 MELBOURNE VIC 3001

Consent Form

Title	Design, Development and Implementation of Decision-Making Framework (DMF) for Infrastructure Project Selection during Front-End Planning (FEP) Phase
Chief Investigator/Senior Supervisor	Dr. Eric Too
Associate Investigator(s)/Associate Supervisors	Dr. Tiendung Le
Research Student(s)	Seng Hansen

Acknowledgement by Participant

I have read and understood the Participant Information Sheet.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my relationship with RMIT.

I understand that I will be given a signed copy of this document to keep.

Name of Participant (please print) ______________________________

Signature ______________________ Date ______________________

Declaration by Researcher†

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher† (please print) ______________________________

Signature ______________________ Date ______________________

† An appropriately qualified member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature.

Appendix 8: EFA SPSS Output

```
GET DATA
  /TYPE=XLSX
  /FILE='\\rmit.internal\USRHome\el3\e36143\RECAP FOR SPSS 2.xlsx'
  /SHEET=name 'Sheet1 (3)'
  /CELLRANGE=FULL
  /READNAMES=ON
  /DATATYPEMIN PERCENTAGE=95.0
  /HIDDEN IGNORE=YES.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
RECODE F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16 F17 F18 F19 F
20 F21 F22 F23
    (MISSING=-1).
EXECUTE.
FREQUENCIES VARIABLES=F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F1
6 F17 F18 F19 F20 F21
    F22 F23
  /ORDER=ANALYSIS.
```

Frequencies

[DataSet1]

Statistics

		F1	F2	F3	F4	F5	F6	F7
N	Valid	104	104	104	103	104	104	104
	Missing	0	0	0	1	0	0	0

Statistics

		F8	F9	F10	F11	F12	F13	F14
N	Valid	104	104	104	104	104	104	103
	Missing	0	0	0	0	0	0	1

Statistics

		F15	F16	F17	F18	F19	F20	F21
N	Valid	103	103	103	103	103	103	102
	Missing	1	1	1	1	1	1	2

Statistics

		F22	F23
N	Valid	103	103
	Missing	1	1

Frequency Table

F1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	1	1.0	1.0	1.0
	5	3	2.9	2.9	3.8
	6	4	3.8	3.8	7.7
	7	12	11.5	11.5	19.2
	8	30	28.8	28.8	48.1
	9	18	17.3	17.3	65.4
	10	36	34.6	34.6	100.0
	Total	104	100.0	100.0	

F2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5	3	2.9	2.9	2.9
	6	5	4.8	4.8	7.7
	7	12	11.5	11.5	19.2
	8	25	24.0	24.0	43.3
	9	22	21.2	21.2	64.4
	10	37	35.6	35.6	100.0
	Total	104	100.0	100.0	

F3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.0	1.0	1.0
	2	1	1.0	1.0	1.9
	5	6	5.8	5.8	7.7
	6	7	6.7	6.7	14.4
	7	14	13.5	13.5	27.9
	8	30	28.8	28.8	56.7
	9	26	25.0	25.0	81.7
	10	19	18.3	18.3	100.0
	Total	104	100.0	100.0	

F4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	3	2.9	2.9	2.9
	5	5	4.8	4.9	7.8
	6	7	6.7	6.8	14.6
	7	19	18.3	18.4	33.0
	8	18	17.3	17.5	50.5
	9	20	19.2	19.4	69.9
	10	31	29.8	30.1	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	1.9	1.9	1.9
	3	1	1.0	1.0	2.9
	4	2	1.9	1.9	4.8
	5	6	5.8	5.8	10.6
	6	7	6.7	6.7	17.3
	7	19	18.3	18.3	35.6
	8	29	27.9	27.9	63.5
	9	19	18.3	18.3	81.7
	10	19	18.3	18.3	100.0
	Total	104	100.0	100.0	

F6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.0	1.0	1.0
	3	1	1.0	1.0	1.9
	4	1	1.0	1.0	2.9
	5	5	4.8	4.8	7.7
	6	5	4.8	4.8	12.5
	7	12	11.5	11.5	24.0
	8	38	36.5	36.5	60.6
	9	23	22.1	22.1	82.7
	10	18	17.3	17.3	100.0
	Total	104	100.0	100.0	

F7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.0	1.0	1.0
	2	2	1.9	1.9	2.9
	4	2	1.9	1.9	4.8
	5	4	3.8	3.8	8.7
	6	6	5.8	5.8	14.4
	7	21	20.2	20.2	34.6
	8	26	25.0	25.0	59.6
	9	24	23.1	23.1	82.7
	10	18	17.3	17.3	100.0
	Total	104	100.0	100.0	

F8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.0	1.0	1.0
	3	1	1.0	1.0	1.9
	4	1	1.0	1.0	2.9
	5	2	1.9	1.9	4.8
	6	6	5.8	5.8	10.6
	7	17	16.3	16.3	26.9
	8	34	32.7	32.7	59.6
	9	28	26.9	26.9	86.5
	10	14	13.5	13.5	100.0
	Total	104	100.0	100.0	

F9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	4.8	4.8	4.8
	3	4	3.8	3.8	8.7
	4	6	5.8	5.8	14.4
	5	11	10.6	10.6	25.0
	6	15	14.4	14.4	39.4
	7	10	9.6	9.6	49.0
	8	25	24.0	24.0	73.1
	9	14	13.5	13.5	86.5
	10	14	13.5	13.5	100.0
	Total	104	100.0	100.0	

F10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	1.0	1.0	1.0
	4	2	1.9	1.9	2.9
	5	6	5.8	5.8	8.7
	6	9	8.7	8.7	17.3
	7	18	17.3	17.3	34.6
	8	31	29.8	29.8	64.4
	9	19	18.3	18.3	82.7
	10	18	17.3	17.3	100.0
	Total	104	100.0	100.0	

F11

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	1.9	1.9	1.9
	4	2	1.9	1.9	3.8
	5	3	2.9	2.9	6.7
	6	1	1.0	1.0	7.7
	7	5	4.8	4.8	12.5
	8	22	21.2	21.2	33.7
	9	30	28.8	28.8	62.5
	10	39	37.5	37.5	100.0
	Total	104	100.0	100.0	

F12

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	3	2.9	2.9	2.9
	4	1	1.0	1.0	3.8
	5	2	1.9	1.9	5.8
	6	5	4.8	4.8	10.6
	7	8	7.7	7.7	18.3
	8	17	16.3	16.3	34.6
	9	22	21.2	21.2	55.8
	10	46	44.2	44.2	100.0
	Total	104	100.0	100.0	

F13

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	1.9	1.9	1.9
	4	1	1.0	1.0	2.9
	5	3	2.9	2.9	5.8
	6	2	1.9	1.9	7.7
	7	11	10.6	10.6	18.3
	8	17	16.3	16.3	34.6
	9	34	32.7	32.7	67.3
	10	34	32.7	32.7	100.0
	Total	104	100.0	100.0	

F14

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	1.9	1.9	1.9
	4	1	1.0	1.0	2.9
	5	5	4.8	4.9	7.8
	6	10	9.6	9.7	17.5
	7	20	19.2	19.4	36.9
	8	27	26.0	26.2	63.1
	9	22	21.2	21.4	84.5
	10	16	15.4	15.5	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F15

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	1.9	1.9	1.9
	2	2	1.9	1.9	3.9
	3	4	3.8	3.9	7.8
	5	1	1.0	1.0	8.7
	6	3	2.9	2.9	11.7
	7	5	4.8	4.9	16.5
	8	15	14.4	14.6	31.1
	9	21	20.2	20.4	51.5
	10	50	48.1	48.5	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F16

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	1.9	1.9	1.9
	3	1	1.0	1.0	2.9
	4	1	1.0	1.0	3.9
	5	2	1.9	1.9	5.8
	6	6	5.8	5.8	11.7
	7	6	5.8	5.8	17.5
	8	19	18.3	18.4	35.9
	9	31	29.8	30.1	66.0
	10	35	33.7	34.0	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F17

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	1.9	1.9	1.9
	5	4	3.8	3.9	5.8
	6	5	4.8	4.9	10.7
	7	9	8.7	8.7	19.4
	8	30	28.8	29.1	48.5
	9	26	25.0	25.2	73.8
	10	27	26.0	26.2	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F18

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.0	1.0	1.0
	3	1	1.0	1.0	1.9
	4	1	1.0	1.0	2.9
	5	2	1.9	1.9	4.9
	6	3	2.9	2.9	7.8
	7	9	8.7	8.7	16.5
	8	22	21.2	21.4	37.9
	9	29	27.9	28.2	66.0
	10	35	33.7	34.0	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F19

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	1.9	1.9	1.9
	5	4	3.8	3.9	5.8
	6	3	2.9	2.9	8.7
	7	11	10.6	10.7	19.4
	8	19	18.3	18.4	37.9
	9	32	30.8	31.1	68.9
	10	32	30.8	31.1	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F20

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	1.9	1.9	1.9
	6	3	2.9	2.9	4.9
	7	9	8.7	8.7	13.6
	8	30	28.8	29.1	42.7
	9	34	32.7	33.0	75.7
	10	25	24.0	24.3	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F21

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	1.9	2.0	2.0
	4	1	1.0	1.0	2.9
	5	1	1.0	1.0	3.9
	6	3	2.9	2.9	6.9
	7	11	10.6	10.8	17.6
	8	25	24.0	24.5	42.2
	9	28	26.9	27.5	69.6
	10	31	29.8	30.4	100.0
	Total	102	98.1	100.0	
Missing	-1	2	1.9		
Total		104	100.0		

F22

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.0	1.0	1.0
	3	2	1.9	1.9	2.9
	4	3	2.9	2.9	5.8
	6	9	8.7	8.7	14.6
	7	11	10.6	10.7	25.2
	8	30	28.8	29.1	54.4
	9	23	22.1	22.3	76.7
	10	24	23.1	23.3	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

F23

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	1.0	1.0	1.0
	4	1	1.0	1.0	1.9
	5	3	2.9	2.9	4.9
	6	4	3.8	3.9	8.7
	7	15	14.4	14.6	23.3
	8	26	25.0	25.2	48.5
	9	22	21.2	21.4	69.9
	10	31	29.8	30.1	100.0
	Total	103	99.0	100.0	
Missing	-1	1	1.0		
Total		104	100.0		

```
RMV /F1_1=SMEAN(F1) /F2_1=SMEAN(F2) /F3_1=SMEAN(F3) /F4_1=SMEAN(F4) /F5_1=S
MEAN(F5) /F6_1=SMEAN(F6)
    /F7_1=SMEAN(F7) /F8_1=SMEAN(F8) /F9_1=SMEAN(F9) /F10_1=SMEAN(F10) /F11_
1=SMEAN(F11)
    /F12_1=SMEAN(F12) /F13_1=SMEAN(F13) /F14_1=SMEAN(F14) /F15_1=SMEAN(F15)
 /F16_1=SMEAN(F16)
    /F17_1=SMEAN(F17) /F18_1=SMEAN(F18) /F19_1=SMEAN(F19) /F20_1=SMEAN(F20)
 /F21_1=SMEAN(F21)
    /F22_1=SMEAN(F22) /F23_1=SMEAN(F23).
```

Replace Missing Values

Result Variables

	Result Variable	N of Replaced Missing Values	Case Number of Non-Missing Values		N of Valid Cases
			First	Last	
1	F1_1	0	1	104	104
2	F2_1	0	1	104	104
3	F3_1	0	1	104	104
4	F4_1	1	1	104	104
5	F5_1	0	1	104	104
6	F6_1	0	1	104	104
7	F7_1	0	1	104	104
8	F8_1	0	1	104	104
9	F9_1	0	1	104	104
10	F10_1	0	1	104	104
11	F11_1	0	1	104	104
12	F12_1	0	1	104	104
13	F13_1	0	1	104	104
14	F14_1	1	1	104	104
15	F15_1	1	1	104	104
16	F16_1	1	1	104	104
17	F17_1	1	1	104	104
18	F18_1	1	1	104	104
19	F19_1	1	1	104	104
20	F20_1	1	1	104	104
21	F21_1	2	1	104	104
22	F22_1	1	1	104	104
23	F23_1	1	1	104	104

Result Variables

	Creating Function
1	SMEAN(F1)
2	SMEAN(F2)
3	SMEAN(F3)
4	SMEAN(F4)
5	SMEAN(F5)
6	SMEAN(F6)
7	SMEAN(F7)
8	SMEAN(F8)
9	SMEAN(F9)
10	SMEAN(F10)
11	SMEAN(F11)
12	SMEAN(F12)
13	SMEAN(F13)
14	SMEAN(F14)
15	SMEAN(F15)
16	SMEAN(F16)
17	SMEAN(F17)
18	SMEAN(F18)
19	SMEAN(F19)
20	SMEAN(F20)
21	SMEAN(F21)
22	SMEAN(F22)
23	SMEAN(F23)

```
FACTOR
  /VARIABLES F1_1 F2_1 F3_1 F4_1 F5_1 F6_1 F7_1 F8_1 F9_1 F10_1 F11_1 F12_1
 F13_1 F14_1 F15_1 F16_1
    F17_1 F18_1 F19_1 F20_1 F21_1 F22_1 F23_1
  /MISSING LISTWISE
  /ANALYSIS F1_1 F2_1 F3_1 F4_1 F5_1 F6_1 F7_1 F8_1 F9_1 F10_1 F11_1 F12_1
F13_1 F14_1 F15_1 F16_1
    F17_1 F18_1 F19_1 F20_1 F21_1 F22_1 F23_1
  /PRINT INITIAL CORRELATION SIG KMO EXTRACTION ROTATION
  /FORMAT SORT BLANK(.512)
  /PLOT EIGEN
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
```

```
/ROTATION PROMAX(4)
/SAVE REG(ALL)
/METHOD=CORRELATION.
```

- F A C T O R A N A L Y
S I S -

Factor Analysis

Correlation Matrix

		SMEAN(F1)	SMEAN(F2)	SMEAN(F3)	SMEAN(F4)	SMEAN(F5)
Correlation	SMEAN(F1)	1.000	.689	.139	.531	.363
	SMEAN(F2)	.689	1.000	.125	.455	.390
	SMEAN(F3)	.139	.125	1.000	.234	.076
	SMEAN(F4)	.531	.455	.234	1.000	.378
	SMEAN(F5)	.363	.390	.076	.378	1.000
	SMEAN(F6)	.309	.289	.191	.264	.503
	SMEAN(F7)	.251	.299	.340	.331	.415
	SMEAN(F8)	.317	.395	.232	.305	.354
	SMEAN(F9)	.039	-.062	.304	-.042	.087
	SMEAN(F10)	.316	.299	.047	.244	.419
	SMEAN(F11)	.286	.321	.155	.285	.255
	SMEAN(F12)	.226	.270	.168	.202	.273
	SMEAN(F13)	.411	.463	.172	.259	.325
	SMEAN(F14)	.432	.407	.198	.325	.499
	SMEAN(F15)	.242	.311	.185	.152	.222
	SMEAN(F16)	.264	.237	.127	.318	.326
	SMEAN(F17)	.286	.306	.334	.364	.356
	SMEAN(F18)	.383	.397	.285	.288	.248
	SMEAN(F19)	.280	.281	.433	.403	.248
	SMEAN(F20)	.436	.496	.177	.470	.405
	SMEAN(F21)	.562	.514	.137	.295	.407
	SMEAN(F22)	.395	.355	.040	.307	.394
	SMEAN(F23)	.533	.521	.129	.490	.491
Sig. (1-tailed)	SMEAN(F1)		.000	.079	.000	.000
	SMEAN(F2)	.000		.103	.000	.000
	SMEAN(F3)	.079	.103		.008	.222
	SMEAN(F4)	.000	.000	.008		.000
	SMEAN(F5)	.000	.000	.222	.000	
	SMEAN(F6)	.001	.001	.026	.003	.000
	SMEAN(F7)	.005	.001	.000	.000	.000
	SMEAN(F8)	.001	.000	.009	.001	.000

Correlation Matrix

		SMEAN(F6)	SMEAN(F7)	SMEAN(F8)	SMEAN(F9)	SMEAN(F10)
Correlation	SMEAN(F1)	.309	.251	.317	.039	.316
	SMEAN(F2)	.289	.299	.395	-.062	.299
	SMEAN(F3)	.191	.340	.232	.304	.047
	SMEAN(F4)	.264	.331	.305	-.042	.244
	SMEAN(F5)	.503	.415	.354	.087	.419
	SMEAN(F6)	1.000	.500	.508	.079	.234
	SMEAN(F7)	.500	1.000	.646	.263	.299
	SMEAN(F8)	.508	.646	1.000	.109	.147
	SMEAN(F9)	.079	.263	.109	1.000	.199
	SMEAN(F10)	.234	.299	.147	.199	1.000
	SMEAN(F11)	.528	.430	.505	-.034	.322
	SMEAN(F12)	.430	.396	.511	.044	.256
	SMEAN(F13)	.540	.402	.595	-.006	.231
	SMEAN(F14)	.489	.487	.467	.058	.411
	SMEAN(F15)	.445	.335	.445	.069	.284
	SMEAN(F16)	.445	.305	.438	.014	.386
	SMEAN(F17)	.492	.553	.561	.199	.302
	SMEAN(F18)	.524	.385	.471	-.038	.174
	SMEAN(F19)	.553	.623	.614	.136	.083
	SMEAN(F20)	.513	.544	.515	.102	.480
	SMEAN(F21)	.572	.503	.614	.012	.359
	SMEAN(F22)	.468	.390	.549	-.026	.278
	SMEAN(F23)	.337	.362	.342	-.039	.407
Sig. (1-tailed)	SMEAN(F1)	.001	.005	.001	.346	.001
	SMEAN(F2)	.001	.001	.000	.265	.001
	SMEAN(F3)	.026	.000	.009	.001	.318
	SMEAN(F4)	.003	.000	.001	.337	.006
	SMEAN(F5)	.000	.000	.000	.191	.000
	SMEAN(F6)		.000	.000	.214	.008
	SMEAN(F7)	.000		.000	.003	.001
	SMEAN(F8)	.000	.000		.135	.069

Correlation Matrix

		SMEAN(F11)	SMEAN(F12)	SMEAN(F13)	SMEAN(F14)
Correlation	SMEAN(F1)	.286	.226	.411	.432
	SMEAN(F2)	.321	.270	.463	.407
	SMEAN(F3)	.155	.168	.172	.198
	SMEAN(F4)	.285	.202	.259	.325
	SMEAN(F5)	.255	.273	.325	.499
	SMEAN(F6)	.528	.430	.540	.489
	SMEAN(F7)	.430	.396	.402	.487
	SMEAN(F8)	.505	.511	.595	.467
	SMEAN(F9)	-.034	.044	-.006	.058
	SMEAN(F10)	.322	.256	.231	.411
	SMEAN(F11)	1.000	.796	.625	.409
	SMEAN(F12)	.796	1.000	.626	.420
	SMEAN(F13)	.625	.626	1.000	.475
	SMEAN(F14)	.409	.420	.475	1.000
	SMEAN(F15)	.769	.795	.616	.374
	SMEAN(F16)	.654	.622	.419	.465
	SMEAN(F17)	.641	.640	.555	.513
	SMEAN(F18)	.755	.660	.618	.388
	SMEAN(F19)	.582	.573	.510	.544
	SMEAN(F20)	.542	.520	.591	.548
	SMEAN(F21)	.609	.520	.689	.595
	SMEAN(F22)	.564	.569	.626	.507
	SMEAN(F23)	.402	.372	.452	.350
Sig. (1-tailed)	SMEAN(F1)	.002	.011	.000	.000
	SMEAN(F2)	.000	.003	.000	.000
	SMEAN(F3)	.058	.044	.041	.022
	SMEAN(F4)	.002	.020	.004	.000
	SMEAN(F5)	.004	.003	.000	.000
	SMEAN(F6)	.000	.000	.000	.000
	SMEAN(F7)	.000	.000	.000	.000
	SMEAN(F8)	.000	.000	.000	.000

Correlation Matrix

		SMEAN(F15)	SMEAN(F16)	SMEAN(F17)	SMEAN(F18)
Correlation	SMEAN(F1)	.242	.264	.286	.383
	SMEAN(F2)	.311	.237	.306	.397
	SMEAN(F3)	.185	.127	.334	.285
	SMEAN(F4)	.152	.318	.364	.288
	SMEAN(F5)	.222	.326	.356	.248
	SMEAN(F6)	.445	.445	.492	.524
	SMEAN(F7)	.335	.305	.553	.385
	SMEAN(F8)	.445	.438	.561	.471
	SMEAN(F9)	.069	.014	.199	-.038
	SMEAN(F10)	.284	.386	.302	.174
	SMEAN(F11)	.769	.654	.641	.755
	SMEAN(F12)	.795	.622	.640	.660
	SMEAN(F13)	.616	.419	.555	.618
	SMEAN(F14)	.374	.465	.513	.388
	SMEAN(F15)	1.000	.623	.546	.638
	SMEAN(F16)	.623	1.000	.589	.547
	SMEAN(F17)	.546	.589	1.000	.597
	SMEAN(F18)	.638	.547	.597	1.000
	SMEAN(F19)	.505	.512	.644	.683
	SMEAN(F20)	.448	.572	.666	.602
	SMEAN(F21)	.584	.505	.598	.581
	SMEAN(F22)	.538	.534	.520	.621
	SMEAN(F23)	.350	.448	.449	.476
Sig. (1-tailed)	SMEAN(F1)	.007	.003	.002	.000
	SMEAN(F2)	.001	.008	.001	.000
	SMEAN(F3)	.030	.099	.000	.002
	SMEAN(F4)	.061	.000	.000	.002
	SMEAN(F5)	.012	.000	.000	.006
	SMEAN(F6)	.000	.000	.000	.000
	SMEAN(F7)	.000	.001	.000	.000
	SMEAN(F8)	.000	.000	.000	.000

Correlation Matrix

		SMEAN(F19)	SMEAN(F20)	SMEAN(F21)	SMEAN(F22)
Correlation	SMEAN(F1)	.280	.436	.562	.395
	SMEAN(F2)	.281	.496	.514	.355
	SMEAN(F3)	.433	.177	.137	.040
	SMEAN(F4)	.403	.470	.295	.307
	SMEAN(F5)	.248	.405	.407	.394
	SMEAN(F6)	.553	.513	.572	.468
	SMEAN(F7)	.623	.544	.503	.390
	SMEAN(F8)	.614	.515	.614	.549
	SMEAN(F9)	.136	.102	.012	-.026
	SMEAN(F10)	.083	.480	.359	.278
	SMEAN(F11)	.582	.542	.609	.564
	SMEAN(F12)	.573	.520	.520	.569
	SMEAN(F13)	.510	.591	.689	.626
	SMEAN(F14)	.544	.548	.595	.507
	SMEAN(F15)	.505	.448	.584	.538
	SMEAN(F16)	.512	.572	.505	.534
	SMEAN(F17)	.644	.666	.598	.520
	SMEAN(F18)	.683	.602	.581	.621
	SMEAN(F19)	1.000	.583	.573	.580
	SMEAN(F20)	.583	1.000	.573	.575
	SMEAN(F21)	.573	.573	1.000	.646
	SMEAN(F22)	.580	.575	.646	1.000
	SMEAN(F23)	.397	.647	.517	.521
Sig. (1-tailed)	SMEAN(F1)	.002	.000	.000	.000
	SMEAN(F2)	.002	.000	.000	.000
	SMEAN(F3)	.000	.036	.082	.342
	SMEAN(F4)	.000	.000	.001	.001
	SMEAN(F5)	.006	.000	.000	.000
	SMEAN(F6)	.000	.000	.000	.000
	SMEAN(F7)	.000	.000	.000	.000
	SMEAN(F8)	.000	.000	.000	.000

Correlation Matrix

		SMEAN(F23)
Correlation	SMEAN(F1)	.533
	SMEAN(F2)	.521
	SMEAN(F3)	.129
	SMEAN(F4)	.490
	SMEAN(F5)	.491
	SMEAN(F6)	.337
	SMEAN(F7)	.362
	SMEAN(F8)	.342
	SMEAN(F9)	-.039
	SMEAN(F10)	.407
	SMEAN(F11)	.402
	SMEAN(F12)	.372
	SMEAN(F13)	.452
	SMEAN(F14)	.350
	SMEAN(F15)	.350
	SMEAN(F16)	.448
	SMEAN(F17)	.449
	SMEAN(F18)	.476
	SMEAN(F19)	.397
	SMEAN(F20)	.647
	SMEAN(F21)	.517
	SMEAN(F22)	.521
	SMEAN(F23)	1.000
Sig. (1-tailed)	SMEAN(F1)	.000
	SMEAN(F2)	.000
	SMEAN(F3)	.096
	SMEAN(F4)	.000
	SMEAN(F5)	.000
	SMEAN(F6)	.000
	SMEAN(F7)	.000
	SMEAN(F8)	.000

Correlation Matrix

	SMEAN(F1)	SMEAN(F2)	SMEAN(F3)	SMEAN(F4)	SMEAN(F5)
SMEAN(F9)	.346	.265	.001	.337	.191
SMEAN(F10)	.001	.001	.318	.006	.000
SMEAN(F11)	.002	.000	.058	.002	.004
SMEAN(F12)	.011	.003	.044	.020	.003
SMEAN(F13)	.000	.000	.041	.004	.000
SMEAN(F14)	.000	.000	.022	.000	.000
SMEAN(F15)	.007	.001	.030	.061	.012
SMEAN(F16)	.003	.008	.099	.000	.000
SMEAN(F17)	.002	.001	.000	.000	.000
SMEAN(F18)	.000	.000	.002	.002	.006
SMEAN(F19)	.002	.002	.000	.000	.006
SMEAN(F20)	.000	.000	.036	.000	.000
SMEAN(F21)	.000	.000	.082	.001	.000
SMEAN(F22)	.000	.000	.342	.001	.000
SMEAN(F23)	.000	.000	.096	.000	.000

Correlation Matrix

	SMEAN(F6)	SMEAN(F7)	SMEAN(F8)	SMEAN(F9)	SMEAN(F10)
SMEAN(F9)	.214	.003	.135		.022
SMEAN(F10)	.008	.001	.069	.022	
SMEAN(F11)	.000	.000	.000	.367	.000
SMEAN(F12)	.000	.000	.000	.327	.004
SMEAN(F13)	.000	.000	.000	.475	.009
SMEAN(F14)	.000	.000	.000	.279	.000
SMEAN(F15)	.000	.000	.000	.243	.002
SMEAN(F16)	.000	.001	.000	.444	.000
SMEAN(F17)	.000	.000	.000	.021	.001
SMEAN(F18)	.000	.000	.000	.353	.039
SMEAN(F19)	.000	.000	.000	.084	.200
SMEAN(F20)	.000	.000	.000	.150	.000
SMEAN(F21)	.000	.000	.000	.450	.000
SMEAN(F22)	.000	.000	.000	.396	.002
SMEAN(F23)	.000	.000	.000	.347	.000

Correlation Matrix

	SMEAN(F11)	SMEAN(F12)	SMEAN(F13)	SMEAN(F14)
SMEAN(F9)	.367	.327	.475	.279
SMEAN(F10)	.000	.004	.009	.000
SMEAN(F11)		.000	.000	.000
SMEAN(F12)	.000		.000	.000
SMEAN(F13)	.000	.000		.000
SMEAN(F14)	.000	.000	.000	
SMEAN(F15)	.000	.000	.000	.000
SMEAN(F16)	.000	.000	.000	.000
SMEAN(F17)	.000	.000	.000	.000
SMEAN(F18)	.000	.000	.000	.000
SMEAN(F19)	.000	.000	.000	.000
SMEAN(F20)	.000	.000	.000	.000
SMEAN(F21)	.000	.000	.000	.000
SMEAN(F22)	.000	.000	.000	.000
SMEAN(F23)	.000	.000	.000	.000

Correlation Matrix

	SMEAN(F15)	SMEAN(F16)	SMEAN(F17)	SMEAN(F18)
SMEAN(F9)	.243	.444	.021	.353
SMEAN(F10)	.002	.000	.001	.039
SMEAN(F11)	.000	.000	.000	.000
SMEAN(F12)	.000	.000	.000	.000
SMEAN(F13)	.000	.000	.000	.000
SMEAN(F14)	.000	.000	.000	.000
SMEAN(F15)		.000	.000	.000
SMEAN(F16)	.000		.000	.000
SMEAN(F17)	.000	.000		.000
SMEAN(F18)	.000	.000	.000	
SMEAN(F19)	.000	.000	.000	.000
SMEAN(F20)	.000	.000	.000	.000
SMEAN(F21)	.000	.000	.000	.000
SMEAN(F22)	.000	.000	.000	.000
SMEAN(F23)	.000	.000	.000	.000

Correlation Matrix

	SMEAN(F19)	SMEAN(F20)	SMEAN(F21)	SMEAN(F22)
SMEAN(F9)	.084	.150	.450	.396
SMEAN(F10)	.200	.000	.000	.002
SMEAN(F11)	.000	.000	.000	.000
SMEAN(F12)	.000	.000	.000	.000
SMEAN(F13)	.000	.000	.000	.000
SMEAN(F14)	.000	.000	.000	.000
SMEAN(F15)	.000	.000	.000	.000
SMEAN(F16)	.000	.000	.000	.000
SMEAN(F17)	.000	.000	.000	.000
SMEAN(F18)	.000	.000	.000	.000
SMEAN(F19)		.000	.000	.000
SMEAN(F20)	.000		.000	.000
SMEAN(F21)	.000	.000		.000
SMEAN(F22)	.000	.000	.000	
SMEAN(F23)	.000	.000	.000	.000

Correlation Matrix

	SMEAN(F23)
SMEAN(F9)	.347
SMEAN(F10)	.000
SMEAN(F11)	.000
SMEAN(F12)	.000
SMEAN(F13)	.000
SMEAN(F14)	.000
SMEAN(F15)	.000
SMEAN(F16)	.000
SMEAN(F17)	.000
SMEAN(F18)	.000
SMEAN(F19)	.000
SMEAN(F20)	.000
SMEAN(F21)	.000
SMEAN(F22)	.000
SMEAN(F23)	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.891
Bartlett's Test of Sphericity	Approx. Chi-Square	1590.898
	df	253
	Sig.	.000

Communalities

	Initial	Extraction
SMEAN(F1)	1.000	.716
SMEAN(F2)	1.000	.683
SMEAN(F3)	1.000	.737
SMEAN(F4)	1.000	.630
SMEAN(F5)	1.000	.649
SMEAN(F6)	1.000	.614
SMEAN(F7)	1.000	.719
SMEAN(F8)	1.000	.703
SMEAN(F9)	1.000	.655
SMEAN(F10)	1.000	.805
SMEAN(F11)	1.000	.821
SMEAN(F12)	1.000	.797
SMEAN(F13)	1.000	.667
SMEAN(F14)	1.000	.599
SMEAN(F15)	1.000	.771
SMEAN(F16)	1.000	.666
SMEAN(F17)	1.000	.698
SMEAN(F18)	1.000	.765
SMEAN(F19)	1.000	.795
SMEAN(F20)	1.000	.689
SMEAN(F21)	1.000	.722
SMEAN(F22)	1.000	.647
SMEAN(F23)	1.000	.659

Extraction Method: Principal Component Analysis.

Total Variance Explained

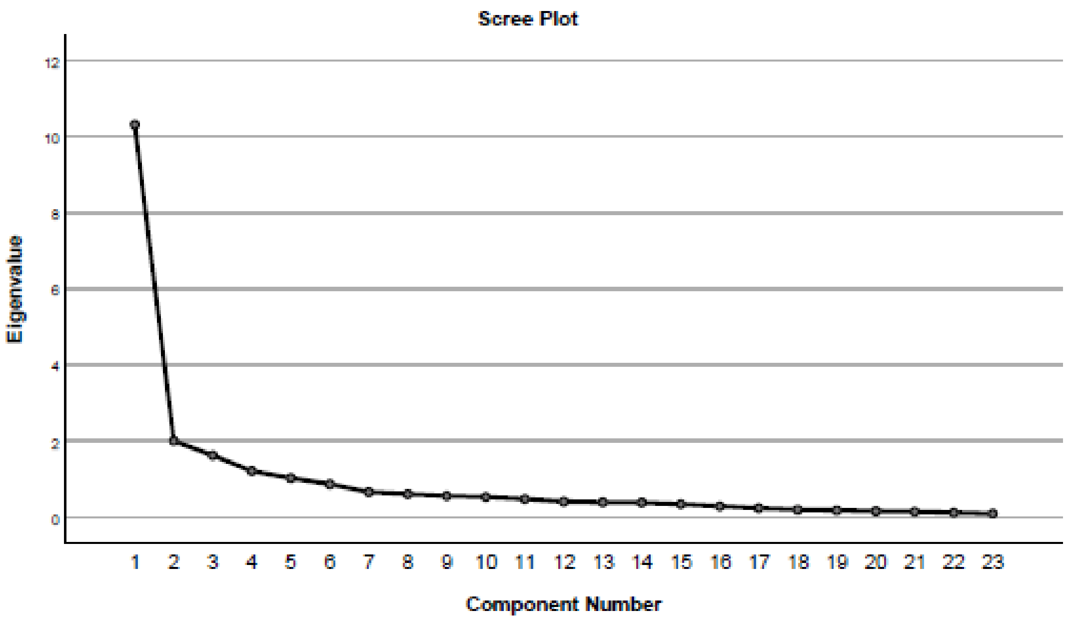
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	10.314	44.841	44.841	10.314	44.841
2	2.010	8.739	53.580	2.010	8.739
3	1.629	7.081	60.661	1.629	7.081
4	1.218	5.295	65.956	1.218	5.295
5	1.035	4.499	70.455	1.035	4.499
6	.875	3.802	74.258		
7	.669	2.910	77.168		
8	.614	2.669	79.837		
9	.568	2.469	82.306		
10	.540	2.346	84.653		
11	.487	2.116	86.769		
12	.417	1.814	88.582		
13	.399	1.733	90.315		
14	.391	1.702	92.017		
15	.349	1.519	93.537		
16	.297	1.292	94.829		
17	.246	1.068	95.896		
18	.205	.892	96.788		
19	.190	.825	97.613		
20	.166	.722	98.335		
21	.152	.661	98.996		
22	.129	.563	99.559		
23	.101	.441	100.000		

Total Variance Explained

Component	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings[a]
	Cumulative %	Total
1	44.841	8.663
2	53.580	8.452
3	60.661	6.514
4	65.956	2.046
5	70.455	1.985
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.



Component Matrix[a]

	Component				
	1	2	3	4	5
SMEAN(F21)	.815				
SMEAN(F20)	.804				
SMEAN(F11)	.790				
SMEAN(F17)	.786				
SMEAN(F18)	.778				
SMEAN(F13)	.770				
SMEAN(F19)	.765				
SMEAN(F22)	.756				
SMEAN(F12)	.752				
SMEAN(F15)	.720				
SMEAN(F8)	.719				
SMEAN(F16)	.707				
SMEAN(F14)	.689				
SMEAN(F6)	.688				
SMEAN(F23)	.661				
SMEAN(F7)	.656				
SMEAN(F2)	.574				
SMEAN(F5)	.541				
SMEAN(F4)					
SMEAN(F1)	.560	.565			

Component Matrix[a]

	Component				
	1	2	3	4	5
SMEAN(F9)			.709		
SMEAN(F3)			.634		
SMEAN(F10)				.662	

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
SMEAN(F15)	.997				
SMEAN(F12)	.970				
SMEAN(F11)	.954				
SMEAN(F16)	.817				
SMEAN(F18)	.762				
SMEAN(F17)	.530				
SMEAN(F13)					
SMEAN(F22)					
SMEAN(F20)					
SMEAN(F8)		.829			
SMEAN(F7)		.826			
SMEAN(F6)		.807			
SMEAN(F14)		.680			
SMEAN(F5)		.673			
SMEAN(F21)		.542			
SMEAN(F19)					
SMEAN(F1)			.898		
SMEAN(F4)			.870		
SMEAN(F2)			.835		
SMEAN(F23)			.670		
SMEAN(F3)				.818	
SMEAN(F9)				.671	
SMEAN(F10)					.832

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Structure Matrix

	Component				
	1	2	3	4	5
SMEAN(F11)	.903	.579			
SMEAN(F12)	.880	.553			
SMEAN(F15)	.861				
SMEAN(F18)	.845	.583	.555		
SMEAN(F16)	.766				
SMEAN(F17)	.748	.685			
SMEAN(F13)	.741	.702	.550		
SMEAN(F22)	.714	.691	.541		
SMEAN(F8)	.588	.807			
SMEAN(F21)	.701	.789	.630		
SMEAN(F7)		.779			
SMEAN(F6)	.558	.772			
SMEAN(F14)		.748			
SMEAN(F19)	.712	.734			
SMEAN(F20)	.678	.693	.671		
SMEAN(F5)		.640			.548
SMEAN(F1)			.837		
SMEAN(F2)			.820		
SMEAN(F23)	.520		.768		
SMEAN(F4)			.752		
SMEAN(F3)				.817	
SMEAN(F9)				.667	
SMEAN(F10)					.858

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Component Correlation Matrix

Component	1	2	3	4	5
1	1.000	.671	.531	.165	.088
2	.671	1.000	.607	.230	.221
3	.531	.607	1.000	.041	.188
4	.165	.230	.041	1.000	-.016
5	.088	.221	.188	-.016	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

RELIABILITY

```
 /VARIABLES=F1_1 F2_1 F3_1 F4_1 F5_1 F6_1 F7_1 F8_1 F9_1 F10_1 F11_1 F12_1
F13_1 F14_1 F15_1 F16_1
   F17_1 F18_1 F19_1 F20_1 F21_1 F22_1 F23_1
 /SCALE('ALL VARIABLES') ALL
 /MODEL=ALPHA
 /STATISTICS=DESCRIPTIVE SCALE
 /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	104	100.0
	Excluded[a]	0	.0
	Total	104	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.933	23

Item Statistics

	Mean	Std. Deviation	N
SMEAN(F1)	8.548	1.3996	104
SMEAN(F2)	8.625	1.3524	104
SMEAN(F3)	8.048	1.6569	104
SMEAN(F4)	8.214	1.6467	104
SMEAN(F5)	7.817	1.7668	104
SMEAN(F6)	8.067	1.5534	104
SMEAN(F7)	7.885	1.7862	104
SMEAN(F8)	8.058	1.4603	104
SMEAN(F9)	6.942	2.3393	104
SMEAN(F10)	7.885	1.5723	104
SMEAN(F11)	8.712	1.5621	104
SMEAN(F12)	8.683	1.6910	104
SMEAN(F13)	8.615	1.5348	104
SMEAN(F14)	7.854	1.5729	104
SMEAN(F15)	8.592	2.1607	104
SMEAN(F16)	8.524	1.7891	104
SMEAN(F17)	8.359	1.5818	104
SMEAN(F18)	8.612	1.5469	104
SMEAN(F19)	8.515	1.6772	104
SMEAN(F20)	8.553	1.3775	104
SMEAN(F21)	8.549	1.4590	104
SMEAN(F22)	8.126	1.7387	104
SMEAN(F23)	8.417	1.4847	104

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
SMEAN(F1)	181.653	547.086	.522	.931
SMEAN(F2)	181.576	548.142	.525	.931
SMEAN(F3)	182.153	557.143	.298	.934
SMEAN(F4)	181.987	545.016	.462	.932
SMEAN(F5)	182.383	538.323	.509	.931
SMEAN(F6)	182.133	534.422	.646	.929
SMEAN(F7)	182.316	527.824	.636	.929
SMEAN(F8)	182.143	535.292	.678	.928
SMEAN(F9)	183.258	566.315	.103	.941
SMEAN(F10)	182.316	549.169	.428	.932
SMEAN(F11)	181.489	527.923	.736	.927
SMEAN(F12)	181.518	525.880	.702	.928
SMEAN(F13)	181.585	530.552	.712	.928
SMEAN(F14)	182.346	533.361	.652	.929
SMEAN(F15)	181.608	513.409	.665	.929
SMEAN(F16)	181.676	526.114	.657	.929
SMEAN(F17)	181.841	525.518	.761	.927
SMEAN(F18)	181.589	529.477	.721	.928
SMEAN(F19)	181.686	524.232	.731	.927
SMEAN(F20)	181.647	532.215	.773	.927
SMEAN(F21)	181.652	529.523	.768	.927
SMEAN(F22)	182.074	524.940	.693	.928
SMEAN(F23)	181.783	538.614	.615	.929

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
190.201	583.213	24.1498	23

Appendix 9: NSFDSS-II Semantic Operators, Semantic Scores and Priority Scores

Semantic Operators		Step	Semantic Score (ia_{1j})	Priority Score (ir_j)
Same		1	0.5	1
	in-between	2	0.525	0.905
Marginally different		3	0.55	0.818
	in-between	4	0.575	0.739
Slightly different		5	0.6	0.667
	in-between	6	0.625	0.6
Quite different		7	0.65	0.538
	in-between	8	0.675	0.481
Markedly different		9	0.7	0.429
	in-between	10	0.725	0.379
Obviously different		11	0.75	0.333
	in-between	12	0.775	0.29
Very different		13	0.8	0.25
	in-between	14	0.825	0.212
Significantly different		15	0.85	0.176
	in-between	16	0.875	0.143
Very significantly different		17	0.9	0.111
	in-between	18	0.925	0.081
Extremely different		19	0.95	0.053
	in-between	20	0.975	0.026
Absolutely incomparable		21	1	0

Source: Chen's work (1998) as cited in Tam, Tong & Zhang (2007).

Appendix 10: DMT Instruction

Decision-Making Tool for Infrastructure Project Selection & Prioritisation

Instruction:

(1) Please read the 'Project Profiles' data to help you understand the conditions and requirements.

(2) Please fill in the 'Data Input' table (pink coloured) by providing your judgment of project score with a scale of 1 to 10 (refer to 'simulation' sheet).

(3) When you are filling up the table, make sure that you have provided your judgment in comparison between one project to another.

(4) The 'Data Analysis' table will assist you in making your final decision.

(5) The priority list will be sorted from the highest to the lowest scores (refer to 'result' sheet).

(6) Radar graphs are produced to visualize the criteria performance for each project proposal.

(7) Provide your opinions regarding the DMF & DMT after you have conducted the simulation (refer to 'expert opinions' sheet).

Alat Pengambilan Keputusan Seleksi & Prioritisasi Proyek Infrastruktur

Instruksi:

(1) Mohon dibaca data 'Profil Proyek' untuk membantu Anda memahami kondisi dan persyaratan proyek.

(2) Mohon mengisi pada tabel 'Input Data' (warna pink) dengan memberikan penilaian proyek dalam skala 1 sampai 10 (silakan merujuk pada lembar 'simulation').

(3) Ketika Anda sedang mengisi tabel tersebut, pastikan Anda telah memberikan penilaian perbandingan antara satu proyek dengan proyek lainnya.

(4) Tabel 'Analisis Data' akan membantu Anda dalam membuat putusan akhir.

(5) Daftar prioritas akan disusun berdasarkan nilai tertinggi ke terendah (merujuk pada lembar 'result').

(6) Grafik radar dihasilkan untuk memvisualisasi kinerja kriteria untuk masing-masing proposal proyek.

(7) Mohon berikan pendapat Anda terkait DMF & DMT setelah Anda mencoba melakukan simulasi ini (merujuk pada lembar 'expert opinions').

Appendix 11: Ethics Approval Letter

RMIT UNIVERSITY

College Human Ethics Advisory Network (CHEAN)
College of Design and Social Context
NH&MRC Code: EC00237

Notice of Approval

Date:	**8 August 2018**
Project number:	**CHEAN B 21600-07/18**
Project title:	**'A Front-End Planning Decision-Making Framework for Infrastructure Projects in Indonesia'**
Risk classification:	**Low risk**
Chief investigator:	**Dr Eric Too**
Status:	**Approved**
Approval period:	From: **8 August 2018** To: **18 June 2021**

The following documents have been reviewed and approved:

Title	Version	Date
Risk Assessment and Application Form	3	7 August 2018
Participant Information Sheet and Consent Form (Focus Group), with Translation	2	18 July 2018
Participant Information Sheet and Consent Form (Expert Interview), with Translation	2	18 July 2018
Participant Information Sheet (Questionnaire), with Translation	2	18 July 2018
Focus group Discussion Themes and Topics	2	18 July 2018
Interview Questions	3	7 August 2018
Questionnaire	2	18 July 2018
Request for Research Permit	1	7 August 2018
Response to CHEAN	1	7 August 2018

The above application has been approved by the RMIT University CHEAN as it meets the requirements of the *National Statement on Ethical Conduct in Human Research* (NH&MRC, 2007).

Terms of approval:

1. **Responsibilities of chief investigator**
   It is the responsibility of the above chief investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by CHEAN. Approval is valid only whilst the chief investigator holds a position at RMIT University.
2. **Amendments**
   Approval must be sought from CHEAN to amend any aspect of a project. To apply for an amendment use the request for amendment form, which is available on the HREC website and submitted to the CHEAN secretary. Amendments must not be implemented without first gaining approval from CHEAN.
3. **Adverse events**
   You should notify the CHEAN immediately (within 24 hours) of any serious or unanticipated adverse effects of their research on participants, and unforeseen events that might affect the ethical acceptability of the project.
4. **Annual reports**
   Continued approval of this project is dependent on the submission of an annual report. Annual reports must be submitted by the anniversary of approval of the project for each full year of the project. If the project is of less than 12 months duration then a final report only is required.
5. **Final report**
   A final report must be provided within six months of the end of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.

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College of Design and Social Context
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6. **Monitoring**
   Projects may be subject to an audit or any other form of monitoring by the CHEAN at any time.
7. **Retention and storage of data**
   The investigator is responsible for the storage and retention of original data according to the requirements of the *Australian Code for the Responsible Conduct of Research* (section 2) and relevant RMIT policies.
8. **Special conditions of approval**
   Nil.

In any future correspondence please quote the project number and project title above.

Dr Marsha Berry
Chairperson, College Human Ethics Advisory Network (CHEAN B)
RMIT University

Dr Scott Mayson
Deputy Chairperson, College Human Ethics Advisory Network (CHEAN A)
RMIT University

cc: Dr David Blades (CHEAN secretary), Mr Seng Hansen, Dr Tiendung Le.

Appendix 12: List of Publications

Following is the list of publications and presentations that have resulted directly from the work undertaken by the author for this PhD thesis.

Peer-reviewed journal publications:

- Hansen, S, Too, E & Le, T 2021, 'Infrastructure Project Selection & Prioritisation: Challenges in the Front End Planning Phase', *International Journal of Structural and Civil Engineering Research*, vol. 10, no. 2, pp. 55-60. DOI: 10.18178/ijscer.10.2.55-60. Presented at *the 4th International Conference on Civil Engineering (ICOCE)*, Dong Hoi, 7 – 9 May 2020.
- Hansen, S, Too, E & Le, T 2018, 'Lessons Learned from a Cancelled Urban Transport Project in a Developing Country: The Importance of the Front End Planning Phase', *International Journal of Technology,* vol. 9, no. 5, pp. 898-909. DOI: https://doi.org/10.14716/ijtech.v9i5.1559.
- Hansen, S, Too, E & Le, T 2018, 'Retrospective Look on Front End Planning: A Comprehensive Literature Review of 30 Years of Research', *International Journal of Construction Supply Chain Management,* vol. 8, no. 1, pp. 19-42. DOI: 10.14424/ijcscm801018-19-42.
- Hansen, S 2018, 'Implementation of PDRI during Front End Planning: A Strategy to Improve Indonesia's Maritime Infrastructure Project Performance', *OISAA Journal of Indonesia Emas*, vol. 1, no. 2, pp. 36-54. Presented at *the Indonesia Global Scholars' Forum (IGSF) 2018*, Murdoch University & The Consulate General of the Republic of Indonesia, Perth, 23 – 24 February 2018.

Peer-reviewed conference presentations:

- Hansen, S, Too, E & Le, T 2020, 'Qualitative Analysis of Factors Affecting the Decision-Making Process of Infrastructure Project Selection', in *the International Conference on Business, Science and Technology for Sustainable Development (ICOSD)*, Jakarta, 9 – 10 December 2020.
- Hansen, S 2020, 'Developing Infrastructure Project Selection Framework (IPSF) as a smart strategy to improve Indonesia's project delivery', in *Konferensi Internasional Pelajar Indonesia (KIPI Digital)*, Canberra, 17 – 18 April 2020.

- Hansen, S, Too, E & Le, T 2020, 'Expected Characteristics and Features of a Decision-Making Framework for Infrastructure Project Selection: A Structured Thematic Analysis of Interview Data', *IOP Conference Series: Earth and Environmental Science*, vol. 537, pp. 012007. DOI: 10.1088/1755-1315/537/1/012007. Presented at *the International Conference on Science, Infrastructure Technology and Regional Development (ICOSITER)*, Institute Technology of Sumatera (ITERA), South Lampung, 25 – 26 October 2019.
- Hansen, S, Too, E & Le, T 2019, 'Criteria to consider in selecting and prioritising infrastructure projects', *MATEC Web Conference Proceedings,* vol. 270, pp. 06004 (2019). DOI: https://doi.org/10.1051/matecconf/201927006004. Presented at *the 2nd Conference for Civil Engineering Research Network (ConCERN-2)*, ITB, 27 – 29 November 2018.
- Hansen, S, Too, E & Le, T 2018, 'Developing a Conceptual Framework for Making Decision during Front End Planning Phase to Select Infrastructure Projects', in *the 14th IRNOP Conference*, RMIT University, Melbourne, 10 – 12 December 2018.
- Hansen, S, Too, E & Le, T 2018, 'Methods in Developing a Decision-Making Framework for Infrastructure Project Selection during Front End Planning Phase in a Developing Country', in *DSC Intertext Symposium*, RMIT University, Melbourne, 30 May 2018.