Integrating Sustainability into Road Infrastructure Development

A dead-end street or a promising road?

Gede Budi Suprayoga

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A dead-end street or a promising road?

Integratie van Duurzaamheid bij de Ontwikkeling van Weginfrastructuur: Een doodlopende straat of een veelbelovende weg?

(met een samenvatting in het Nederlands)

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Preface

"Sustainability" has become a buzzword in both science and policy, and academics and politicians not only use the term often and in many different contexts, but also assign it multiple meanings. The emergent meanings are contradictory, ambiguous, and diverse. There is no straightforward way to grasp what the notion means without examining who interprets it, when, where, and why.

This dissertation arose from this observation. As a government employee for more than 11 years, I found that the words "sustainability" and "sustainable development" had started to appear in policy documents, the speeches of senior staff, and politicians' statements. However, it is challenging to translate the abstract notion into a clear public program, policy, and project with specific and coherent expected outcomes.

In infrastructure planning, planners started engaging in what they call "sustainable" projects. As shown in this dissertation, planners seem to be less well trained and equipped with proper instruments to make projects sound and effective in planning documents and operationalization, while they also have to share their image of what sustainability looks like with other stakeholders in the infrastructure sector. These stakeholders are mostly engineers with a strong focus on the supply and hardware sides, such as pavement structure, material supply, energy consumption, and equipment deployment. The different languages spoken in the two professions make it difficult to agree on what aspects should be incorporated to achieve the intended project goals.

While I was writing this dissertation, the Indonesian government invested a lot of public money in speeding up the construction of around 80 major road projects. The aim of these and other infrastructure projects is to improve the country's economic competitiveness, and I was fascinated by how the project developers—usually the government—brought "sustainability" into the projects. The aim of the central government is truly ambitious, namely to increase national economic growth by 7%. The early implementation of the projects led to contention between the public and the government about the social and environment benefits and costs in space and time. One thing that is certain is that environmental considerations are more or less still on the margins, which threatens how the projects can keep aligned with sustainable development.

The aim of this dissertation is to help promote convergence among the key stakeholders in sustainable road infrastructure development. I hope it can provide a common language for dialogue around such development and ensure a more consistent approach to critical barriers and opportunities. Planning is the most crucial phase for the integration task as more action spaces are available for planners and policymakers. Moreover, planning provides lessons that are learned early enough to anticipate possible barriers. The result of this dissertation should,

therefore, promote the planning of road investments in more sustainable ways and help the stakeholders to deliver the international agenda on sustainable development.

Utrecht, September 2020
Gede Budi Suprayoga

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Gede Budi Suprayoga

Abstract

The background to this dissertation lies in attempts made to integrate sustainability into the planning of road infrastructure development. Better integration is necessary to ensure that the three pillars of sustainable development (i.e., the economic, social, and environment pillars) and the intergenerational equity principle are also considered. The focus is on spatial planning, because more action spaces are available early on in this process than later in the project lifecycle (i.e., construction and operation). Indonesia was selected as a case study because it represents a typical case of a developing country with limited capacity for, and limited awareness among stakeholders of, integrated decision-making. The main research question of the research underlying this dissertation was: *What features explain the successful or limited integration of sustainability into planning road infrastructure development, and what specific strategies can be revealed by this investigation into the particular case of Indonesia as a developing country?* In the present research, mixed data collection methods were used, namely a desk study, semi-structured interviews, and an online questionnaire. Qualitative and quantitative analyses were carried out to explore the explanatory features for integrating sustainability into road planning from three perspectives, that is, content, context, and process. The results show that from the *content* perspective, the integration is determined by the coherent use of indicators included in the practiced assessment. Second, from the *context* perspective, the case of Indonesia shows that it is necessary to improve the broader decision-making context (e.g., leadership, shared interests, and inclusive participation of stakeholders). Third, from the *process* perspective, the framing and reframing of missions/goals and the effective use of environmental impact assessment to reflect the problems and solutions are necessary. In conclusion, this dissertation proposes a dual pathway to successful integration: (1) the improvement of institutions for integrated decision-making in the long run and (2) the mapping of opportunities to balance environmental and economic interests through more inclusive decision-making. The role of planners and policymakers is to navigate between both pathways to strengthen the governance of road infrastructure planning toward sustainable development.

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1. Introduction

Dewa Ruci intersection, Denpasar, Indonesia ©Tresnasumarjaya13

1.1. Challenges of Achieving Sustainable Development

1.1.1 The global sustainability challenge

Since the late 1980s, the emergence of the concept of *sustainable development* has attracted the interest of scholars in many fields, including spatial planning (e.g., Eggenberger & Partidário, 2000; Nilsson, 2003; Van Stigt et al., 2013; Vroom & Van Straalen, 2016). Since then, both public and private bodies have initiated numerous spatial policies aimed at reducing the adverse environmental effects of spatial projects and improving the quality of life of urban regions (Boone & Fragkias, 2012; Devuyst, 2001; Goldman & Gorham, 2006; Van Stigt et al., 2016). In 1987, the Brundtland Commission published a report titled Our Common Future that defines sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987, Chapter 2, Article 1). At the 1992 United Nations Conference on Environment and Development (UNCED), this concept obtained formal international recognition and is now known as the Rio Declaration. The conference called for the integration of environmental considerations into the conventional development model (Dernbach, 2003).

Almost three decades later, the concept is still being criticized for its wide range of interpretations and its lack of sufficient robust analytical and systematic frameworks. This raises concerns regarding the operationalization and measurement of the concept (Ashford & Hall, 2011; Gudmundsson et al., 2016). This has proven to be not a straightforward process. Stakeholders have multiple interpretations of the notion that shape its various meanings (Gibson, 2013). Sustainability is commonly defined as a balance between the three pillars/dimensions of sustainable development (i.e., the economic, social, and environmental pillars). This definition allows for trade-offs between dimensions that encourage the division of policy mandates and expertise (Gibson et al., 2005). Another definition is based on associated criteria/aspects as requirements that reflect the full account of sustainability, such as socio-ecological system integrity, and time and space dimensions (Gibson, 2006; Gibson et al., 2005). The choice of which definitions should be adopted determines how the concept is operationalized in the form of decision support tools (Gudmundsson et al., 2016).

The incorporation of all pillars is nevertheless insufficient unless attention is paid to the third principle of the Rio Declaration—namely *intergenerational equity* – which informs how present and future generations can meet their developmental and environmental needs. Scholars have made attempts to integrate this principle into assessment tools aimed at assisting decision-making toward sustainability in products, projects, and institutional appraisals (Bond et al., 2012; Sala et al., 2015). However, questions remain: To what extent do such tools include all sustainability principles and criteria? How do the tools assist decision-making effectively in contexts in which numerous stakeholders have varying degrees of control toward

expected outcomes? It appears that methodological and social complexity affects the integration of sustainability in many development fields, including spatial development.

The pursuit of the integration of policy content is seen as the core business of planning (Boelens, 2010; Van Stigt, 2013). In such an attempt, planning involves stakeholders with various long- and short-term interests operating in a multi-scalar setting (i.e., local, regional, national, and international). This often results in decisions with a narrow time-frame produced at the expense of the environment (Van Stigt et al., 2013). Studies have shown that planners and policymakers encounter various barriers to integrating environmental interests in spatial projects, such as urban renewal, housing, and public transportation (Banister, 2006; Nykvist & Nilsson, 2009; Van Stigt, 2013). To investigate this integration, this dissertation is focused on road infrastructure development, as it mostly consumes huge amounts of public money (Gartner, 2016) and environmental consideration is often integrated only later on in the process (Diaz-Sarachaga et al., 2017). Planning has a vital role here, as the chance of incorporating environmental considerations decreases as the road infrastructure development moves through the project lifecycle (Reid et al., 2012). In contrast, successful integration in the planning phase would largely determine how various stakeholders obtain long-term benefits from extensive road investments.

1.1.2 Challenges of integrating sustainability into road infrastructure development

Road infrastructure is a part of transportation systems that are intended to ease the movement of people and goods (Gudmundsson et al., 2016). It has several characteristics. First, the infrastructure constitutes the main physical features that closely interact with the socio-ecological systems, such as the landscape, the people, and the neighborhood at multiple spatial scales (Cumming et al., 2006; Gudmundsson & Höjer, 1996). Such an interaction consists of the flows of energy and matter that enter and leave the system as fuels, land acquired for project sites, construction materials, and byproducts (e.g., vehicles, equipment, and waste emissions). The flows leave the system as emissions, waste, or material outputs that affect the environmental quality at the local and the global level (Joumard & Nicolas, 2010). Second, the road infrastructure interacts with society to a large extent through the movement of people and freight for social and commercial purposes, such as recreation and business. These movements are dynamic and influence the environmental quality through, for example, gas emissions, vibration, soil pollution, and light dispersion. Studies have shown that the massive expansion of road infrastructure networks often displace landscape (Ree et al., 2011) and may displace communities (Delphine et al., 2019). Such displacement produces ecological and social consequences that have both an immediate effect (e.g., biodiversity depletion

and public health) and a prolonged effect (e.g., water quality and community cohesion) (Gellert & Lynch, 2003).

In most parts of the world, sustainability is frequently treated as a merely sectoral concern (Gudmundsson et al., 2016; Nykvist & Nilsson, 2009). A clear national framework is rarely available to guide a comprehensive and holistic decision-making approach that leads to integration (Gudmundsson et al., 2016). In road infrastructure development, the leading government agencies seem to be focused only on limited project scopes (concerning time and space) as a solution to traffic problems: bottleneck measures, orientation on aligning with formal requirements, and end-of-pipe mitigation procedures (Arts et al., 2014). Such an attitude prevents these agencies from achieving successful integration. Research still emphasizes the selective elements of infrastructure development, such as emissions, materials, pavement structures, and traffic monitoring devices (e.g., Kolosz et al., 2013; Molenaar, 2013; Oltean-Dumbrava et al., 2016; Santos et al., 2015). It appears that there is an incomplete understanding of how the sustainability pillars can be fulfilled, and how the integration can be made effective in the planning phase. The context in which decision-making takes place is still often fragmented into sectors, making it difficult for stakeholders to achieve integration. It seems difficult to improve the context, particularly in developing countries, where awareness of the integrative aspects of sustainability is lacking and sectoral fragmentation deepens the disintegration (Pojani & Stead, 2015).

Numerous tools and approaches have been applied to facilitate the integration of sustainability into transportation projects. Impact assessment procedures—such as strategic environment assessment (SEA) and environmental impact assessment (EIA)—are commonly used to integrate all pillars of sustainable development considerations into transportation projects. However, the application of such procedures is insufficient to advance integration. Fischer (1999) investigated this failure and concluded that there are two persistent problems: inadequate preparation and a lack of stakeholder involvement across jurisdictions. Planners and policymakers find it challenging to include the interests of other stakeholders beyond the project's jurisdiction, making it problematic to cover all related spatial concerns that affect the sustainability of road infrastructure development (Fabbro et al., 2015). In addition, Soria-Lara et al. (2015) found several process-related barriers, such as limited cooperation between sectors, time limitations, and unstructured scoping phases. These results have substantiated the critical role of context and process for successful integration.

In response to such shortcomings, scholars have proposed a new procedure/tool called sustainability assessment (SA), which promises to better integrate the pillars of sustainable development (Bond et al., 2012; De Ridder et al., 2007; Hacking & Guthrie, 2008). Regardless of the increased application of this tool, several points of criticism have emerged amongst scholars. First, the tool fails to integrate both short-

and long-term considerations (Gasparatos, 2010). The tool mostly emphasizes measuring tangible impacts (Bueno et al., 2015) and pays limited attention to the time dimension, which is necessary to cover intergenerational equity considerations. Second, in almost all road development projects the scope of concern is still limited; that is, it is commonly focused on the physical infrastructure. Howitt (2013) found that project stakeholders still focus on partial spatial scales and fail to assess the development effects across these scales. As a result, projects turn out to be disruptive to the environment and society at a broader spatial scale (Howitt, 2013). Stoffle et al. (2013) argue that such a scope limitation often arises from less transparent and accountable decision-making in the development planning. It can be concluded from these criticisms that integration faces several challenges in terms of content, context, and process that planners and policymakers need to overcome.

1.2. Paving Pathways to Integrate Sustainability into the Planning of Road Infrastructure Development

1.2.1. Integrating sustainability in spatial planning

The fragmentation and decentralization of decision-making has led to a call for greater policy integration. Many stakeholders, including those outside public bodies, are involved in policymaking processes. In addition, there is a greater emphasis on public participation, and it is challenging to include different stakeholders from various sectors (Healey, 2006). The integration requires these stakeholders to overcome sectoral fragmentation across interrelated environmental, social, and economic problems, and to cover different time and space dimensions of these problems.

According to the online Merriam–Webster Dictionary, "*integrate*" means "*to form, coordinate, or blend into a functioning or united whole*," and "*integration*" is "*the act of integrating*." In spatial planning, however, the definition of integration is far from consistent or straightforward. Different terms are found in the literature, referring to, for instance, the horizontal management of sectoral policy (Geerlings & Stead, 2003). Stead (2008) argues that policy integration consists of activities that include dialogue and information, transparency and avoidance of policy conflicts, and joint working to create synergies between policies. These activities imply a complex interaction between policy outputs, sectors, and levels of organizations.

The integration of sustainability in spatial planning is also beset by intricate political balancing between long-term environmental values and a diverse set of socioeconomic values. (Hull, 2008). For example, Jordan and Lenschow (2009) show that the environmental policy itself is frequently unable to achieve its objectives because of the strong influences of other sectors, such as transportation, energy, and industry. Environmental policy integration (EPI), as Jordan & Lenschow (2009)

propose, is advanced to integrate environmental policy objectives into the plans or policies in other sectors (Van Stigt, 2013). EPI serves multiple functions, including functioning as a communicative instrument (i.e., clarifying what needs to be integrated), an organizational instrument (i.e., assisting when and where to integrate), and a procedural instrument (i.e., arranging how to integrate).

In infrastructure planning, Ike et al. (2004) refer to environmental and infrastructure planning (EIP) as "the built fabric of public spaces, institutions, facilities, and services that together constitute 'infrastructure', that shape and sustain [sic] daily life in an environmentally friendly way" (Ike et al., 2004, p. 12). The integration of environment and infrastructure considerations in planning is aimed at improving the living environment through integrated management that entails the broadest range of policies, methods, and actions. It results in several operational strategies that can be implemented in a specific context of political and administrative frameworks. Such strategies are helped by various means, such as assessment tools and statutory procedures, involving multiple stakeholders in different jurisdictions.

In short, so far several attempts have been made to integrate sustainability in spatial planning. Such attempts have indicated features that determine successful integration. The features can be extracted from different angles, such as (i) coherence in expected outcomes in space and time (i.e., from a content perspective), (ii) integrated political and administrative frameworks (i.e., from a context perspective), and (iii) integrated stakeholders' interactions, procedures, and restructured power relations (i.e., from a process perspective). The following subsection explores these features in more detail, to substantiate the usefulness of the perspectives of content, context, and process.

1.2.2. Analytical framework: Integration of content, context and process perspectives

Spatial planning is often considered an interactive process undertaken in a social context, rather than a purely technical process of spatial design, analysis, and management (Healey, 2007). From a new institutionalism approach, Healey (2006) divides planning components into three categories. The first components are the stakeholders, who are positioned as the central agencies that perform the planning process. These stakeholders have multiple values, beliefs, and interests that shape the content (e.g., expected outcomes/policy objectives in space and time). The second category of components are the planning outcomes, which are determined by the quality of the process through which trust and understanding can develop through social interactions. The third category is related to the context in which the decision-making takes place. Context determines the outcomes through power structures and the cultural and institutional embeddedness that the stakeholders use as a guidance

to pursue their interests. Healey (2006) argues that there is a complex interplay of content and context, and substance (i.e., content) and process, so that planning is more than just a rational decision-making process using analytical tools/ instruments.

Through a new institutionalism lens, integration is achieved through both formal and informal rules that construct the interaction of the agency action of individuals and organizations. The expected result is that such an interaction improves dialogue and information sharing, transparency, and joint working between stakeholders to create synergies. This lens differs from the "old" institutionalism approach that positions formal rules (policy and regulation) as the primary rules that society must obey (Bell, 2011). However, such an approach failed to understand the rapid changes in and the development demands of society. Here, institutions are defined as "rules of the game" that determine the behavior and interaction behavior through formal and informal constraints (North, 2009). Formal rules include legal instruments and are a product of formal institutions, typically written in law and legislation, while informal rules are dynamic, usually unwritten (Ellertdottir, 2014; Helmke & Levitsky, 2004), and imply a social sanction affecting people within a similar culture.

The new institutionalism approach addresses the interaction in institutions as continuously changing in response to internal factors (agency and rules) and external culture (culture and social norms) (Bell, 2011; Peters, 2012). The approach has an extensive coverage, focusing not only on formal rules as structures, but also on the combination with informal rules (Koelble, 1995; Peters, 2012). Moreover, it also addresses the behavior of groups and individuals to accommodate interaction and power distribution (Bell, 2011; Hall & Taylor, 1996). Here, this interaction is investigated through the understanding of the actors' or stakeholders' capacity to act on the integration, mediated by contextual factors. The approach also connects the idea of institutions with the social construction of content (e.g., the expected outcomes in time and space). Darmoyono (2019), for example, shows that road development in Indonesia is strongly influenced by its cultural context and the complex formal institutions (bureaucracy) under a decentralized system. The planning agency is therefore not independent of its decision environment, but continuously interacts with it.

The application of the new institutionalism lens in the present research helped in the investigation of how institutions act as constraints on managing, and as capacities to manage, the interaction between agencies, formal rules, and culture, and to mobilizing actions toward sustainable development. This approach is closely linked with the features of integration that were mentioned earlier in terms of content, context, and process perspectives (Figure 1.1). Figure 1.1. locates the stakeholders at the center of the integration between content, context, and process, as

they are the only elements that interpret the content, act on the context, and experience the process independently of the rest.

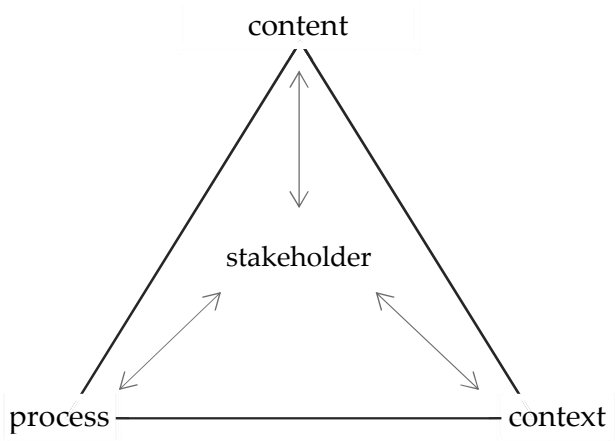


Figure 1.1 The planning framework (after Spit et al., 2015)

As an illustration of this framework, Bond et al. (2013) support the usefulness of the content, context, and process perspectives to explore features that determine effective assessment toward sustainable development. First are the content-related features, reflected by substantive and normative effectiveness. Such effectiveness guides the assessment of what features should be integrated, including assessment principles/norms and values (Gibson, 2006). Second are the process-related features, which focus on procedural and transactive effectiveness, such as compliance to standards and broader public participation. Bond et al. (2013) add two features from a pluralistic process perspective: the inclusion of stakeholders with different interests, and the adaptiveness of decision-making processes based on a specific governance setting (e.g., the nature of stakeholders' interactions).

Furthermore, Jordan and Lenschow (2009) distinguish three perspectives on the features that affect the integration of environmental objectives into sectoral policies, namely the cognitive, the political, and the institutional perspective. The cognitive perspective focuses on ideas/initiatives related to what to integrate and how to do it. Second, Jordan and Lenschow (2009) use the political perspective to examine how cultures and multiple interests are integrated into a sectoral policy. Finally, the institutional perspective views integration as a coordination problem and focuses on an action to transform organizations and institutions. Later on, Van Stigt (2013) redefined these three perspectives as a substantive (i.e., content) perspective, a political (i.e., process) perspective, and an institutional (i.e., context) perspective to explore the integration of environmental objectives into urban development planning. Thus, the three perspectives in Figure 1.1 were applied to explore several features that explain the successful or limited integration of sustainability into road infrastructure development. The following section further explores these features.

1.3. Exploring the Features for Successful/Limited Integration

This section explains why and how some features are relevant to advance the integration of sustainability into road infrastructure development. Each of these features is examined in a separate chapter, guided by a specific sub-research question.

1.3.1. Multiple conceptualizations of sustainability

Sustainability is a contested concept (Pope & Morrison-Saunders, 2013; Söderbaum, 2008). Different stakeholders have multiple interpretations of the notion, and some discourses often dominate the meaning in actual implementation (Bond & Morrison-Saunders, 2009). Thus, successful integration requires a clear understanding of what sustainability means and how it applies to planning. The challenge is that stakeholders often have differing interests and outcome expectations. The differences are tightly embedded in their values (Bond et al., 2013). Therefore, the first step toward achieving integration is to clarify the concept of sustainability and how it can be operationalized into planning and the implementation of decision support tools.

To elaborate, Söderbaum (2008) explores issues surrounding the concept of sustainable development. He states that some of the documents that mention the concept, such as the Brundtland Report, are "not very clear and may even be contradictory in their arguments" (Söderbaum, 2008, p. 18). In his conception, the traditional ideas about economic growth are presented along with pleas for strengthened environmental protection. Moreover, sustainability is beyond a simplistic categorization of dimensions/ pillars (Gibson et al., 2005). It consists of multiple ranges of considerations, including governance, adaptive management, and time dimensions. Without the full account of these considerations, policymakers, who often rely on pillar-based evaluations, find it challenging to establish the overall implications for sustainability. Therefore, Gibson (2005; 2006) elaborates criteria/requirements to test whether decisions or assessment results are truly aimed at achieving sustainable development. The criteria imply that the integration of pillars is insufficient without the inclusion of the time and space dimensions (Howitt, 2013; Stoffle et al., 2013) and governance dimensions, such as public participatory process (Gibson, 2006, 2013).

From a content perspective, the first feature examined here is the extent to which the assessment approaches that are usually applied for planning and decision-making have successfully integrated sustainability into road infrastructure development. Bueno et al. (2015) divide these approaches into three categories: project appraisal methods for decision-making; techniques for social/environmental impact assessment; and sustainability assessment methodologies. The first approach comprises tools to deliver sustainable project options, namely cost–benefit analysis (CBA)—which is expanded to monetarily account for social and environmental

impacts—and multi-criteria analysis (MCA), which reflects all pillars of sustainable development simultaneously (Beria et al., 2012). The second consists of a life cycle assessment (LCA) and a social-life cycle assessment (S-LCA) aimed at quantifying the sustainability impacts of road projects throughout the lifecycle (Jørgensen et al., 2008; Stripple, 2001). The third approach comprises system rating tools, indexes, and guideline frameworks to evaluate sustainability performance based on best project practices (e.g., Diaz-Sarachaga et al., 2017; Jeon et al., 2013). Planners and policymakers should at least be aware of the different concept, and what requirements need to be considered in the presently available approaches to integrate sustainability into road development planning.

1.3.2. Sectoral views and constraints for a comprehensive perspective

In addition to the multiple concepts of sustainability, another concern is the dominant sectoral views on sustainability, which hamper a comprehensive perspective. Sustainable development is considered to be achieved by connecting various activity areas of government with the "sustainability challenges," such as climate change, biodiversity protection, and economic equality (Ashford & Hall, 2011; Gudmundsson et al., 2016). However, a public works department, for example, focuses on a climate change issue independently of other departments that are responsible for environment protection, energy conservation, and agriculture production. A public works department has policy initiatives for reducing energy use and minimizing greenhouse gas emissions during construction. The drawback of such a view is that other critical policy concerns have failed to include, for instance, the displacement of tree habitat species, which affects the ability of the ecosystems to absorb the emissions.

To achieve successful integration, first, responsible departments should expand the comprehensiveness of the sectoral concerns included in a policy (Miller & De Roo, 1999). As a result, each department should cover multiple sectoral issues considered and mobilize various resources. In contrast, Partidario and Voogd (1999) argue that a comprehensive policy is also inefficient and will never be fully realized because of the "ad hoc" character of the actual decision environment. Also, resources are often too limited to cover a broad range of sustainability considerations (i.e., development effects in space and time). Time, funding, and personnel can also act as constraints on successful integration (Cornet & Gudmundsson, 2015; 2016; Pei et al., 2010). Connecting multiple sectoral perspectives needs cross-sectoral thinking that eliminates sectoral fragmentation (Banister, 2008).

Scholars recognize that sectoral and comprehensive perspectives can co-exist to integrate sustainability into transportation development (Gudmundsson et al., 2016; Litman, 2007; Ramani et al., 2011). Öberg et al. (2017) show that the sustainability of major European transportation corridors is supported by numerous sectoral policies,

such as regional development, traffic safety, and environmental protection. There are advantages and disadvantages to using both perspectives. First, the sectoral perspective provides an efficient way to produce applicable decisions within each organizational control and resource constraint. Through, negatively put, tunnel visioning, a public works department, for example, contributes to sustainability by reducing materials and energy consumption during construction. Second, a sectoral approach opts for a realistic policy result, as it considers the mandates and resource capacities of the respective departments (Gudmundsson et al., 2016; Witte et al., 2012; Witte & Spit, 2014). The comprehensive perspective, on the other hand, comprises many sectoral contributions, but tends to ignore the resource constraints of the responsible departments (Witte et al., 2012; Witte & Spit, 2014). To resolve the drawbacks of both perspectives, this study proposes a mixed scanning methodology (Etzioni, 1967, 1986) to scrutinize (i) fundamental strategic issues that all sectors contribute to solving and (ii) relevant specific matters that individual sectors can contribute to solving independently.

1.3.3. Context-specific barriers embodied in institutions

Context determines to a large extent the successful integration of sustainability considerations in planning practices (Bina, 2008). Different planning cultures affect the context and specific cultural conditions determine the dominant values, views, norms, and beliefs in policymaking and appraisal practices (Gazzola et al., 2011). Based on this description, context informs the "rules of the game" or the institutions that determine the behaviors and practices of individuals, organizations, and stakeholders' interactions. March and Olsen (1989, p. 160) define institutions as "collections of interrelated rules and routines that define appropriate actions in terms of relations between roles and situations."

In this study, context refers to "the organisational and institutional location of the decision-making processes which are themselves situated within and influenced by a given society and its broader social, cultural, and political values" (Bina, 2008, p. 719). As a consequence, any attempt to integrate sustainability in planning is embedded in institutions in many forms, including bureaucratic, cultural, and political practices (Partidário & Voogd, 1999). In Indonesia, for example, scholars suggest that the ability to deliver more integration of sectoral policies into road infrastructure development is contingent on the institutional barriers at the individual level, such as a lack of funding resources and trained personnel (e.g., Darmoyono, 2019; Delphine, 2019). The removal of such barriers is called an "agency-centered" intervention, and it only partly explains the barriers to integration. Less intangible structural constraints, such as political commitment at a higher level, also contribute to the result of effective policy integration (Turnpenny et al., 2008). Institutions explain how present impact assessment tools, such as

sustainability assessment (SA), are failing to assist integration, and research results have shown that the advancement of these tools alone is less fruitful (Sheate, 2009).

From a context perspective, institutions are discussed as a complicated and multitudinous relationship issue involving "agency" and "structure" (Clemens & Cook, 1999; Hall & Taylor, 1996). From this perspective, multiple layers of institutions create the context and affect the integration of sustainability into the planning of road infrastructure development. As this relationship is complex, this study adopted an approach that distinguishes three layers of institutions, viz. the micro-level (individual), meso-level (organization), and macro-level (networked stakeholders) (Turnpenny et al., 2008). Therefore, the approach allowed for a detailed examination of context-specific barriers.

1.3.4. Ambiguity and uncertainty of the planning process

The integration of sustainability in spatial planning consists of a series of decisions that are taken before an alternative is finally agreed upon. Stakeholders, however, rarely have a single interest, understanding, and frame concerning what sustainability means and what the expected outcomes are (Bond & Morrison-Saunders, 2009). Such a situation is called "strategic ambiguity" (Giezen et al., 2015), which challenges stakeholders involved in a consensus-building process. Stakeholders hardly know how to resolve the differences, since arenas for decision-making are disconnected. Formal decision-making is disrupted because the linkages between the goals and the means are often unclear, making it challenging to agree on specific goals. Impact assessment procedures frequently fail to identify development impacts and necessary measures that satisfy all stakeholders (Van Stigt et al., 2013).

As a result, Nilsson and Dalkman (2009) argue that planning is a "boundedly rational" process, which explains the suboptimal effect of impact assessment as a decision support tool. Different rationalities play roles, characterized by the diverse values and political powers that play a part in the decision-making (Richardson, 2005). Stakeholders are also involved in multiple and partly overlapping arenas that complicate the discussions and the negotiations about the problems and the solutions (Van Bueren & Ten Heuvelhof, 2005). Several consecutive decisions often result in a chaotic chain of decisions that are hardly connected with each other (Van Bueren et al., 2003). As a consequence, stakeholders only collect partial information about the problems and the solutions, which also explains the uncertainty of the final decisions.

From a process perspective, this study examined how decision-making processes can be structured to integrate sustainability into road infrastructure development. Two particular consequences were examined. First, as impact assessments frequently fail to offer sensible solutions to the problems instantly, because diverse

stakeholders' interests may be difficult to mediate (Van Stigt et al., 2013), some influential stakeholders may also drive the outcome (Salling & Banister, 2009). Another consequence is that the policy processes are unable to incorporate all interests mobilized by stakeholders. Regarding the process perspective, this study identifies which factors or elements help planners and policymakers to integrate sustainability under ambiguity and uncertainty. This knowledge can be used to structure the decision-making process in a context where multiple interests of stakeholders exist.

1.3.5. Contested scale frames of the development impacts

Sustainable development is aimed at securing the quality of human and natural resources so that they remain or increase over time (Bell & Morse, 2010). However, the different scale frames that are of relevance here, are often contested. At a local spatial scale, road infrastructure can improve accessibility and enhance economic wellbeing (Cumming et al., 2006). At a broader spatial scale, however, it can also displace the landscape and communities (Delphine, 2019; Gellert & Lynch, 2003). It is well known that the success of megaprojects is defined to only a limited degree in terms of budget, schedule, and scope (Flyvbjerg, 2017; Samset, 2008). Project developers view problems and solutions as reasonably stable with a clearly defined aim, a time path, and a previously specified end product (Samset, 2008). The result, however, is that affected stakeholders are frequently left out of the discussions on the development effects (Delphine, 2019). The delivery of megaprojects, for example, is steered by both strategic decisions (i.e., contribution to the desired societal goals in a financially sustainable way) and tactical decisions (i.e., creation of utility/benefit at the lowest possible costs) (Samset, 2008; Volden & Samset, 2017). Such a delivery approach is likely to fail to capture the complexity of socio-environmental impacts across multiple scales (e.g., across time and space).

Through the lens of a politics-of-scale approach, scales are viewed as fluid and contested. Scales are, therefore, not "value-neutral" entities. They can be parts of the power relations between stakeholders; they are dynamic or change over time. For example, project developers tend to shorten the time scale in impact assessment to create the impression of fewer environmental risks (Flyvbjerg et al., 2003; Mentis, 2015; Stoffle et al., 2013). They also favor a limited spatial scale to inform people that project impacts are manageable, although broader jurisdictions are often also influenced (Fabbro et al., 2015). Moreover, the involvement of environmental groups introduces concerns about prolonging projects and their broader consequences that are hard to escape in a democratic and pluralistic society (Priemus et al., 2008). Therefore, stakeholders' interests in sustainable outcomes differ. Stakeholders also think, articulate, and frame the problems and solutions differently in time and space (Gudmundsson et al., 2016).

From a process perspective, this dissertation draws upon the concept of scale framing as a means to analyze how stakeholders mobilize arguments about problems and solutions in different times and spaces (e.g., Kurtz, 2002; Sadler & Kurtz, 2014). It discusses how such frames have evolved throughout the development phases, namely pre-construction, construction, and usage. The evolution of those frames is linked with the power contestation between stakeholders. Moreover, stakeholders frequently change their requirements and expectations in such a way that they influence the outcomes. This is especially visible in the implementation phase, where the project impacts have materialized in various forms, such as pollution emissions and commercial benefits, and affected the livelihood of the local stakeholders in many tangible ways, such as traffic congestion (Delphine et al., 2019b). This study investigated how a megaproject delivery approach leads to the failure to integrate sustainability into road development because of the lack of accountability and transparency between project developers. From this viewpoint, the study established certain strategies to deal with this deficit.

1.4. Aim, Scope, and Research Questions

1.4.1. Aim

The research underlying this dissertation was concerned with the integration of sustainability into road infrastructure development. The results contribute to efforts aimed at integrating sustainability into road development, particularly in a global South context (with Indonesia as a typical case). This context is characterized by a less favorable setting for integrated decision-making and a lack of awareness of the integrative aspects (Pojani & Stead, 2015). The dissertation advances the discussions about collaborative planning processes involving multiple stakeholders to integrate various interests (i.e., economic, social, and environmental) in spatial planning (Boelens, 2010; Healey, 2006, 2007). In this dissertation, such a process is depicted involving stakeholders in land use and infrastructure planning that Arts et al. (2016) identify as “builders” and “planners.” The “builders” tend to focus on “hard” elements, such as material selection, construction process, and traffic technology devices, with a strong sectoral and engineering perspective; whereas the "planners" concentrate mostly on "soft" components, such as urban environmental quality and integrated transportation provision, with a comprehensive view on sustainable development. The present research examined how such integration is made possible.

1.4.2. Scope

Sustainable development often illustrates the intended fulfilment of objectives in the three pillars/dimensions of sustainability, namely economic growth, social equity, and environmental protection (Jeon et al., 2013). This study took a nuanced and

pragmatic approach to sustainability, shown by the balanced interests between stakeholders, representing the pillars of sustainable development. The integration is difficult to achieve in a context in which stakeholders have multiple competing claims about what sustainability means.

The focus on the developing world was vital for a thorough investigation of road infrastructure. In this context, the infrastructure is commonly developed with an ambitious economic objective, such as decreasing logistics costs and improving economic competitiveness. Yet, environmental considerations are often integrated only later on in the development process (Diaz-Sarachaga et al., 2017). In the Indonesian cases presented in this dissertation, the scope of the research is limited to large-scale road development projects that are characterized by a multitude of social complexities and a contestation between multiple sectoral policies (economic vs. environment). The insights obtained from the cases are expected to be applicable in the context of the developing world. In this setting, a considerable number of studies about large-scale transportation projects are being performed (Flyvbjerg, 2017), but it appears that policymakers are struggling to incorporate sustainability as the context is not favorable for integrated decision-making (Pojani & Stead, 2015).

1.4.3. Research questions

The main objective of the research underlying this dissertation was the successful integration of sustainability into road infrastructure development. The focus was on Indonesia as a developing country with specific features that determine the successful or limited integration from the content, context, and process perspective. The main research question, thus, was:

> ***What features explain the successful or limited integration of sustainability into planning road infrastructure development, and what specific strategies can be revealed by this investigation into the particular case of Indonesia as a developing country?***

The question was further detailed by using the three perspectives mentioned in section 1.2.2. First, from a content perspective, the features investigated include: (i) the coherent conception of sustainability (e.g., inclusion of time and space dimensions and the sustainability pillars) in the practiced assessment, and (ii) sectoral and comprehensive elements that constitute the policies on sustainable road infrastructure development. The first and the second sub-research questions were therefore:

> *RQ-1: To what extent have assessment tools incorporated sustainability in planning road infrastructure projects?*

RQ-2: How are time and space dimensions included in a sectoral and a comprehensive perspective on planning for sustainable road infrastructure development?

Second, the context perspective prompted a research question focusing on the multiple layers of institutions that affect successful/limited integration. Through a new institutionalism lens, this research examined several barriers and established the most prominent features that determine limited integration. The related sub-research question was:

RQ-3: What institutional barriers affect the integration of sustainability in road project planning?

Third, the two last research questions focused on the process perspective. The questions here were targeted at understanding in what ways stakeholders balance multiple interests that reflect the sustainable development pillars. The research questions examined how these interests compete with each other, and how power contestation between stakeholders complicates the planning and implementation of the project toward sustainable development.

RQ-4: How do stakeholders balance economic and environmental interests in planning sustainable road development?

RQ-5: In what ways do the contested scale frames of the problems and solutions affect the prolonged sustainability outcomes?

Figure 1.2 links the mentioned perspectives to the research questions. It starts from sustainability literature to operationalize the sustainability concept into road infrastructure development (RQ-1, RQ-2). Hence, the contribution of features for the integration are added from the context and process perspectives (RQ-3, RQ-4, RQ-5). These perspectives are inseparable, and each one has features that link to other features in different perspectives. The five sub-research questions are shown below in the planning framework context. The answers to the sub-research questions culminated in an answer to the main research question, which is reflected in the central triangle in the figure below.

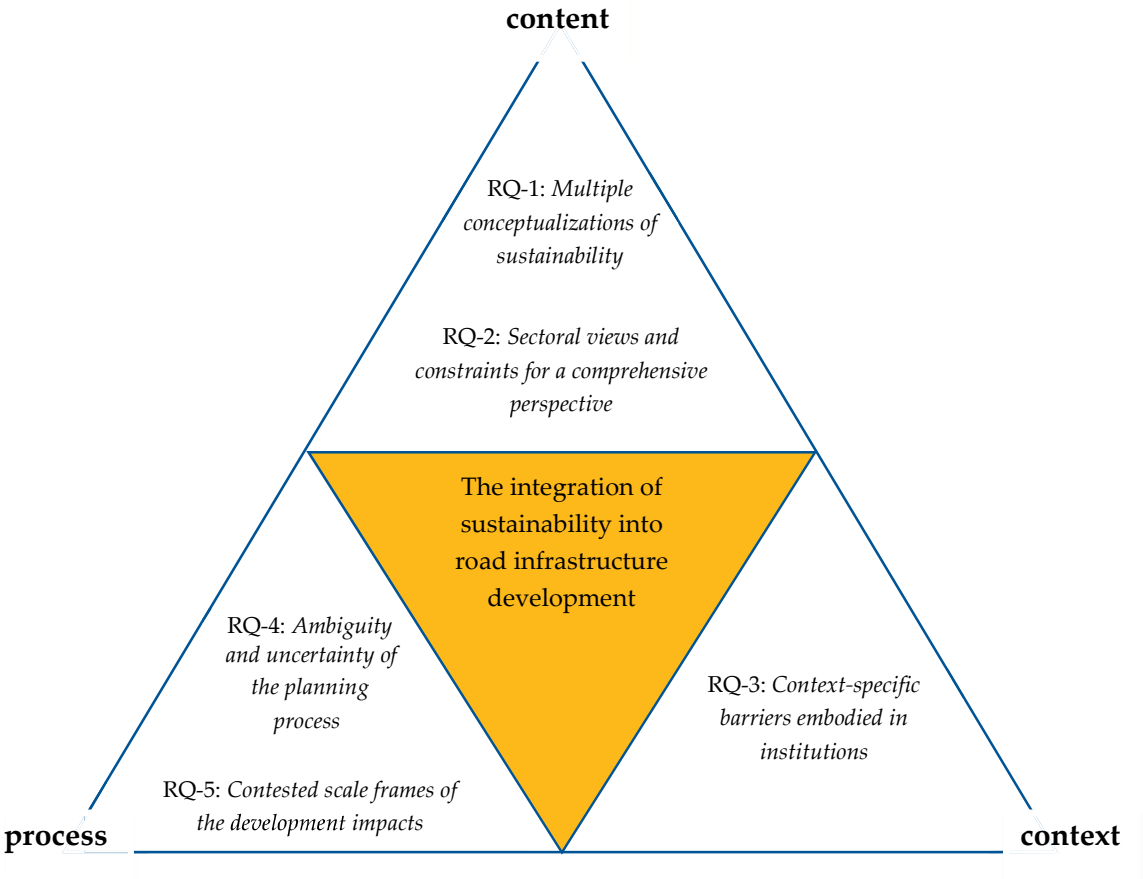


Figure 1.2 Guiding research questions to explore features

1.5. The Indonesia Road Infrastructure Development as a Case

Road infrastructure in developing countries plays a significant role in enhancing economic growth (Diaz-Sarachaga et al., 2017). In Indonesia, more than 70% of people and freight movement are facilitated by road networks (MPWH, 2015) and more than 60% of the public works budget is dedicated to constructing and maintaining roads (Prabowo, 2019). Road networks are seen as vital for the country to enhance its global competitiveness (CMEA, 2011; Schwab, 2016). Therefore, a good-quality, well-connected road network is essential for overall economic development. Road networks are also the main backbones of transportation infrastructure systems. They are intended to distribute economic growth spatially, connect isolated regions, and strengthen regional connectivity (MDP, 2014; CMEA, 2011).

The Ministry of Public Works (MPW) of Indonesia enacted the Strategic Plan 2010 to promote the sustainability concept in infrastructure development. The department conceptualized the integration of the concept in terms of the incorporation of the three pillars of sustainable development. The main aim is to

"balance the three pillars" in actual policymaking for infrastructure development (MPW 2012, p. 125). In 2015, the ministry—in its new incarnation as the Ministry of Public Works and Housing (MPWH)—published a guideline aimed at implementing the sustainability concept throughout the project lifecycle (i.e., planning, design, construction, operation/usage, demolition) (MPWH 2015b). The guideline clarifies the contributions of the individual departments to the efficient use of energy and materials during the construction work (MPWH 2015a). This sectoral (or infrastructural) view leaves out discussions about the broader development impacts, such as landscape and community displacement.

The political ambition of the proponents (mostly government bodies) influences how the development objectives are shaped. This often occurs at the expense of sustainability considerations in actual policy processes. In Indonesia, research has shown that socio-environmental effects are rarely identified during the project planning phase (Delphine et al., 2019). These effects include land-use changes, water conservation, and landscape disruption (e.g., Bueno et al., 2015; Joumard & Nicolas, 2010), which have both immediate and prolonged impacts (Gellert & Lynch, 2003). Indonesia has recently widely adopted a megaproject approach to deliver infrastructure development (KPPI, 2016; Delphine, 2019). This delivery approach tends to reduce social complexity to a limited range of technical or engineering solutions to social and environmental problems (e.g., Kardes et al., 2013; Samset, 2008). The factors used to measure the success of a development project are often limited to scope, budget, and time (Flyvbjerg, 2017; Mišić & Radujković, 2015). Affected stakeholders often have difficulty participating in the decision-making process, which makes the approach less accountable and participative (Delphine, 2019). An open and transparent decision-making process is rare in Indonesian spatial planning (Rukmana, 2015), which increases the probability that these stakeholders are excluded from the entire development process. Othman (2013) found that policymakers in most developing countries frequently struggle to integrate short-term and long-term objectives into the planning phase of development projects. Regmi (2014) argues that ineffective coordination and a lack of awareness are common in most Asian countries, which makes it difficult to achieve a sustainable transportation system. This argument is reflected in the challenge of achieving the integration of sustainability into road infrastructure development in Indonesia, or in developing countries in general.

The above shows that road infrastructure development can be a crucial exercise for policymakers in Indonesia to contribute to sustainable development. The development potentially creates social conflicts as a result of pollution, minimal local benefits (services or job creation), and the loss of natural resources or ecosystem services. Deficiency of project planning occurs in the form of a lack of transparency and accountability, creating severe social conflicts (Delphine, 2019; Othman, 2013). The conflicts also lead to delays, cost overruns, and reputational damage for the government (Watkins et al., 2017). The increasing power of civil society adds to this

complexity, but it can also create opportunities to generate tailor-made solutions (Van Marrewijk et al., 2008). Therefore, the investigation of how sustainability is integrated in Indonesia can potentially ensure that road investments are less harmful to the environment and more beneficial socially and economically in the long run. The methodologies used to analyze specific projects cases are elaborated in the following section.

1.6. Research Methodology

This section elaborates on the research strategy, the case selection, and the data acquisition and analysis methods. It presents a systematic investigation of features from the content, context, and process perspective from the project cases investigated in depth.

1.6.1. Research strategy

This dissertation is the outcome of five research papers highlighting the answer to each research question. Each of the papers presented in the following chapters has specific methodologies that are elaborated in the individual chapters. The overall research strategy was as follows.

Chapter 2 reports on a systematic review of the degree of integration of sustainability into road project assessments. The review was started by defining some key search terms, followed by a literature search in academic databases (i.e., Scopus and Web of Science), that affect process transparency and repeatability (Gough et al., 2012). Chapter 3 presents the results of semi-structured interviews carried out to collect data. Chapter 4 identifies institutional barriers to integration in the context of Indonesia based on mixed-data collection methods (i.e., semi-structured interviews, followed by an online survey). Chapters 5 and 6 were based on a case study method that had two purposes, namely to investigate in depth a complex interaction of factors affecting the integration (Yin, 2014) and to explain the perspectives and behaviors of stakeholders in specific settings of road projects (Flyvbjerg, 2006).

This research strategy allowed the inference of conclusions despite the limited number of cases. Several stakeholders in specific project settings were selected as interviewees. The stakeholders included project managers, decision-makers, technical project staff, spatial/transportation planners, environmental consultants, and—when appropriate—NGOs and community leaders. Desk research of underlying documents (e.g., policy statutes, assessment reports, spatial plans) was used to complement the study and enhance the internal validity of the research.

1.6.2. Case selection

The study was prompted by the attention paid to integrating sustainability into road infrastructure development in Indonesia (MPWH, 2015a). For detailed investigations, three large-scale road infrastructure projects in different geographical contexts were selected (Figure 1.3). One project consists of multiple road projects spanning 1,200 km of the Trans-Java Road Network Corridors (no. 2 in Figure 1.3). The project was initiated in the 1990s and should be completed by 2022 (KPPI, 2016). Two other projects (no. 1 and no. 3 in Figure 1.3) were launched between 1990 and 2006; they were completed in 2013 and 2014, respectively.

Note: 1) Kelok-9 Highway (West Sumatra), 2) Trans-Java expressway and corridors (Java), and 3) Bali Mandara Highway (Bali). The detail map of each project case is in the respective chapter.

Figure 1.3 Location of the road project cases

The cases investigated are presented in Table 1.1, together with the primary interests at stake. All projects included sustainability considerations as the goals/missions, as identified in policy statements, spatial and project plans, and impact assessment reports. In all these cases, at least two of the following sustainability concerns/interests were considered problematic: road construction inside a nature conservation area, road connectivity improvement to boost economic growth and competitiveness, and the societal wellbeing of the local community. The selection and description of each case are further explained in the subsequent chapters.

Table 1.1 The road infrastructure project cases investigated

Project case	**Location/detail location**	**Main interests that were integrated**		
		Social	**Economic**	**Environment**
The Trans-Java Road Network Corridors	• Regional roads (primary network system)	• Equal access of the people to	• Economic competitiveness	• Conversion of agricultural

Project case	Location/detail location	Main interests that were integrated		
		Social	Economic	Environment
	▪ West Java ▪ Central Java ▪ East Java • Urban roads (secondary network system) ▪ Purwakarta ▪ Cirebon ▪ Semarang ▪ Surabaya	road infrastructure • Jobs/employment • Participation of local communities in sub-local road management • Multifunctional infrastructure provision	(at the national level) • Areal (regions and transportation hubs) connectivity • Elimination of regional disparity (between the northern and the southern part of the Java region)	lands to urban functions • The ecosystem's carrying capacity (degradation of water and land quality) • Forest conservation
Bali Mandara Highway	Bali	• Fisheries' access to sea • Religious site displacement • Social wellbeing and jobs/ employment	• Congestion relief to boost tourist visits • Larger investments in tourism sectors • Regional spatial (metropolitan) cohesion	• Perception of urban environmental quality • Marine resource protection • Land use/ landscape change
Kelok-9	West Sumatera	• Local people's empowerment	• Bottleneck relief for freight and passenger movements • Elimination of regional disparity • Supra-regional competitiveness	• Forest conservation • Habitat fragmentation • Biodiversity loss

Although all cases were taken from the planning practice in Indonesia, they reflect efforts throughout the world to integrate sustainability into transportation infrastructure projects (Fischer, 1999b, 1999a). The cases echo broad concerns in the global South, where the desire for economic development is urgent, but environmental considerations are still on the margins (Diaz-Sarachaga et al., 2017; Othman, 2013).

1.6.3. Data collection and analysis

Empirical data were collected through a mixture of methods, namely desk/document research, semi-structured interviews, and an online survey. The methods were selected because they were complementary and facilitated triangulation. The application of multiple methods has been proven to increase research validity through the cross-checking of multiple data sources and analysis results (Kumar, 2014). Overall, the study applied three methods, which are briefly described in Table

1.2. Each empirical chapter that follows elaborates in more detail the types of data collection and analysis methods.

Table 1.2 Data collection and analysis methods

Chapter	Case	Data collection methods			Data analysis methods
		Desk study	Semi-structured interviews	Survey/ online question-naire	
Chapter 2	Sustainability assessment of road projects reported in academic databases	X			• Quantitative content analysis (multivariate analysis) • Qualitative content analysis (bottom-up coding)
Chapter 3	The Trans-Java Road Network Corridors	X	X		• Quantitative analysis (descriptive analysis: tabulation) • Qualitative analysis (axial coding)
Chapter 4	The Indonesian planning practice in implementing the integration	X	X	X	• Quantitative analysis (descriptive analysis) • Qualitative analysis of the interview results (axial coding)
Chapter 5	Bali Mandara Highway, Kelok-9	X	X		• Policy document analysis • Qualitative analysis (bottom-up coding)
Chapter 6	Bali Mandara Highway	X	X		• Policy document analysis • Qualitative analysis (bottom-up coding)

Desk research

A content analysis of academic reports, policy and planning documents, assessment reports, websites, and newspaper articles was used for specific project cases. It was performed from October 2016 to October 2018. This method was applied to gain insights into sustainability indicators in assessment reports, project missions, and goals in monographs and project plans, and spatial policy documents and plans. By using this method, the researcher also collected sufficient data and information on different interests and expected outcomes of the road projects from online and printed newspapers and the governments and NGOs' official websites.

Semi-structured interviews

Seventy six semi-structured interviews were conducted with project managers, decision-makers, environmental and planning consultants, tool developers, road engineers, spatial/transportation planners, and experts in public agencies and

universities between August 2017 and October 2018. The interviews provided insights into multiple perspectives and frames on the sustainability of road development projects, possible barriers, and capacities that the actors had experienced in striving to integrate sustainability into those projects. The selection of the interviewees was made by scanning project monographs and reports via the connection provided by the Ministry of Public Works and Housing, and then through snowball sampling.

The interviewees were selected based on the following criteria: (i) their tasks related to spatial, infrastructure, and environmental planning, and project management in public departments, NGOs, research institutes, or universities; (ii) their positions as policymakers/ decisionmakers, technical staff, planners, community leaders, and consulting experts; (iii) they operated where the road projects were carried out. Some interviews were held more than once if the researcher wanted to clarify information or gather more information. All interviews were performed through face-to-face interaction, unless the interviewees requested otherwise (i.e., phone interviews). On average, the interviews lasted 50–60 minutes. They were digitally recorded, transcribed, and stored by the researchers (unless the interviewees requested otherwise). Appendix A contains a list of the interviewees, and Appendix B includes the interview questions related to the integration of sustainability into road projects.

Online survey

An online survey was conducted by sending a questionnaire form to the spatial planners and road engineers of two prominent associations in planning consultancy: the Indonesian Association of Planners (IAP) and the Indonesia Road Developer Association (IRDA). The survey was carried out between August and October 2018, with the aim of obtaining the perceptions of planning practitioners of the barriers to implementing a sustainability assessment tool. Lists of practitioners were gathered from both associations, and the questionnaire was sent via email and messenger applications.

The questionnaire was based on the data gathered from the interviews and desk research. It was constructed prior to the data collection with the assistance of seven researchers and experts from research institutes and universities who were members of the working group at the Ministry of Public Works and Housing with tasks to develop guidelines for road development projects. Appendix C presents the final content of the questionnaire. Data collected from interviews and surveys among different stakeholders and those obtained from secondary sources were related to one another by triangulation. The selection of documents and the sampling of interviewees is explained in more detail in the following chapters.

1.7. Dissertation Structure

As mentioned, this dissertation is structured around five research papers either submitted or accepted for publication, and two chapters consisting of the introduction (this chapter) and the conclusion (Chapter 7). The chapters submitted to the scientific journals which are included into this dissertation are based on their latest form of publications or review processes. Each paper addresses one of the five sub-research questions and contributes to answering the main research question. The title of each chapter and its publication status are given in Table 1.3.

Table 1.3 Chapter titles and publication status

No.	Chapter/Title	Journal	Status
1.	Ch. 2: A systematic review of indicators to assess the sustainability of road infrastructure projects	European Transport Research Review	Published
2.	Ch. 3: The sectoral lens and beyond: Exploring the multidimensional perspectives of sustainable road infrastructure development	Research in Transportation Business & Management	Published
3.	Ch. 4: Identifying barriers to implementing an SA tool for road project planning: An institutional perspective from practitioners in Indonesia	Environmental Planning and Management	Published
4.	Ch. 5: Coping with strategic ambiguity in planning sustainable development: Balancing economic and environmental interests in two highway projects in Indonesia	Impact Assessment and Project Appraisal	Published
5.	Ch. 6: Contestations of scale frames over the sustainability of mega-infrastructure project development: The case of the Bali Mandara Highway	Submitted	Under review

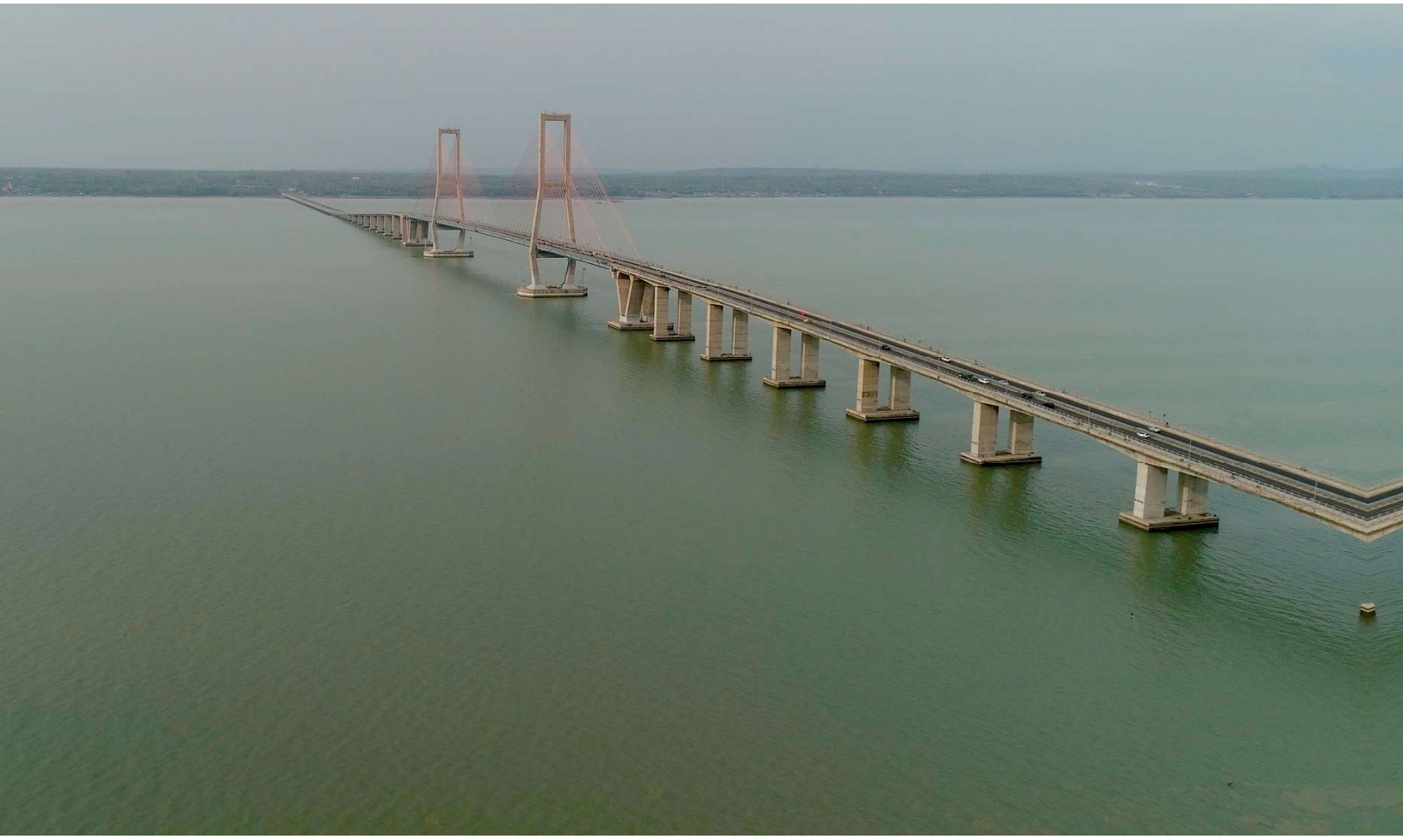
Chapter 2 first discusses the extent to which road infrastructure assessment tools have incorporated sustainability. It then further examines the content features of the integration, such as the time and space dimensions, and environmental considerations, that are commonly deployed in sustainability assessment. The knowledge gathered helps to explore the possibility of constructing an integrative approach that brings together diverse sectoral elements constituting the comprehensive perspective of the sustainability of road infrastructure development. Chapter 3 explains the limitations of sectoral and comprehensive perspectives on

sustainable development. Chapter 4 focuses on the analysis of the institutional constraints on integrating sustainability into road project planning. This chapter promotes an understanding of the role of context in limited integration and uses the results to develop strategies for dealing with the deficit.

Chapter 5 outlines strategies to cope with the ambiguity and uncertainty of project planning processes. By using two cases of large-scale road infrastructure projects, the chapter explores specific policy elements that contribute to integration. This chapter will help planners and policymakers structure decision-making processes to deal with ambiguity and uncertainty, by making use of impact assessment procedures more effectively. In Chapter 6, the dissertation applies a political scale framing theory to illustrate social interactions on viewing the complexity of development impacts. The chapter substantiates the presence of multiple frames of problems and solutions at various scales that complicate the integration of sustainability throughout the development phases.

Chapter 7 presents of the main findings of and reflections on the study. It brings together the conclusions of the individual papers and concludes with the features that determine the successful or limited integration of sustainability into road infrastructure development.

2. A Systematic Review of Indicators to Assess the Sustainability of Road Infrastructure Projects



Suramadu suspension cable bridge, Surabaya, Indonesia ©Alexpunker

Abstract

Background and Objective: This study aims to (i) identify promising approaches that include indicators reflecting core sustainability criteria, (ii) determine the criteria that were insufficiently covered as indicators, (iii) develop an integrated indicator set covering all criteria.

Study Design/Materials and Methods: A systematic review was performed to obtain all related papers/reports in two academic databases, Scopus and Web of Sciences. The indicators extracted from papers/reports were first coded, then evaluated by quantitative and qualitative content analysis.

Results: The project appraisal methods for decision-making is found to be a promising approach that covers more extensive criteria than others. Two criteria – namely *adaptation and precaution* and *intergenerational equity* – were hardly ever adopted as indicators. Ten main groups of indicators were extracted to construct an integrated set that incorporates all criteria.

Conclusion: Some criteria appear to have become mainstream indicators, while others deserve attention. The safest choice is to combine multiple methods/tools or adopt the integrated set developed for an exhaustive criteria inclusion.

Keywords: *sustainability criteria, impact assessment, cost-benefit analysis, cluster analysis, intergenerational equity*

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2.1 Introduction

Since the late 1980s, the emergence of the *sustainable development* concept has sparked interest from academia, government agencies, business organizations, and civic communities in developing a tool to help decision-making towards sustainability, called sustainability assessment (SA). SA refers to "a methodology that can help decision-makers and policy-makers decide what actions they should take in an attempt to make society more sustainable" (Devuyst, 2001, p. 9). The main aim of SA is to ensure that plans and activities make an optimal contribution to sustainable development (Verheem, 2002). SA has increasingly become a common practice in various areas, such as product, policy, and institutional appraisals (Sala et al., 2015), as well as in project evaluations (Bueno et al., 2015). As a concept, sustainability generally denotes a balance of economic, social, and environmental goals with a long-term (intergenerational) concern (Gudmundsson et al., 2016; Sala et al., 2015).

In transportation projects, SA is applied to evaluate whether a project "contributes to favor economic development and fulfill the transportation needs of the society in a manner consistent with ecological and human values" (Bueno et al., 2015, p. 642). SA is an advanced methodology to ensure that decision-making is comprehensive and inclusive, meaning that it covers all three dimensions/pillars of sustainable development (i.e., environmental, social, and economic dimensions), including the indirect effects (Hacking and Guthrie 2008; Sala et al., 2015). Political ambition can play a huge part in the planning of road projects. Such projects have vital roles in enhancing regional growth and economic competitiveness, especially in developing countries (Diaz-Sarachaga et al., 2017). However, environmental aspects are relatively neglected and frequently only incorporated later on. Traditional impact assessment tools are often solely concerned with the environmental dimension, while the social and economic dimensions are less often considered (see Fischer (1999) for strategic environmental assessment of transportation projects). This paper focuses on road infrastructure projects because of their impacts on the environment and society (Goodenough & Page, 1994; Lidskog & Soneryd, 2000; Willetts et al., 2010). These projects are often key drivers of landscape transformations, habitat fragmentation, and societal change on both global and local scales (Friedrich, 2015; Ree et al., 2011), with impacts lasting for long periods (e.g., Feitelson, 2002; Santos et al., 2010) and producing intergenerational consequences (e.g., Grieco, 2015; Lucas, 2006). Therefore, a better inclusion of sustainability dimensions is needed.

Bueno et al. (2015) categorized methods and tools for the SA of transportation projects into three distinct approaches: (1) project appraisal methods for decision-making, (2) techniques for impact assessment, and (3) sustainability assessment methodologies. These approaches often adopt generic indicators that allow for uniform application in different situations. The purpose of these indicators is to identify trends, predict problems, set targets, evaluate solutions, and measure

progress (Litman, 2007). The indicators also serve as a compass for desirable development paths and communicate knowledge through the use of specific variables. The investigation of indicators in the SA of road infrastructure projects can provide general insights into whether a project and its components are contributing to sustainability. First, these approaches differ in their application of the indicators with regard to focus, number of attributes, and the methodological concepts (and frameworks) used (Gudmundsson et al., 2016). Second, the interpretation of indicators varies concerning what sustainability means and which indicators to include (Bond & Morrison-Saunders, 2009).

After years of deliberation and experimentation, "it is not difficult to discern a limited number of common themes and broadly accepted general positions" to interpret sustainability (Gibson et al., 2005, p. 95). Gibson et al. (2005) developed eight basic requirements to attain greater sustainability that highlight the main criteria/aspects in SA. Based on these criteria/ aspects, this study examined the indicators for the SA of road projects in academic papers. Bond and Morrison-Saunders (2009) suggest that, at present, SA seems prone to manipulation to suit particular discourses. This paper therefore provides a starting point for the development of an inclusive and balanced use of indicators. Such an effort can avoid the tendency to promote a specific frame of outcomes (such as economic growth instead of societal wellbeing) in the SA of road infrastructure projects. The primary research question (RQ) was: *To what extent have sustainability criteria/aspects been incorporated as indicators to assess road infrastructure projects?* Three sub-RQs were also formulated:

(1) Which sustainability criteria have the papers already included as indicators to assess road infrastructure projects? Is there a robust assessment approach based on the inclusion of these criteria?

(2) Which sustainability criteria are sufficiently or insufficiently covered as indicators in the examined papers?

(3) How can an integrated indicator set be developed and be further implemented to assess the sustainability of road infrastructure projects?

In order to answer the RQs, both quantitative and qualitative research methods were employed. A systematic literature search was conducted in two databases, Scopus and Web of Sciences. The following section outlines the theoretical framework. This is followed by the research methods.

2.2 Theoretical Framework

2.2.1 Approaches to the Sustainability Assessment of Road Infrastructure Projects

Scholars distinguish SA approaches differently. Sala et al. (2015) categorize them according to the level of integrated-ness, ranging from a general method for decision support (such as multicriteria analysis and fuzzy analysis) to a more integrated tool/method (such as a genuine progress indicator or lifecycle sustainability assessment). De Ridder et al. (2007) divide the approaches based on their potential role in the assessment phases: (i) participatory tools, (ii) scenario tools, (iii) multicriteria tools, and (iv) accounting and model tools. Bueno et al. (2015) classify the methods and tools in the SA of transportation projects into three distinct approaches: (i) project appraisal methods for decision-making, (ii) techniques for assessing impacts, and (iii) sustainability assessment methodologies. This study adopted Bueno's classifications to investigate how SA is applied to guide decision-making in different project stages (i.e., planning, construction, usage) in order to capture various sustainability elements of road infrastructure throughout its lifecycle. The first approach has been extensively used by decision-makers to plan road projects. Some of the tools in the third approach, such as the rating system tool, have now become popular (Griffiths et al., 2018).

Project appraisal methods for decision-making

This approach is employed as an ex-ante evaluation to compare and select alternatives once it has been decided to implement a road project. Two methods are included in this approach. First, cost-benefit analysis (CBA), which supports sustainability by providing a "tangible and rational" judgment of the benefits and costs associated with alternative versions of a project (Damart & Roy, 2009). CBA is based on the monetary values of user benefits (e.g., travel time savings) and other "negative" effects (e.g., energy consumption, resource use, and CO_2 emissions). The second method is multi-criteria analysis (MCA). By using this method, several criteria – including those that are difficult to monetize and quantify – can be considered simultaneously (Beria et al., 2012). MCA can cover project impacts comprehensively (i.e., the environmental, social, and economic impacts) and enable the involvement of stakeholders through the inclusion of their subjective judgments (Pope & Morrison-Saunders, 2013).

Techniques for assessing environmental/social impacts

The second approach is aimed at quantifying the environmental efficiency of road projects (Stripple, 2001). Life-cycle assessment (LCA) is a technique used to assess the environmental impacts of a product, activity, or process (mostly in construction and operation stages). It is deployed to evaluate the sustainability performance of the whole project cycle, from cradle to grave (material extraction, manufacturing, transportation and distribution, utilization and maintenance, energy consumption,

and waste handling) (Santos et al., 2015). Second, social LCA (SLCA) was developed to incorporate social impacts in LCA (Jørgensen et al., 2008). This method – which is often called a social impact assessment – quantifies the social and distributional effects of projects throughout their lifecycles. Bueno et al. (2015) argue that SLCA uses a broad definition of social impacts, but still lacks a specific framework to guide implementation.

Sustainability assessment methodologies

The sustainability assessment methodologies approach is an ex-post project evaluation, aimed at assessing full accounts of project effects based on best practices. Bueno et al. (2015) elaborate it into (i) rating systems and certification, and (ii) frameworks, models, and guidelines. First, the rating system and certification contain a collection of best practices to incorporate sustainability into road projects (Lew et al., 2016). This tool is associated with a standard metric of points or credits that are used to evaluate and compare the sustainability elements of projects (e.g., pollutant loading in stormwater runoff, pavement design life, recycled material uses, pedestrian access). The rating system often comprises a self-evaluation mechanism developed for civil infrastructure projects, e.g., Greenroads, GreenLites, I-LAST, INVEST, and BE2ST-In-Highways. The second category has a much broader scope and includes software tools for modelling and forecasting. Some of the tools have already been extensively applied, such as the UK Department of Transport Analysis (Web TAG) and Scottish transport appraisal guidance (STAG). These tools are deployed to (i) to represent best practices, (ii) provide expert advice for transportation projects, and (iii) establish criteria for assessing options. Therefore, tools in this approach use criteria to provide information about best practices and procedures related to ideal road projects and to improve road sustainability performance based on the assigned criteria (Bueno et al., 2015).

2.2.2 Core Sustainability Criteria for Evaluating Indicators

Numerous sustainability criteria can be extracted from literature to examine indicators in SA. The literature provides criteria for extensive areas of practice, including agricultural undertakings (Becker, 1997), urban development (Devuyst, 1999), nature conservation (Guijt et al., 2001), and spatial planning (Pope et al., 2004). However, none of the criteria found is explicitly used for assessing road infrastructure projects. The criteria of Gibson et al. (2005) are used here to develop what they refer to as "a minimal set of core [sustainability] requirements" (p. 95) and "key changes needed for progress towards sustainability" (p. 115). The criteria are elaborated into (i) socio-ecological system integrity, (ii) livelihood sufficiency and opportunity, (iii) intragenerational equity, (iv) intergenerational equity, (v) resource maintenance and efficiency, (vi) socio-ecological civility and democratic governance, (vii) precaution and adaptation, and (viii) immediate and long-term integration.

Based on these criteria, this paper gauges whether approaches and indicators in the SA of road infrastructure projects have already considered sustainability in implementation.

Gudmundsson et al. (2016) distinguish three aspects of indicators for transportation development, namely (i) dimension, (ii) comprehension, and (iii) staging/position. The "dimension" refers to the movement of the indicators (in space and time) to illustrate the importance of contexts in SA. The comprehension of indicators conveys an inclusion of information about what needs to be measured, for example, sustainability pillars (i.e., economic, social, and environmental). The staging presents activities at different stages (i.e., design, planning, construction, usage) that the indicators support to achieve the sustainability of projects. The sustainability criteria and aspects of indicators are listed in Table 2.1 The criterion *immediate and long-term integration* is omitted from the list because it includes cross-cutting criteria that should be evaluated at once.

Table 2.1 Core sustainability criteria (a1–g4) and indicator aspects (h–j) to evaluate the papers (based on Gibson, 2006; Gibson et al., 2005; Gudmundsson et al., 2016)

No.	Criteria/aspects	Code	Description/*Example of Indicators*
1.	Socio-ecological system integrity	a1	Build human-ecological relations to establish and maintain the long-term integrity of socio-biophysical systems, e.g., *reducing barrier effects of species, avoiding species habitat fragmentation.*
		a2	Protect irreplaceable human and ecological life support functions upon which human and ecological wellbeing depend, e.g., *avoiding land-use change of agriculturally valuable areas, protection of water bodies.*
2.	Livelihood security and opportunity	b	Ensure that everyone and every community has a decent life and that everyone has opportunities to seek improvements in ways that do not compromise future generations' possibilities for sufficiency and opportunity, e.g., *enhancing cost-efficient movement of goods and people, improving access to jobs/employment.*
3.	Intra-generational equity	c	Ensure that sufficiency and effective choices for all are pursued in ways that reduce gaps in sufficiency and opportunity (and health, security, social recognition, political influence, etc.) between the rich and the poor, e.g., *providing walking and cycling facilities for vulnerable groups of people, improving affordability of road-based transportation services.*
4.	Intergenerational equity	d	Preserve or enhance the opportunities and capabilities of future generations to live sustainably, e.g., *reducing road traffic injuries in children.*
5.	Resource maintenance and efficiency	e1	Ensure sustainable livelihoods for all, while reducing threats to the long-term integrity of socio-ecological systems by reducing extractive damages, e.g., *utilizing*

No.	Criteria/aspects	Code	Description/*Example of Indicators*
			locally obtained materials to reduce energy consumption, reduction of water use in construction.
		e2	Avoid waste production, e.g., *reducing traffic emissions (NO_x, CO, and CO_2) in construction and operation.*
		e3	Cut overall material and energy use per unit of benefit, e.g., *reusing pavement sections for reconstruction.*
6.	Socio-ecological civility and democratic governance	f1	Improve the capacity, motivation, and habitual inclination of individuals, communities, and other collective decision-making bodies to apply sustainability requirements through more open and better-informed deliberations, e.g., *participating communities in assessments and decision-making, conformance with standards and requirements (e.g., technical, environmental, social).*
		f2	Foster reciprocal awareness and collective responsibility, e.g., *improving trained personnel and awareness of sustainability.*
		f3	Strive for the more integrated use of administrative, market, customary, and personal collective decision-making practices, e.g., *integrating project plans with the spatial plans and environmental management plan.*
7.	Precaution and adaptation	g1	Respect uncertainty, *e.g., providing stormwater treatment with a higher level of output quality.*
		g2	Avoid even poorly understood risks of severe or irreversible damage to the foundations of sustainability, e.g., *avoiding disaster-prone areas (e.g., erosion, landslide, other natural hazards).*
		g3	Plan to learn, *e.g., improving individuals and organizations' capacities to mitigate cross-scale effects.*
		g4	Manage for adaptation, e.g., *reducing run-off from pavement areas, providing tree covers to reduce heat gains of paved areas.*
8.	Complete staging	h	The reviewed papers cover materials, energy, and workflows/processes involved in projects throughout the lifecycle (i.e., design, planning, construction, usage).
9.	Comprehension of pillars	i	The examined paper covers all sustainability pillars (social, economic, and environmental) in indicators
10.	Dimension (time, space)	j	The examined paper addresses project-context specificity based on time and space (location)

Table 2.1 was also used to extract detailed indicators from the reviewed papers. The following section explains the research methods used to investigate the approaches, the criteria, and the indicators.

2.3 Methods

2.3.1 Selection and categorization of papers

A systematic literature search was conducted by using two academic databases – Scopus and the Web of Sciences – on June 24 and 25, 2019. The search strategy was initiated by identifying diverse terms that may refer to SA in the databases, such as "sustainability appraisal," "sustainability impact assessment," "sustainability evaluation," and "integrated assessment" (e.g., Hacking and Guthrie, 2008; Pope et al., 2004; Gibson, 2006) (Table 2.2). Both the singular and the plural form of these terms were searched for.

Table 2.2 Synonyms and replacement words as key search terms

Sustainability	Sustainability assessment	Road infrastructure projects
sustainable development	assessment method	transport infrastructure
sustainable	assessment tool	road
	assessment approach	highway
	sustainability appraisal	freeway
	integrated assessment	roadway
	sustainability impact assessment	motorway
	sustainability-based assessment	street
	sustainability evaluation	transport project

In this first selection, 490 papers were extracted by using the key search terms in Table 2.2. Papers representing assessments of other infrastructure projects, such as waterways, energy, and railways, were excluded from our selection. We also excluded papers on small or fragmented elements of road infrastructure (e.g., pavements, roadside facilities) and technological assessments (e.g., innovative construction materials, intelligent systems) to concentrate on the road project scope. Next, we filtered out papers identified as similar reports. Finally, a dataset consisting of 31 papers was analyzed (Figure 2.1). The papers in the dataset originated from the disciplines of engineering, ecology, environmental sciences, geography, and social sciences. Most (15) papers concern European countries, namely Germany, UK, Spain, France, Denmark, Croatia, Poland, and Hungary. North American countries constituted cases in eight papers. Seven papers originated from Asian countries and one from an African country.

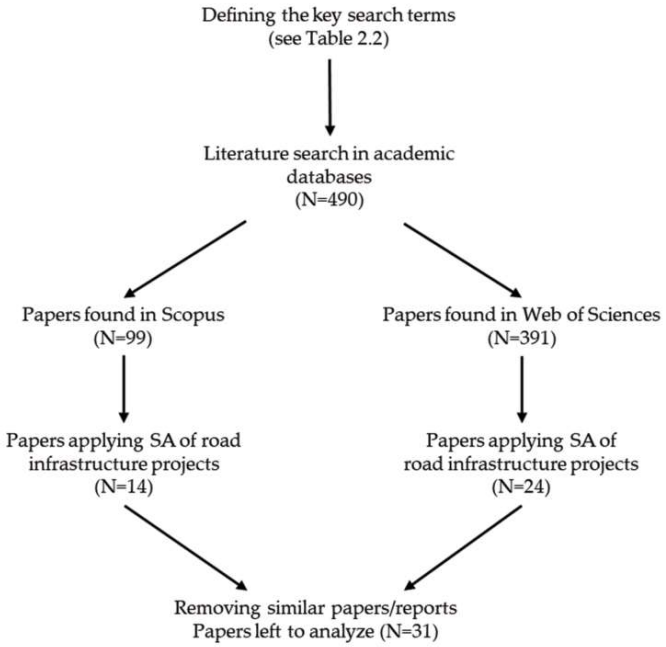

Figure 2.1 The search process

We extracted all indicators found in the examined papers. We categorized the indicators into core sustainability criteria and elaborated on the criteria based on the descriptions given in Table 2.1. The number of criteria applied was also noted.

2.3.2 Analysis methods

Both a quantitative and a qualitative method were used to examine the paper set. To answer the first sub-RQ, we grouped papers by using a cluster analysis, based on the coded description from "a" to "j" in Table 2.1. For the second sub-RQ *(Which criteria are sufficiently or insufficiently covered as indicators in the examined papers?),* we counted the number of papers using the criteria in indicators. The third sub-RQ was based on qualitative content analysis.

Quantitative content analysis

The clusters were formed using a complete-linkage technique, namely an agglomerative hierarchical clustering technique that is appropriate for the analysis of a relatively small sample size (Mooi et al., 2017). Papers with similar characteristics were combined into a cluster (Mooi and Sarstedt, 2011). The application of this technique has more flexibility because no predefined number of clusters should be set. It allows a more intuitive way to define the number (Sinharay, 2010) by exploring the similarity of the characteristics of the dataset in detail based on the criteria included. The cluster set was represented in a tree diagram (a "dendrogram"). There is no exact rule about defining the sample size (Mooi et al., 2018). Dolnicar (2002) observes this size ranging from 10 to 20,000 elements and, by

using Pearson's and Spearman's correlation, concludes that "even very small sample sizes are used for clustering in very high dimensional attribute space" (p. 2). The size may be less relevant to consider since the analysis works with an unknown structure (see Dolnicar et al., 2014).

We used the descriptions in Table 2.1 to establish the coverage of the criteria. A descriptive statistic was applied to represent mode and the percentage of the criteria. Next, categorical principal component analysis (CatPCA) was performed to evaluate the correlation between the criteria. We used the Varimax rotation method to examine the correlation between the criteria and visually present their proximity so that they could be grouped into smaller criteria. The method maximizes the sum of the variances of the squared loadings (or squared correlations) within fewer dimensions (Meulman and Heiser, 2013). The result was a bi-plot informing the dimensions of correlated criteria.

Qualitative content analysis

We started the analysis by extracting all indicators found in the examined papers. All indicators were grouped by using a configurative method (Gough et al., 2012) to develop an integrated set. If an indicator did not match a specific group, a new group was added as complementary to the set. To avoid redundancies, we also investigated whether the extracted indicators addressed specific criteria. Lastly, we compared the findings with the result of the quantitative content analysis.

2.4 Results 1: Sustainability criteria in the SA of road infrastructure projects

Figure 2.2 presents the outcome of the cluster analysis. Four major clusters were identified. Cluster 1 contains the largest number of papers (n = 21) with no more than seven criteria adopted in each paper. This cluster can be divided into two smaller groups (sub-clusters 1a and 1b). Sub-cluster 1a contains all papers using the criteria *socio-ecological system integrity* (a1) and *livelihood security and opportunity* (b). Sub-cluster 1b contains papers that include indicators that apply the criteria *socio-ecological system integrity* (a1), *resource maintenance and efficiency* (e3), and *comprehension of pillars* (i).

Only three papers were found in cluster 2, and only two in cluster 3. These clusters included indicators with more exhaustive and diverse criteria than the other clusters. Finally, cluster 4 comprises five papers with indicators that adopt three similar criteria: *socio-ecological civility and democratic governance* (f1 and f3) and *comprehension of pillars* (i).

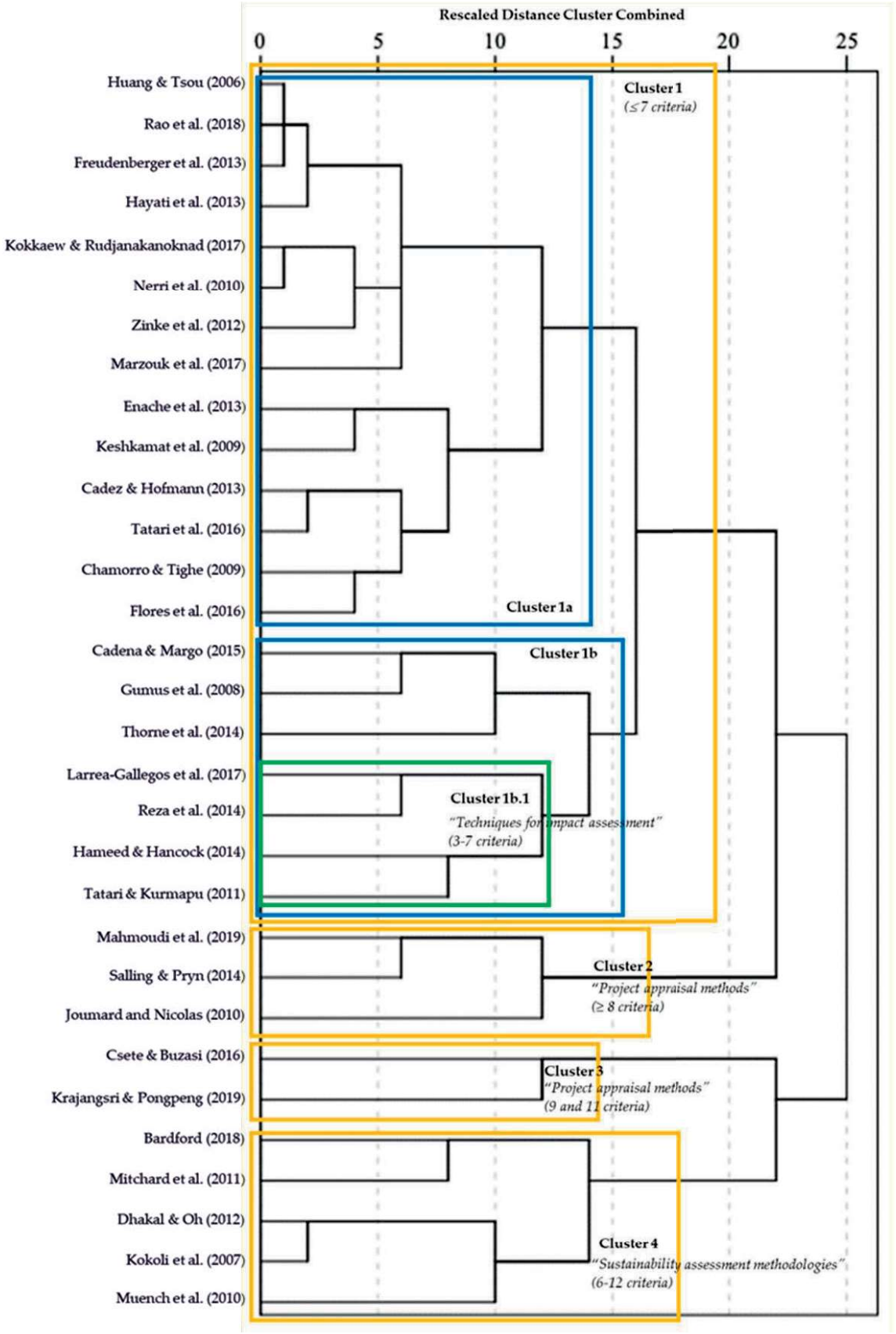

Figure 2.2 The resulting clusters and grouping of the examined papers

In Figure 2.2, the clusters represent the diverse approaches deployed. Cluster 1 contains papers applying all three approaches. One sub-sub-cluster (cluster 1b.1) mainly comprises papers deploying "techniques for impact assessment." All papers in sub-cluster 2 and cluster 3 apply "project appraisal methods." In cluster 4, all papers deploy "sustainability assessment methodologies." Considering that clusters 2 and 3 adopt more criteria as indicators, the approach deployed can be considered more comprehensive than the others. Papers in clusters 2 and 4 successfully adopt the criterion *comprehension of pillars* (i).

The bar plot in Figure 2.3 shows the number of papers that adopt the criteria in Table 2.1 as indicators. Criteria a1 and b are the most used criteria, adopted in 29 of the 31 papers (93.5% of the papers). The criterion *socio-ecological system integrity* (a1 and a2) is used in 28 and 18 papers, respectively. The least adopted criteria are *precaution and adaptation* (g3) and *intergenerational equity* (d) (each appear in only one paper). On average, seven criteria are adopted as indicators in the examined papers.

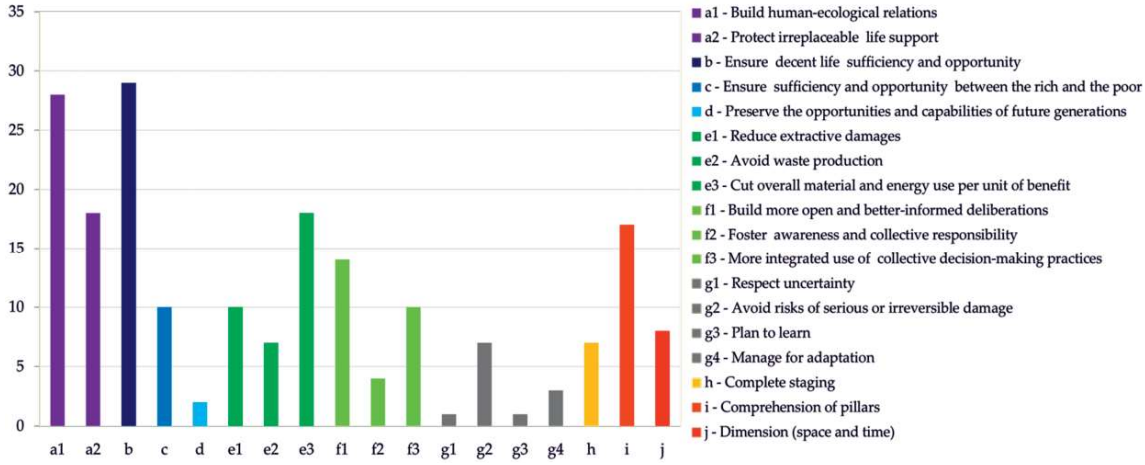

Figure 2.3 Bar plot showing the sustainability criteria addressed as indicators in the papers reviewed

Figure 2.4 depicts two principal components (PCs) that position the proximity between the sustainability criteria/aspects and the approaches. The line direction (vector) visualizes the correlation of the criteria/aspects with the PCs. A strong correlation is shown by the vector proximity that corresponds to the PCs. PC1 and PC2 represent 19.6% and 16.2% of the total variance, respectively. Four criteria strongly correlate with PC1, namely: *socio-ecological system integrity* (a2), *resource maintenance and efficiency* (e2), *comprehension of pillars* (i), and *dimension* (j). This implies that the criteria/aspects can be grouped into fewer criteria. However, these criteria are in a negative correlation with "techniques for impact assessment," meaning that they are hardly included as indicators in this approach.

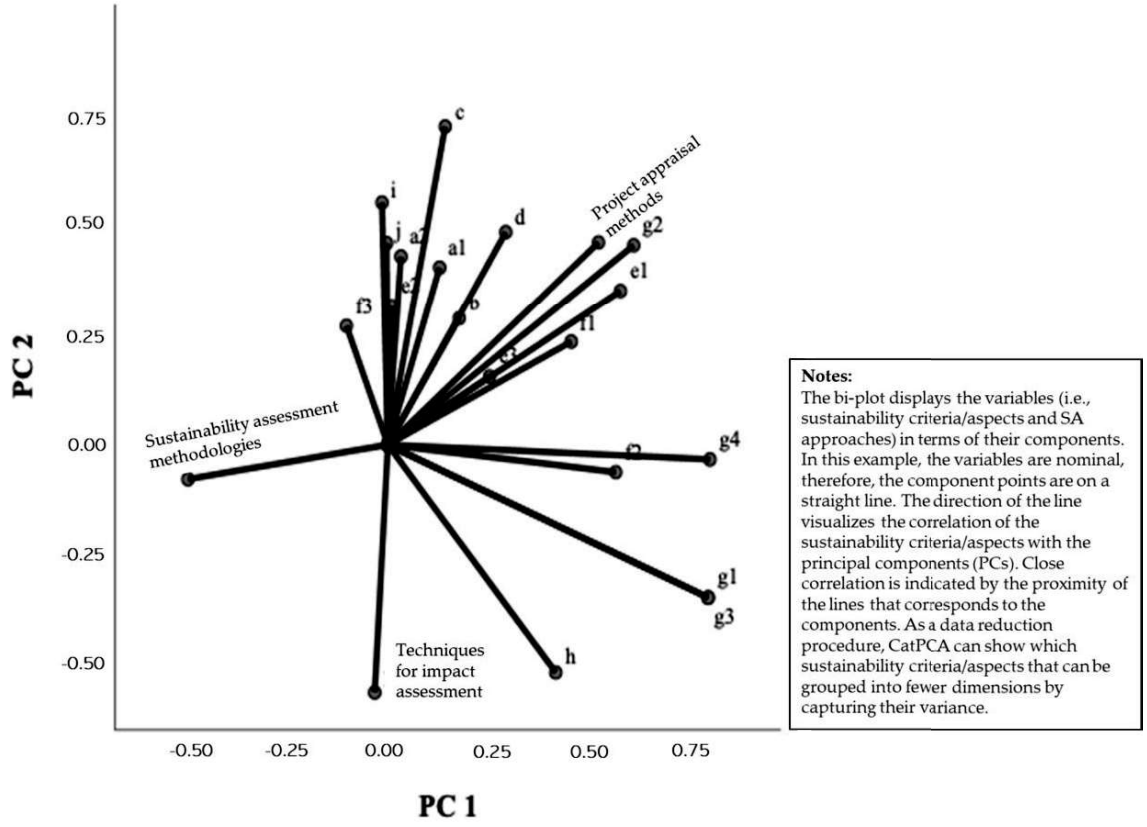

Figure 2.4 The bi-plot of CatPCA derived from the coded descriptions in Table 2.1

Figure 2.4 shows that the criteria *intergenerational equity* (f2) and *precaution and adaptation* (g4) and the "sustainability assessment methodologies" approach strongly correlate with PC2. Both the criteria and the approach are in negative correlation, meaning that the criteria are less adopted as indicators in the approach. The other criteria are more independent than previously mentioned, so they are grouped into a much smaller number of criteria. The figure also shows that the "project appraisal methods" approach has a similar direction to the criterion *'precaution and adaptation* (g4), implying that the approach consistently adopts the criterion. Another finding is that the "techniques for impact assessment approach" has a closer relationship with the aspect of *complete staging* (h).

2.5 Results 2: Sustainability indicators extracted from the examined literature

The qualitative content analysis revealed 10 major groups of indicators in the examined papers (see Appendix D for details). These groups categorized the assessment indicators into: (1) Mitigation of species habitat fragmentation and land use management, (2) Mobility and accessibility improvement, (3) Pollution (soil, water, air, light, noise) prevention, (4) Climate change adaptation and resilient

infrastructure, (5) Community livability improvement, (6) Resource efficiency, (7) Societal wellbeing and equity (both intrageneration and intergeneration), (8) Integrative planning and decision-making, (9) Technological utilization for impact mitigation, and (10) Context-sensitive development.

The findings show that the indicators adopted are not limited to environmental protection aspects (mitigation of habitat fragmentation, land use management, pollution prevention, and resource efficiency), but also cover socioeconomic aspects (community livability, societal wellbeing, and equity) – thus revealing the importance of integrative decision-making to achieve sustainability goals. Two distinct groups of indicators were found concerning the utilization of technology for impact mitigation and context-sensitive development. The finding implies that both process and context are vital in the SA of road projects. The results show that road projects are assessed against various indicators and that some indicators are used more often than others. Without considering the adoption of the sustainability criteria in Table 2.1, the SA of road infrastructure projects may serve specific discourses, such as the mitigation of ecological impacts. The following section discusses this matter.

2.6 Discussion

Based on the results, this section discusses i) the robust SA approach to road infrastructure projects, ii) the criteria sufficiently or insufficiently covered, and iii) the development and operationalization of an integrated indicator set.

2.6.1 Finding a robust approach to assess road infrastructure projects

This paper shows that although considerable efforts have been made to include sustainability criteria in SA approaches to road infrastructure projects, none of the approaches includes all criteria/aspects. This finding substantiates the conclusion drawn by Bueno et al. (2015, p. 643) that "none of the [existing] methods and tools can be used to carry out a holistic appraisal." Figure 2.2 shows that two clusters (clusters 2 and 3) use a more exhaustive set of criteria than the others. Both clusters contain papers applying “project appraisal methods” that consistently adopt more than eight criteria. MCA, in particular, identifies criteria, evaluates alternatives, assigns weighting coefficients to the criteria, and finally evaluates sustainability criteria by ranking the alternatives (Beria et al., 2012). The method allows decision-makers to account for complex problems within biophysical and socioeconomic systems through the inclusion of multiple elements using the criteria (see Kowalski et al., 2009). Pope and Morrison-Saunders (2013) also argue that MCA allows many considerations to be incorporated into the decisions and enables diverse stakeholder perspectives to consider transparently. The “project appraisal methods” approach

therefore has the potential to enhance project performance, as the chance of incorporating sustainability improves in the early part of the project lifecycle (Reid et al., 2012).

Both the "project appraisal methods" and the "sustainability assessment methodologies" approach have become useful to incorporate all pillars of sustainability, as found in clusters 1b and 3. The rating system tool is mostly applied to "rank and score projects against sustainability performance by putting economic, environmental, and social aspects together" (Bueno et al., 2015, p. 632). The "techniques for impact assessment" approach tends to include the criterion *complete staging* (h). The bi-plot result (Figure 2.4) indicates that the approach and the criterion are closely correlated. This finding substantiates that LCA is better deployed to assess project sustainability performance with regards to the efficient use of material and energy throughout the lifecycle (reuse, recycling, recovery, and final waste handling). As few papers apply it, this finding is just a weak indication.

The cluster analysis also shows some problems with the deployment of the approaches. First is the lack of coherence use of criteria to develop indicators in the assessments. The selection of these indicators tends to be arbitrary. Gibson (2006) suggests a sustainability test by using the core criteria set to distinguish whether the assessments are genuinely aimed at achieving sustainability. Second, none of the approaches can successfully include indicators based on the criteria/aspects in Table 2.1. The realistic way to include all criteria is to combine diverse approaches/methods, such as the combination of LCA and CBA. LCA can better assess the inter-temporal aggregation of impacts (intergenerational equity), while CBA covers thoroughly the sustainability pillars as the basis for identifying the project effects in monetary terms (e.g., Manzo & Salling, 2016).

2.6.2 Sustainability criteria fully covered/uncovered as indicators

This paper demonstrates that the sustainability criteria have been varyingly incorporated as indicators. The two most frequently used criteria are *socio-ecological system integrity* and *livelihood security and opportunity*. The criterion *socio-ecological system integrity* is often used to develop indicators that refer to project effects across scales from climate change and ozone layer depletion at a global scale (Csete & Buzasi, 2016; Flores et al., 2016; Larrea-Gallegos et al., 2017; Marzouk et al., 2017; Salling & Pryn, 2015), to soil and local water quality at a fine spatial scale (Kokoli et al., 2007; Muench et al., 2010; Thorne et al., 2014). The criterion *socio-ecological system integrity* is associated with the indicators concerning the mitigation of species habitat fragmentation, land use management, and pollution prevention. The criterion *livelihood security and opportunity* is adopted to construct indicators related to the socioeconomic effects of projects. These indicators can be grouped into mobility and accessibility improvement, community livability (Čadež & Hofmann, 2013; Dhakal &

Oh, 2011; Flores et al., 2016; Kokoli et al., 2007; Larrea-Gallegos et al., 2017; Marzouk et al., 2017; Mitchard et al., 2011; Zinke et al., 2012), and societal wellbeing and equity (Chamorro & Tighe, 2009; Enache et al., 2013; Gumus et al., 2008; Joumard & Nicolas, 2010; Salling & Pryn, 2015). Several indicators concern intergenerational equity (e.g., direct and indirect effects on employment), and transportation costs are also derived from the criterion (Joumard and Nicolas, 2010; Salling and Pryn, 2015).

Two criteria are the least covered as indicators in the examined papers. One is *precaution and adaptation*, which is aimed at evaluating whether irreversible damage and risks to people and the environment have been taken into account in projects (UNCED, 1992). A group of indicators reflects this criterion: resilient infrastructure and climate change adaptation. By using the criterion, indicators are developed to assess the ability of road infrastructure to withstand shocks and unpredicted events (e.g., climate disaster, earthquakes) (Joumard and Nicolas, 2010). Gibson et al. (2005) identify the possible barriers to their incorporation: (i) unawareness of the assessor, (ii) cognitive uncertainty regarding the condition being assessed, and (iii) methodological difficulties. Salling and Pryn (2015) suggest a certainty analysis in CBA to estimate future costs and possible changes in the value of benefit and cost ratios. Bueno and Magro (2015) also recommend the application of sensitivity analysis in MCA to identify to what extent the geographical context of the projects has varied, resulting in different risks (and uncertainty) to consider in the assessments.

The second least adopted criterion is *intergenerational equity*. The criterion is used to evaluate the cross-generational effects of projects through indicators concerning societal wellbeing and intergenerational equity (e.g., long-term employment opportunities). The inherent methodological limitation is often blamed for the lack of inclusion. Gasparatos et al. (2009) argue that most SA methods/tools focus only on economic efficiency, and not on equity. Bueno et al. (2015) state that the "traditional" assessment methods/tools only identify impacts for limited time-horizons, most of which are intangible. Joumard and Nicolas (2010) express the criticism that the typical linear accounting method (such as CBA) imposes a much lower present impact valuation, which is critical for future generations. Therefore, the components of the discount rate need to be reframed in such a way that the intergenerational inequity concerns of the projects can be included and evaluated, such as concerns about agricultural land losses and community disruptions. These findings show that pragmatism might play a role in the inclusion of the indicators. Therefore, a robust SA approach to road infrastructure projects based on the criteria included is still a long way off.

2.6.3 Developing an integrated indicator set

This study categorized assessment indicators in the examined papers into 10 main groups. These groups show that sustainable road infrastructure projects are reflected not only in the mitigation of environmental impacts, but also in the improvement of societal wellbeing and community livability. Some papers included indicators about processes to ensure that sustainability is achieved. Consequently, a group of indicators concerning integrative planning and decision-making was added to the set.

Two criteria – namely *intergenerational equity* and *precaution and adaptation* – were identified in one cluster, and the two are closely correlated (see Figure 2.2). However, both are infrequently adopted as indicators, but can be incorporated in the SA of road projects by applying scenarios, adaptive management plans, and socio-environmental risk estimations (Joumard and Nicolas, 2010). The criteria are further elaborated in two groups of indicators, that is, "resilient infrastructure and climate change adaptation" and "technological utilization for impact mitigation."

Three criteria – *resource maintenance and efficiency*, *socio-ecological civility and democratic governance*, and *comprehension of pillars* – were identified in a similar dimension and are highly correlated in the bi-plot (see Figure 2.4). On the one hand, administrative and market arrangements (standards, regulations, and carbon markets) can enforce efficient uses of energy and materials in road construction and operation. On the other hand, efficiency can be achieved if these arrangements are available and used to guide decision-making if no conflicts are found between the arrangements and the actual implementation (Flores et al., 2016). However, Bond and Morrison-Saunders (2013) doubt that on their own, the arrangements will ensure effective implementation.

Better inclusion of the aspect of *comprehension of the pillars* can be made possible if inclusive decision-making is carried out (Muench et al., 2010). This finding underlines that sustainability is not only about outcomes, but also about processes, such as stakeholder involvement, the coordination of responsible agencies, and sustainable funding mechanisms (Gudmundsson et al., 2016; Ramani et al., 2011). Therefore, integrative planning and decision-making are included as one distinct group of indicators.

Sustainability needs to take into account the aspect of dimensions (space and time) so that the assessment can differ according to the place and the social conditions (Bueno et al., 2015). The qualitative content analysis explored a group indicator that includes options and actions to harmonize road development with the surroundings ; for example, roads are designed to suit local contexts (e.g., safe streets for school zones) and to meet local regulations and standards. In the examined papers, road infrastructure projects already take into account aesthetic,

environmental, and art/culture/community values (Litman, 2007; Muench et al., 2010).

2.6.4 Operationalizing the indicator set

The integrated indicator set provides a guideline on which indicators should be included in the SA of road projects or whether sustainability has already been considered. The full application of the set may be difficult because resource availability (e.g., money, funding, and data) and the complexity of the decision-making process can act as barriers. How should the indicators be chosen in actual assessments?

Some scholars suggest that a framework is needed as a constraining factor when choosing the appropriate indicators (Donnelly et al., 2007; Gudmundsson et al., 2016). This framework maintains the link between the sustainability objective and the indicators applied to monitor progress. Svarstad et al. (2008) show that frameworks tend to favor the particular discourses of the organizations that construct them. For example, the DSPIR (driver–state–pressure–impact–response) framework tends to focus on the pressure indicators (e.g., mobility improvement in congested regions) rather than the state or impact indicators (e.g., species habitat fragmentation and community disruption) (Thérivel et al., 2009). Bell and Morse (2010) suggest that the participation of affected stakeholders can obviate the selection bias and increase opportunities to incorporate multiple discourses in the indicators.

Still, the sustainability outcomes of road projects will depend on the tested alternatives and the baseline against which the individual indicators are applied. For example, if the aim of a proposed road passing through a protected forest is to connect isolated communities, an alternative policy may entail the construction of the road away from the forest, but lead to much longer travel times. Another alternative is to adopt indicators with regard to the mitigation of species habitat fragmentation. But this option may not be so beneficial to people's mobility and areal accessibility, or to intra-generational equity and societal wellbeing (improved access of community members to public services). Irrespective of the indicators chosen, the choice often depends on the decision makers offering contextually sensitive solutions that respect the local environmental and community values, and applying technologies that make the project less harmful to the surrounding area.

This study suggests that the SA of road infrastructure projects should prioritize the inclusion of indicators that can secure natural capital and manage its long-term changing state. Most of the examined papers acknowledge that negative impacts are inevitable and use indicators to illustrate these impacts (e.g., pollution prevention and technological utilization for mitigation). But the assessments are applied without testing whether any critical natural capital is lost or secured (see Thérivel et

al., 2009). As a consequence, the criteria *precaution and adaptation* and *intergenerational equity* – both of which are less considered in the examined papers (Figure 2.3) – need to be incorporated as indicators. By integrating these criteria, SA can identify those who are affected by the change of critical resource/capital and in what ways road infrastructure projects cause less damage to the environment.

2.7 Conclusion

This paper examined the extent to which the assessment of road infrastructure projects has considered sustainability through the inclusion of indicators closely associated with sustainability criteria in the literature. Some criteria appear to have become mainstream indicators, while others deserve attention. None of the reviewed papers considers all criteria, probably for feasibility reasons, but also sometimes out of pragmatism. Special attention should be paid to the criteria *precaution and adaptation* and *intergenerational equity*. Both criteria are either tricky or inconvenient to elaborate as indicators. We therefore suggests that these criteria should be included as indicators more often in future applications. The safest choice is to follow the "methodological pluralism" argument (i.e., the combination of multiple methods/tools) (Gasparatos et al., 2009) for an exhaustive criteria inclusion. Without considering the core sustainability criteria in Table 2.1, the development and implementation of indicators can become arbitrary and tend to serve particular discourses of outcomes (Bond & Morrison-Saunders, 2009). The integrated indicator set presented here provides the full account of the discourses.

The advantage of using a systematic review is evidential with regard to transparency (Petticrew & Roberts, 2005). However, there are also drawbacks. First, in our case, relatively few papers were evaluated, raising the question whether the studied sample was sufficiently representative. Only a small selection of instances of the SA of road infrastructure projects are published in peer-reviewed scientific journals, and we have to bear in mind that these somehow deviate from the majority, which are published in the grey literature. For a paper to be accepted in a scientific journal, it needs to contain some innovative elements, such as the use of an innovative method or a new set of indicators. If that is indeed the bias of our sample, it suggests that the broader body of the literature is likely to be more "on the beaten track" than the papers evaluated here. This issue means that specific indicators are probably even more pronounced in the grey literature.

Future research should be able to elaborate further on the integrated indicator set. The set needs to be completed so that all sustainability criteria can be fully incorporated. The criteria *intergenerational equity* and *precaution and adaptation* require further elaboration, as do the ways in which frameworks can be constructed to better incorporate the criteria. Another research avenue is the investigation of distinct perspectives on sustainable development, namely the comprehensive and the

sectoral view (Gudmundsson et al., 2016), which may influence the selection of these indicators. The use of the indicators also differs according to the scale of the assessments in which they are applied (e.g., global, regional, local, or neighborhood level). Context-specificity may determine how the indicators are selected. The present study shows that the SA of road infrastructure projects is not only a matter of technical deployment of the approaches, but also an integrated decision-making process (Sheate, 2009). Therefore, to improve effectiveness, not only must the approaches be advanced, but also the process and contextual barriers must be identified.

3. The Sectoral Lens and Beyond: Exploring the Multidimensional Perspectives of Sustainable Road Infrastructure Development

Ungaran (a segment of Trans-Java expressway), Semarang, Indonesia ©Ximagination

Abstract

The incorporation of sustainability into road infrastructure development by public agencies in developing countries is limited by what they understand by the notion and how it can be adopted into their tasks. A limited sectoral perspective often dominates this understanding, leading a limited focus on specific sectoral elements included in a policy. This paper offers a framework and a methodology that will equip the agencies to incorporate the concept in an integrative way. A literature review was first conducted to develop the framework, followed by its exploration in the case study of Indonesia's Trans-Java road network corridors. This framework expands the sectoral perspective into a more comprehensive one, conceptualizing sustainability as contributions of various sectoral elements that are still less integrated. The framework accounts for infrastructure and spatial and temporal dimensions, in which environmental, social, and economic effects of road development are discussed and shown to be interrelated. Institutional and political aspects were also added to the framework that demonstrates capacities for and constraints on integration. This study suggests a mixed scanning methodology to incorporate sustainability into road infrastructure development by paying attention to public agencies' tasks and the application's contexts.

Keywords: *sustainability, sectoral policies, spatial perspective, mixed-scanning methodology, micro-level analysis, Indonesia*

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3.1. Introduction

Since the late 1980s, sustainable development has attracted much interest from government agencies, businesses, and civic groups, resulting in various sectoral policy initiatives. The Brundtland Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). This definition has since been widely adopted in many development fields. Bueno et al. (2015, p. 624) define transportation development projects as “sustainable” when they “contribute to favor economic development and fulfill the transportation needs of the society in a manner consistent with natural laws and human values." In the policy sphere, many sectoral policies contribute to sustainable development. Gudmundsson et al. (2016) present these policies in several government activity areas that provide essential public goods and services: health and the environment, housing and urban development, manufacturing, transportation, agriculture, and energy. Öberg et al. (2017) also substantiate that various sectoral policies, such as economic and natural resource efficiency, regional cohesion, and transportation safety, constitute the full account of the Trans-European Transport Network (TEN-T).

Thus, the sustainability of transportation infrastructure networks is supported by many sectoral elements from different public agencies. The sector-specific approach provides focused elements that guide the development policies, programs, and plans under the control of a specific agency (Gudmundsson et al., 2016). The application of this approach in highway planning is profoundly dedicated to mitigating and compensating for adverse environmental impacts (Heeres et al., 2016). On the other hand, a comprehensive perspective links multiple sectoral policies from various agencies (e.g., biodiversity protection, efficient energy use) beyond what a single agency can cope (Gudmundsson et al., 2016; Ramani et al., 2011).

However, a comprehensive account of sustainability is difficult to attain because of limited resources (e.g., knowledge, funds, and skilled personnel) and sectoral fragmentation (e.g., Gudmundsson et al., 2016). A few scholars have documented a systematic framework to identify numerous sectoral contributions and connect them on both a temporal and a spatial scale. For example, Cornet and Gudmundsson (2015) presented a meta-framework to construct a comprehensive and balanced set of indicators to assess sustainable transportation development. However, the empirical support for this framework in a specific institutional setting is lacking. Moreover, intergenerational equity (or the time dimension) is implicitly considered (Suprayoga et al., 2020). This paper explores various sectoral elements in a specific empirical setting and presents a framework and methodology for incorporating multiple sectoral elements into a comprehensive policy on sustainable road infrastructure development. Public agencies often have different objectives and

resources, affecting how the sectoral elements are framed and measured on specific times and spaces. A new framework should cover a comprehensive set of these elements from the perspectives of these agencies (Gudmundsson et al., 2016).

The Trans-Java road networks (TJRNs) development project launched by the government in the 1990s was used as a case. First, road investment now constitutes more than one-third of Indonesia's public works (Prabowo, 2019). Most of this investment is allocated in Java to enhance economic competitiveness (CMEA, 2011) and support economic growth while reducing income inequality and poverty (Dharma, 2016). Second, road expansion is still mainly seen as a way to ease congestion in urban regions, as is the case in many Asian countries (Pojani & Stead, 2015). In Java, such an expansion was found to displace some people and bring about land conversion that threatened food security and ecosystem integrity (Davidson, 2015). Lastly, The World Bank (2014) reported that the road sector in Indonesia produced more than 30% of the country's total emissions, in which most cities producing the emissions are located in Java.

In pursuing sustainable development, public agencies have to incorporate all aspects (i.e., economic, social, and environmental) into policies and measurable indicators. However, this attempt is hindered by strong sectoral fragmentation. From an infrastructural sector perspective, Indonesia's Ministry of Public Works and Housing (MPWH) published a policy guideline on sustainable infrastructure construction, stressing reducing the adverse environmental impacts of road construction (MPWH, 2015). The Ministry of Development Planning, although only indirectly involved in road development, emphasizes road network expansion to link urban regions and isolated regions (MDP, 2014). Both policies focus on different sectoral elements, namely environmental impact mitigation on the one hand, and spillover effects on economic growth on the other. The Ministry of Transportation is responsible for policies on road safety (e.g., GoI, 2011). All of these policies are isolated from each other because of sectoral fragmentation, making it difficult to obtain an integrated view.

The following section presents a literature review. It first elaborates on the sectoral infrastructure perspective, and then adds other sectoral views to present a more comprehensive perspective. The developed analytical framework is then explored in the TJRNs. The third section explains the methodology applied to the case study. The fourth section presents the results, a discussion, and the conclusion.

3.2. Unraveling Sustainable Road Infrastructure Development as an Integrative Matter: The Analytical Framework

A framework is "a way to organize information according to a particular purpose or practice" (Gudmundsson et al., 2016, p. 214). It is needed to identify elements and

the general relationships among them that one needs to consider to achieve particular objectives (Ostrom, 2011). Pei et al. (2010) compare frameworks for sustainable transportation and identify six criteria that a framework must meet to be robust, namely, it should (i) be comprehensive, (ii) connected to goals, (iii) have internal integration, both horizontal (i.e., between departments) and vertical (i.e., between government levels, that is, national, provincial, and municipal levels), (iv) capture the interactions of development effects, (v) use agencies' perspectives, and (vi) identify agencies' capacities and constraints. A systematic literature search was conducted to find sources in Scopus and Web of Sciences to develop such a framework.[1] The review generated a conceptualization of four unique perspectives informing how sustainability is organized as indicators derived from various sectoral elements. The first is the infrastructure perspective, representing one group of these elements that Indonesia's policy strongly focuses. Three perspectives were then added to develop a comprehensive view by including other sectoral elements. As a starting point, an analytical framework was adapted from Witte et al. (2012) to categorize the elements into perspectives. Each perspective comprises elements that can be divided into dimensions for a detailed discussion.

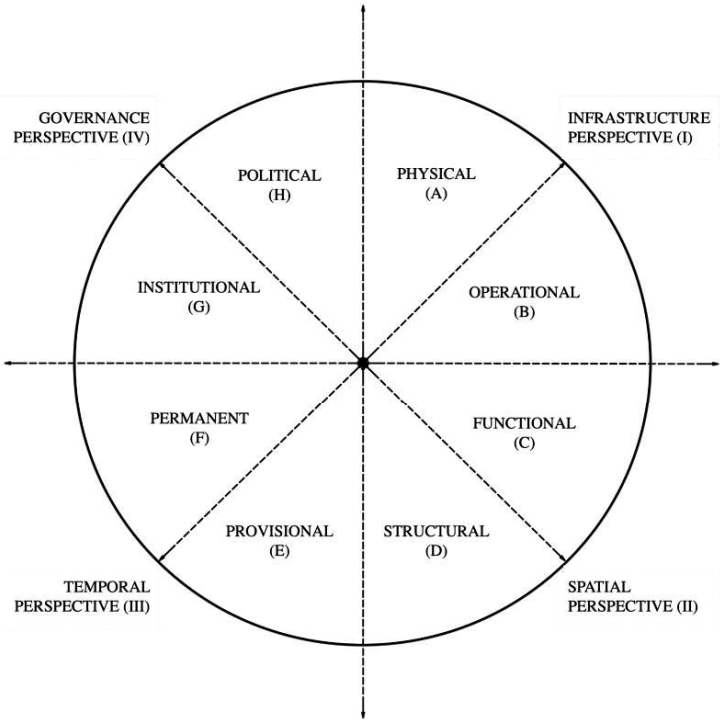

Figure 3.1 The analytical framework (adapted from Witte et al., 2012)

[1] The search process was conducted on June 25, 2019, and resulted in 490 research articles covering the period 2006–19. Only relevant articles were scanned and used for analysis. The contributions stem from the disciplines of engineering, ecology, environmental sciences, geography, and social sciences. In this review, we only highlighted the relevant works (N=31), where the sectoral elements to construct the framework were found. The search terms and the list of examined articles are provided as supplementary material.

Witte et al. (2012) developed the framework to assess and recommend solutions to transportation bottlenecks along the TEN-T Corridor 24. For this study, the framework is used to evaluate multiple elements connected to a single goal (i.e., sustainable road infrastructure). We use the operational dimension instead of the organizational dimension as in the initial framework to present sectoral elements regarding road traffic activities and their impacts. The framework includes a temporal perspective that captures sectoral aspects from a short-term (provisional) and a long-term (permanent) perspective of road development, something that public agencies in some developing countries have failed to do (Othman, 2013). The governance dimensions are included as institutions, and various forms of political support by public agencies are still less coherent to support an integrated policy in developing countries (Pojani & Stead, 2015). Finally, a "lens" analogy is used for these dimensions as "a way of seeing" the elements (e.g., Cornet & Gudmundsson (2015)) by the agencies and as a way to locate the levels (e.g., a micro-and macro-level) at which the elements are found.

3.2.1 Infrastructure perspective (I)

This perspective coincides with sectoral infrastructure elements that focus on the physical aspects of road development. It acknowledges the mitigation of adverse impacts of this construction on the environment. For example, the Indonesia government policy refers to sustainable infrastructure as "… a concept that guides subsequent development activities in constructing a physical infrastructure that complies with economic, social, and environmental considerations" (MPWH, 2015, Article 1). Based on our review, this perspective also pays attention to minimizing the negative impacts of vehicular traffic.

Our literature review revealed that the physical dimension (A) comprises three sectoral aspects: First, the importance of the efficiency of resources (both materials and energy) used in road construction (e.g., Hameed & Hancock, 2014). Second, the importance of road pavement lifetime and durability is to the consumption of the resources (e.g., Dhakal & Oh, 2011). Third, sustainability is related to road resiliency, in which roads can cope with climate and other natural disasters (Csete & Buzasi, 2016). In this dimension, various physical road features (e.g., pavement structures, drainage systems, and soils) are necessary to obtain the resiliency. Regmi (2014, p. 11), for example, suggests that sustainability can be achieved by incorporating "higher design standards for [road] structural elements [by] considering lifecycle cost, using innovating construction technology and sustainable materials."

In the operational dimension (B), the literature discusses sustainability regarding how the road operation can be made more environmentally and socially friendly. First, traffic pollutants—such as GHGs, NO_x, SO_x, traffic noise, and vibration—should be sufficiently mitigated (e.g., Kokoli et al., 2007; Tatari et al., 2016; Tatari &

Kurmapu, 2011). Second, sustainability is advanced as ensuring safe and secure mobility for all by, for example, minimizing accident risks and reducing the social costs of these risks (e.g., Litman, 2007). Third, access to roads (and their facilities) should be secured for all groups of people, especially vulnerable ones, including the disabled, the elderly, and children (e.g., Muench et al., 2010). This perspective frames sectoral elements into physical and operational dimensions. However, the dimensions disregard interactions with the broader social and natural environments in time and space that will be explored below.

3.2.2 Spatial perspective (II)

The spatial perspective concerns the interrelatedness of road infrastructure and other spatial functions (e.g., housing, offices, manufacturing). These functions can be both conflicting—producing externalities—and complementary, creating spillover effects (Heeres et al., 2016). Heeres et al. (2016) consider that road infrastructure can be perceived as functional—connecting locations—and relational, as a part of areas. To focus on our case, the Indonesia Spatial Planning Act (GoI, 2008) refers to spatial management as the "expression of objects in spaces with their pattern (functional) and structural relationships [of these objects] in spaces." The functional dimension refers to the allocation of various land uses and their distribution in space. The structural dimension highlights that road network development can stimulate spatial quality and socio-economic improvement in specific regions, which are discussed in the literature about Land-use Transport Interaction (e.g., Arts et al., 2014).

In the functional dimension (C), roads are perceived as potentially fragmenting neighborhoods and species' habitats and disrupting the landscape integrity (Thorne et al., 2014). Scholars discuss spatial elements of the development as externalities: noise, air, water, and soil pollution. Second, the reviewed literature discusses externalities resulting from land-use conversion to road surfacing (e.g., asphalt) (Csete & Buzasi, 2016). The conversion can occur at the expense of agricultural land and biodiversity (Joumard & Nicolas, 2010). Moreover, new road development can generate vehicular traffic volume and accelerate urban agglomeration (Pojani & Stead, 2015), which displaces green spaces (Neri et al., 2010).

In the structural dimension (D), sectoral elements are discussed concerning the impact of accessibility, connectivity, and regional spillover on economic development because of road development. For example, road expansion may improve access to workplaces, schools, recreation sites, and other activity centers (e.g., Keshkamat et al., 2009). The construction of a new highway also affects goods delivery and passenger mobility, further improving economic growth and competitiveness (Joumard & Nicolas, 2010; Salling & Pryn, 2015). Road

infrastructure development also serves as elements of a spatial sector strategy to distribute urban activities in space and connect vast isolated regions.

3.2.3 Temporal perspective (III)

The temporal perspective pinpoints the core concept of sustainability as a process that enhances both the current and the future potential to meet human needs and aspirations (Brundtland, 1987). From the definition, this perspective categorizes sectoral elements into two temporal aspects of road development: the short-term and the long-term effects. Both effects should be seen as integrated (Dernbach, 2003). The first aspect covers the provisional elements of the development that affect intragenerational equity, and the latter refers to the permanent elements that can determine intergenerational equity.

In the provisional dimension (E), scholars identify sectoral elements influencing sustainability regarding the immediate and temporary effects of development (Joumard & Nicolas, 2010). These effects include landscape change and the temporary displacement of people caused by road construction. The creation of jobs resulting from the construction is also mentioned (Salling & Pryn, 2015; Joumard & Nicolas, 2010). Some other consequences are identified, such as pollutants produced during the construction stage that affect water, soil, and air quality (Larrea-Gallegos et al., 2017).

The literature review explores sectoral elements regarding the permanent effects of a (new) road development, such as the creation of a new structure of logistics costs (Tatari & Kurmapu, 2011) and the status of protected ecosystems and species' habitats (Thorne et al., 2014). Scholars also discuss the direct and indirect effects of road development, such as impacts on ecosystems' carrying capacity and future land-use changes (e.g., Joumard & Nicolas 2010; Keshkamat et al., 2009). Ripple effects, such as climate change and ozone layer depletion at a larger scale, are also identified (Marzouk et al., 2017). The irreversible and uncertain effects are also underlined. In this dimension, scholars also point out sustainability as the ability of road infrastructure to withstand natural disasters and catastrophic events (Joumard & Nicolas, 2010; Salling & Pryn, 2015).

3.2.4 Governance perspective (IV)

Governance is the management of the common affairs of political communities working in networks, involving all sectors and actors in the processes of regulation, coordination, and control (Alexander, 2005; Healey, 2006). Treib et al. (2007) categorize the elements of governance into three dimensions: (i) polity (i.e., actors' interactions can be either hierarchically or non-hierarchically structured), (ii) policy (i.e., regulations, directives, and decisions that are legally binding on different

actors), and (iii) politics (i.e., the interaction of state and private actors in decision-making). Based on the papers reviewed, dimensions (i) and (ii) are grouped into the institutional (G) dimension, and dimension (iii) is included into the political (H) dimension.

The institutional dimension consists of both informal rules (e.g., sanctions and customs) and formal rules (e.g., constitutions and laws) that act as constraints on social interaction (North, 1991; Salet, 2002). Institutional fragmentation, including a lack of coordination, is mentioned as a constraint on sustainable transportation planning for public agencies (Hull, 2008; Stead, 2008) and is a common implementation problem in road infrastructure development or redevelopment (Heeres et al., 2016). Some scholars (e.g., Dhakal & Oh, 2011; Muench et al., 2010; Thorne et al., 2014) assert that agencies have to overcome fragmentation to agree on a set of objectives and mobilize resources. Flores et al. (2016) highlight individual sectoral arrangements (e.g., laws, standards, and guidelines) that guide public agencies' actions toward sustainability.

The political dimension concerns the human agency and interactions of the sectoral actors to manage development processes (Redclift, 1991). The first aspect reviewed includes actors' knowledge, awareness, and other capacities (e.g., Muench et al., 2010; Thorne et al., 2014). Second is the relatively narrow focus and defensive positions of actors to agree on a common goal (Ramani et al., 2011). The dimensions in this perspective categorize elements that act as capacities for and constraints on integrating sustainability into transportation development (Gudmundsson et al., 2016).

3.2.5 Toward an integrative approach to the sustainable development of road infrastructure

Sectoral approaches are not explicitly considered the interrelations between sectoral elements. Such approaches consider infrastructure elements and other sectoral elements as isolated problems. Infrastructure agencies and other government bodies have explored an integrative approach to dealing with the interaction between sectors within a fragmented institutional context (Heeres et al., 2016). Integration, therefore, is about coordinated planning and decision making among several sectoral agencies. These agencies have various frames of thinking in time and space that add a comprehensive perspective on sustainable development (e.g., Gudmundsson et al., 2016).

Related policies on sustainable road infrastructure often show a firm infrastructural sectoral approach (e.g., MPWH (2015) in the Indonesian case). This paper intends to broaden the infrastructure perspective into a more comprehensive one by incorporating the spatial, temporal, and governance perspectives. Figure 3.1 shows that the sectoral elements within the dimensions and perspectives interact

with each other. Following Witte et al. (2012), each dimension/perspective in Figure 3.1 is associated with the others and is represented as interrelated. For operationalization purposes, Figure 3.1 is used as a lens consisting of four sides/quadrants (I–IV), each of which has two dimensions (A–H). Different sides of the lens reflect different sectoral elements. The analytical framework is used to identify (i) which elements do stakeholders perceive to contribute to sustainability, (ii) at which levels the elements are found, and (iii) how they may be interrelated.

3.3. Case Study and Methods

3.3.1 Case study

The TJRNs project is an ambitious large-scale road development project, with 1,167 km of toll expressways connected by arterial and local roads on the corridor networks (Tempo.co, 2017). The expressways are parts of the Trans-Asian Highways (AH-2) (UNESCAP, 2016) and are the main backbone for surface logistics transportation and passenger mobility in the populous island of Java (Figure 3.2). The networks connect major urban regions, such as Jakarta, Bandung, Semarang, and Surabaya, where industrial and service activities and transportation hubs (e.g., airports and seaports) are located. Better connectivity between these regions is expected to enhance economic competitiveness at both the international and national levels through efficient logistics movement (i.e., time travel saving) (CMEA, 2011). The strategic role of TJRNs makes it essential for the central government to take responsibility for the implementation. Provincial and municipal jurisdictions are concerned that the road investment will induce local economic development and accessibility improvement only at the micro-level, that is, in urban regions.

As mentioned in section 3.2.5, the policy regarding road sustainability refers to the mitigation of physical construction's adverse impacts on the environment (i.e., MPWH, 2015). Such definitions regard road development as isolated from other concerns, such as land-use planning, traffic pollution reduction, employment, local economic development, ecosystem conservation, social displacement, and other socio-environmental concerns. In integrating environmental policies into the road infrastructure development, planners and decision-makers rely on two environmental assessment procedures, namely the project-level environmental impact assessment (EIA/AMDAL) (MPW, 2011) and the corridor-level strategic environmental assessment (SEA/KLHS). Both procedures capture environmental impacts; economic and social impacts are only briefly considered (e.g., Fischer (1999)). It is inevitably difficult to achieve integration for some reason. First, no mandatory SEA of the corridors was performed to guide the road development plan. Second, EIA has weaknesses in terms of a lack of macro (strategic) analysis of impacts and a fragmented focus on small projects. Third, both tools are performed too late in the planning process to provide useful recommendations. Finally, the

political interests of building roads to boost economic development have threatened the value of implementing the procedures and recommendations, particularly for the local government, where there is limited financial capacity and innovation to manage roads within their administration (Darmoyono, 2019).

Figure 3.2 The Trans-Java Road Network

3.3.2 Methods

Following Witte et al. (2012), this study applied a mixed-scanning methodology to explore sectoral elements derived from public agencies' perspectives on the sustainability of road infrastructure development. The methodology reduces the discrepancies between the rationalist and the incrementalist approach (Etzioni, 1967, 1986). In the first approach, policy actors become aware of a problem, establish a goal, carefully weigh alternative means, and choose among them. The incrementalist approach seeks to adapt strategies to handle the actors' limited cognitive capacities and reduce the scope and cost of information collection through serial evaluations. Etzioni (1967) suggests the analogy of two cameras to illustrate the application of the methodology: "a broad-angle camera that would cover all parts of the sky but not in great detail, and a second one which would zero in on those areas revealed by the first camera to require a more in-depth examination" (Etzioni, 1967, p. 389). In this study, a macro-level analysis scanned sectoral elements that concern all the network corridors. In contrast, the micro-level analysis stressed the elements found at a specific level, namely urban regions. Several levels with varying degrees of detail and coverage can be included (e.g., national, regional, local); thus, "the [elements] selected can be explored as fully as is feasible" (Etzioni, 1967, p. 389).

For data collection, we initially conducted semi-structured interviews with 24 key interviewees from public agencies operating at national, provincial, and municipal levels. The selection was based on their knowledge and their involvement in road infrastructure development during one or more phases of the TJRNs project, such as planning/design, construction, and operation. The interviewees were decision-makers, middle managers, and planners in agencies' units for road management/public works (5 persons), regional development (4), spatial/infrastructure planning (8), environment (2), and transportation management (5). In the interviews, they positioned themselves as the representatives of the agencies with legal mandates. An interview protocol was developed to guide the interviews. We structured our interview questions as follows: (i) What missions and tasks do the organizations own to support the sustainability of the road infrastructure development?; and (ii) What attempts have been made, and at which levels do the organizations accomplish the goal? To gather in-depth qualitative data about elements at the micro-level, we interviewed spatial/transportation planners in four urban regions, namely Purwakarta (2 persons), Cirebon (1), Semarang (3), and Surabaya (3). Davidson (2015, p. 46) argues that these fast-growing urban regions represent Jakarta's suburban expansion, spanning "across Java's dense north coast, [and] … expressway project designed to connect Jakarta [the capital] with Surabaya (and beyond)." Therefore, specific stakeholders' perspectives regarding road development in these regions also need to be considered.

All interviews were audio-taped and then transcribed verbatim. Before the analysis, the transcripts were sent to the interviewees for comments and confirmation. Texts from the transcripts were extracted and categorized for content analysis (Silverman, 2014) to confirm and expand sectoral elements in each dimension/perspective (Figure 3.1 and sections 3.2.1–3.2.4). We added responses from researchers and experts from universities and research institutes to confirm and refine the levels where the element should be considered (Appendix E). In total, 37 stakeholders were interviewed.

3.4. Multidimensional Perspectives on Sustainable Road Infrastructure Development

3.4.1 Macro-level analysis

Concerning the physical dimension (A), interviewees mentioned sectoral elements that support the sustainability of road infrastructure development (Table 3.1). First, one interviewee said that the efficient use of resources (materials and energy) in road construction is essential in this, as already found in the infrastructural sector policy (i.e., MPWH, 2015). Second, they said that the use of local materials minimizes the amount of energy consumed by transportation. Other sectoral elements complement the dimension, including road resiliency, reliable pavement designs, and well-

functioning drainage systems. Road resilience was said to be the ability of road infrastructure to withstand disaster events and protect the road pavement structure from damage that shortens the lifetime. The interviewees mentioned that reliable pavement designs and pavement durability helped anticipate future traffic growth and obviated early reconstruction, which would consume excessive material and energy.

Table 3.1 Sectoral elements contributing to sustainable road infrastructure development

No.	Perspective/Dimension/Sectoral elements	Level		# of sources	No.	Perspective/Dimension/Sectoral elements	Level		# of sources
		Macro	Micro				Macro	Micro	
I.	**INFRASTRUCTURE PERSPECTIVE**				**III.**	**TEMPORAL PERSPECTIVE**			
A.	**Physical Dimension**				**E.**	**Provisional Dimension**			
	Efficient energy use	X	X	1		Reduction of pollutant emissions during construction		X	3
	Use of local materials	X		1		Just and proper land acquisition and community resettlement		X	5
	Resilience to disasters	X		6		Monitored health and safety of the project's surroundings		X	5
	Sufficient drainage capacity against early damage	X		3		Allocation of jobs to local people		X	4
	Use of recycled pavement materials	X		3		Management of traffic delays (during construction)		X	2
	Reliable pavement design	X	X	5		Water use efficiency		X	4
	Pavement durability	X	X	8					
B.	**Operational Dimension**				**F.**	**Permanent Dimension**			
	Reduction of GHG release	X		3		The maintained ecosystem's carrying capacity	X	X	10
	Enhancement of driving comfort	X	X	5		Mitigation of damage to the ecosystem	X	X	6
	Level of service (LOS) improvement (congestion relief)	X	X	8		Minimization of changes to the landscape		X	5
	Multifunctional infrastructure design		X	3		Minimization of social displacement		X	9
	Multimodal infrastructure provision (walking, cycling)		X	5		Restructured transportation costs	X	X	4
	Mitigation of traffic noise and other polluting emissions	X	X	7					
	Accident risk reduction	X	X	10					
	Travel time saving		X	2					
II.	**SPATIAL PERSPECTIVE**				**IV.**	**GOVERNANCE PERSPECTIVE**			
C.	**Functional Dimension**				**G.**	**Institutional Dimension**			
	Designs based on topographical limitations		X	6		Compliance with regulations and standards	X	X	14
	Provision of green features		X	5		Continual monitoring of compliance	X		10
	Formation of land-use patterns		X	11		Cooperation and coordination of agencies	X	X	11
	Improvement of access to urban centers and transportation hubs		X	8		Implementation of best practices	X		4
	Aesthetic enhancement		X	6		Public participation		X	10
	Locally sensitive street design		X	7		Public-private partnerships	X	X	5
	Protection of agricultural lands	X	X	14		Funding capacity		X	6
	Preservation of forests and species' habitats	X	X	14					
D.	**Structural Dimension**				**H.**	**Political Dimension**			
	Ending regional isolation	X	X	4		Actors' awareness of integrative issues		X	6
	Accessibility enhancement	X	X	10		Shared vision	X	X	5
	Connectivity improvement	X	X	14		Commitment to a long-term plan	X	X	8
	Distribution of spatial development	X	X	16		Actors' knowledge	X	X	5
	Increased economic growth (and competitiveness)	X	X	13		Actors' leadership	X	X	11
						Transparency and trust		X	3
						Presence of a long-term vision	X	X	9

The interviewees named several sectoral elements related to the operational dimension (B). First, three of them said that present road development had increased road traffic volume, inducing a massive release of GHGs into the atmosphere. These

interviewees from the highway unit told the policy of "predict and provide" (e.g., Tennøy (2010)), in which road capacity expansion is required to increase levels of service (LoS) and reduce the amount of GHGs released as a result of congested roads. The policy stipulates that the mitigation of GHG emissions includes increasing average speeds, which had been recorded far below the maximum speed limit (50 km/h on urban roads and 80 km/h on interurban roads) (i.e., MPW, 2011, 2012). When there is congestion, vehicles spend more time on the road, and numerous acceleration and deceleration events lead to an increase in emissions (e.g., Smit et al., 2008). Sustainability was also related to reducing polluting emissions, such as air, noise, and vibration, from vehicular traffic. However, the gas emission sources other than GHGs were not specified in the interviews. Driving comfort was mentioned as facilitating swift logistics and passenger movements (economic benefits from time travel saving). The results show that sustainability is also associated with reducing accident risks, aimed at saving people's lives and improving societal welfare (i.e., GoI, 2011).

From a spatial perspective, the study identified several sectoral elements connecting to sustainability. In the functional dimension (C), interviewees mentioned a concern about preventing the loss of agricultural and forest lands, threatening food security. They admitted that the development has encouraged the rapid conversion of agricultural lands to urban functions (e.g., housing, offices, and factories) and endangered the landscape integrity by fragmenting species' habitats and eliminating biodiversity. In the structural dimension (D), some sectoral concerns were stated, including the connectivity of isolated regions, accessibility and people's mobility, and regional development. Moreover, the interviewees pointed out a spatial development policy to remove isolated regions, facilitate goods and people movement, and attract foreign investment throughout the road network corridors (i.e., MDP (2015)).

Concerning the temporal perspective (III), at the macro-level, sustainability is mostly linked to anticipating the long-term effects of road development. First, the interviewees were concerned about the ecosystem's carrying capacity across the network corridors. They highlighted two central sectoral issues: water scarcity and soil quality degradation because road development is followed by an enormous demand for housing and public utilities. Second, sustainability is associated with overall economic development in the corridors through the restructuring of transportation costs due to reduced travel times and vehicle operating costs. This claim reflected the sectoral policy concerning economic competitiveness (i.e., CMEA, 2011).

The governance perspective (IV) explored the sectoral elements from the institutional (G) and the political dimension (H). In the first dimension, interviewees emphasized the role of regulations and standards in meeting higher environmental requirements. They also pointed out the responsibility of public agencies to monitor

compliance with the requirements. Second, cooperation and coordination between sectoral agencies across different jurisdictional levels were necessary to resolve the competing interests and expand the limited capacities (e.g., a lack of skilled personnel and limited funds). Partnerships with the private sector were also mentioned as being of relevance to enhance funding capacities. The second dimension (H) included several policy elements as being crucial: co-shared visions, political commitments, knowledge of integrated issues, and leadership. These elements were considered to be lacking. The leadership and commitment were necessary to resolve competing interests between sectoral agencies and secure the resources needed to achieve a long-term goal, such as sustainable development.

The findings of the macro-level analysis show that multiple sectoral elements contribute to the sustainability goal, as discussed in the analytical framework. Therefore, sustainable road infrastructure development is not only the contribution of particular agencies responsible for road management. However, the contribution comes from various agencies, which are still less incorporated into the present policy (i.e., MPWH, 2015). The framework proves useful to expand perspectives of the contributing elements that can be further explored at the micro-level.

3.4.2 Micro-level analysis

The micro-level analysis revealed several additional sectoral elements. At the micro-level, sustainability is closely related to the mitigation of road development effects on the urban environment. The interviewees also used a limited time perspective to identify issues related to the displacement of people during road construction. The result shows that limited funding is the primary constraint on maintaining road conditions and enhancing urban regions' connectivity (and accessibility). The findings at this level complement sectoral elements identified at the macro-level, mostly located in the operational (I-B), functional (II-B), provisional (III-E), permanent (III-F), and institutional (IV-G) dimensions (Table 3.1).

In the operational dimension (I-B), the mitigation of traffic impacts on the urban environment was highlighted. First, sustainability is closely related to the improvement of non-motorized transportation modes, such as cycling and walking (i.e., in Semarang). The interviewees mentioned sustainability concerning equal access to roads and facilities for vulnerable users (e.g., the disabled, the elderly, and children). It was said that road expansion in an urban region would balance the area's size and that the traffic volume (i.e., in Semarang and Surabaya) would relieve congestion, decrease fuel consumption, and reduce traffic emissions. This response reflects a common situation in cities in the global South, where road capacity is too small to accommodate present traffic volumes (e.g., Cervero, 2013). The congestion has increased GHG emissions, as noted in the Indonesian government policy (i.e., MPW, 2012). The design of multifunctional roads, such as a combination of road rest

areas and local markets, would unlock the economic potential because it facilitates a meeting place between local sellers and regional travelers (i.e., in Purwakarta and Semarang).

From the functional dimension (II-C), the interviewees underlined harmonization between urban landscapes and road/street layouts. They suggested planting "green" roadsides to create a less harmful and intrusive environment and improve visual aesthetics, including installing street furniture and designing streets for pedestrian safety (i.e., in Cirebon). This concern implies that urban roads/streets can be made attractive and pleasant and environmentally friendly, for example, to promote active travel (e.g., Vale et al., 2016). The interviewees also linked sustainability with the improvement of people's access to public facilities, such as schools, at a city scale (i.e., in the case of Semarang).

Both the provisional (III-E) and the permanent (III-F) dimension were discussed at this level. The interviewees said that road construction impacts the local environment and the community—in the form of, for instance, people displacement, health and safety problems, traffic congestion, and water use—require immediate attention. In the long run (III-F), interviewees said that they needed to pay attention to the consequences of landscape change and social displacement. One interviewee mentioned that the displacement had eroded trust among community members, as road construction created a physical barrier that divided them into smaller neighborhoods (i.e., in Cirebon). However, trust can be sustained and developed through network management strategies that are more than just physical contacts (e.g., Klijn et al., 2010).

Finally, the institutional (IV-F) dimension elaborated some elements as constraints (i.e., funding limitation and low public participation). The interviewees acknowledged that there are limited public funds to support regular maintenance (e.g., Darmoyono, 2019), and poor road condition has threatened people's mobility and access to urban facilities. Public agencies perceived that low public participation as a constraint on gaining public support to related policies and programs, improving ownership, and encouraging self-management of local roads (e.g., urban streets). At this level, broad participation is stimulated as funding is limited to maintenance and rehabilitation. The following section will discuss an integrative approach that captures the interactions of sectoral elements.

3.5. Conclusion

The results show that the sustainability of road infrastructure development is contributed by various sectoral elements from the infrastructure, spatial, temporal, and governance perspectives. Therefore, sustainability is not merely a matter of mitigating road construction impacts, which the existing policy strongly focuses on (i.e., MPWH, 2015). By using the analytical framework, from a spatial perspective,

this study explores the contributions of other sectors, such as regional planning, economic development, environmental management, agriculture, and forest conservation. The temporal perspective revealed numerous sectoral contributions, such as job and employment in short-term and ecosystem degradation, and restructured transportation costs in the long-term. The governance perspective explored the mobilization of sectoral mechanisms, processes, and arrangements by different public agencies for integrating sustainability into road infrastructure development. A vast majority of these sectoral elements were confirmed in this study by focusing on the micro-level.

The identified sectoral elements are not isolated from each other; they intersect and jointly contribute to achieving the sustainability goal. Such interactions are found within and between dimensions/perspectives and between the levels of analysis (i.e., macro- and micro-levels). For example, efficient energy use in road construction can be achieved by utilizing local materials. An improvement in the level of service (LoS) and in time travel saving can contribute to increased economic growth. However, the interaction is complex, and political factors also determine the outcomes (Banister & Berechman, 2001). The identified elements also interact between levels. For example, urban regions, whose primary function is to collect and distribute goods and services, influence sustainability at the macro-level through better connectivity of different land functions (e.g., housing, offices, factories) in urban regions. In other words, sectoral elements found at a higher level are constituted by those at a lower level. Otherwise, sectoral elements found at the lower level affect sustainability at a higher level; for example, traffic congestion that increases GHG emissions at a city scale affect the total production of the emissions globally.

This paper also explored the possible application of a mixed-scanning methodology to unravel the intricate nature of the sectoral elements at a macro and micro level. Most literature on this exploration is still fragmented into sectors and levels, focusing solely on either the micro-level (e.g., urban region) or the macro-level (e.g., network corridor) (Fabbro et al. (2015)). The framework and the methodology presented in this study explicitly show sustainability as an integrative matter, involving various sectoral contributions at different levels. For managerial practice, the methodology helps to identify numerous sectoral elements that should be incorporated into a more comprehensive policy and indicator on sustainable road infrastructure development. The methodology is also valuable to show that public agencies have diverse tasks and mandates, but also a limited capacity (e.g., knowledgeable and skilled personnel, funds, coordination, and political commitment) to include all sectoral elements into a single policy. Thus, in the pursuit of sustainable development, public agencies must become aware of others' tasks and coordinate effectively.

3.6. Discussion

Most decision making by individual public agencies is often carried out in sectoral thinking (Ashford & Hall, 2011). Our study appears to be fragmented sectoral focuses, and the public agencies tend to use sectoral perspectives to incorporate sustainability into a road development policy. Various sectoral elements are found to interact with others (e.g., Jeon et al., 2013). The analytical framework (section 3.2) helps the public agencies to recognize the multiplicity of perspectives on the elements and move away from merely a reactive approach (i.e., impact mitigation of road construction). For public agencies, the framework presented here expands their perspectives on these elements and prepare for the necessary coordination with relevant actors from other sectors for integration (Heeres et al., 2016). As Pojani and Stead (2015) argued, public agencies in developing countries show less awareness of the interrelatedness of these elements and less recognizing the merits of coordination, making it challenging to arrive at a comprehensive policy.

The results show that the mitigation of road construction impacts on the environment is only a part of the overall elements that constitutes sustainability. As in the analytical framework, sustainability is also related to the promotion of economic and societal wellbeing—although the latter is still less explicitly mentioned. Therefore, the pursuit of the sustainability goal cannot be represented only by a particular agency (i.e., road management/highway agency). Other agencies are also responsible, and they are those assigned to economic development, regional planning, road safety, forest conservation, environmental protection, public administration, standardization, and others. In Indonesia or elsewhere, such a comprehensive view is still less well-formulated in policies because of limited funding and personnel capacities and lacks coordination between public agencies (Darmoyono, 2019; Delphine, 2019; Regmi, 2014).

To sum up, one can lose track of multi-sectoral and multilevel analysis when using a sectoral perspective, but a comprehensive perspective is limited by agencies' capacities. The realistic choice is to apply both perspectives where appropriate. It can be performed by mapping and evaluating the sectoral elements at particular levels into specific tasks of the agencies and policy objectives. The mixed-scanning methodology helps to identify which policy elements need to consider at a macro-level (i.e., network corridors) or a micro-level (i.e., urban regions), and which agencies are responsible for achieving specific policy objectives in a fragmented decision-making environment. Therefore, coordination between these agencies can also be enhanced. The results shown in the Appendix are not for generalization, but they refine the sectoral elements into more detailed spatial levels and provide an overview of the distributions. We suggest that follow-up research transforms the

elements into policies and indicators at appropriate levels and include other stakeholders, such as NGOs and communities, for further exploration.

4. Identifying Barriers to Implementing a Sustainability Assessment Tool for Road Project Planning: An Institutional Perspective from Practitioners in Indonesia

Cisumdawu highway and tunnel, Sumedang, Indonesia ©Klasikdisko

Abstract

There has been a growing interest in developing tools for assisting decision-making in moving towards sustainable development, such as Sustainability Assessment (SA). It is argued here that more advanced and sophisticated tools are less useful than strengthening institutions when it comes to better engagement of stakeholders and more integrated decision-making. This paper aims at understanding barriers that impede the implementation of a SA tool for road project planning by examining how and when practitioners experience these barriers. From the empirical perspective of Indonesian road planning practitioners, the study reveals the five most influential barriers, including i) insufficient funding support, ii) limited skilled personnel that can use the tool, iii) unavailability of data and information, iv) unavailability of a specific arena for decision-making, and v) unavailability of detailed procedures/manuals. This research discusses strategies for successful implementation, particularly in a context that is less favorable to integrated decision-making, such as Indonesia.

Keywords: *institutions, impact assessment, online survey, micro-level, Indonesia*

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4.1 Introduction

Since the emergence of the sustainability concept in the 1980s, there has been a growing interest in developing methodologies for assisting decision-making in moving towards sustainable development. Sustainability Assessment (SA) has recently become a common practice in different areas, such as product, policy, and institutional appraisals (Bond et al., 2012; Sala et al., 2015). Devuyst (2001, p. 9) defines SA as "a methodology that can help decision-makers and policy-makers decide what actions they should take in an attempt to make society more sustainable". Verheem (2002) explains that SA is aimed at ensuring that "plans and activities make an optimal contribution to sustainable development". SA has three characteristics: (i) strategic, having a broader spatial scope than the project itself with a long timescale perspective, (ii) comprehensive, including all dimensions/themes of sustainable development (i.e., economic, social, and environment), and (iii) integrated, using combined/compared techniques (Bond et al., 2012; Hacking & Guthrie, 2008).

For transportation projects, Bueno et al. (2015) categorized SA into three main approaches: 1) project feasibility studies (e.g., Cost-Benefit Analysis and Multi-Criteria Decision Analysis) that evolve towards inclusion of all sustainability dimensions; 2) techniques for impact assessment (e.g., Life Cycle Assessment and Social-Life Cycle Assessment); and 3) sustainability assessment methodologies (e.g., rating systems and certifications, indexes, and guiding frameworks). Among these categories, the first approach is commonly applied as an ex-ante evaluation that supports appraisal and decision-making in selecting road project alternatives. Tsai and Chang (2012) argue that the sustainability impacts of road projects could be maximized if sustainability is considered early in planning and design. Moreover, applicators' opportunities to incorporate sustainability decrease as the project moves throughout its life cycle (Reid et al., 2012).

Following Bina (2008), this paper argues that more advanced and sophisticated assessment tools are less useful than strengthening institutions in seeking better engagement of stakeholders and more integrated decision-making. Indeed, some technical advancements have been made to improve the application in indicator choices, data aggregation, data requirements, data collection, and analysis procedures (e.g., Bueno & Magro (2015), Joumard & Nicolas (2010)). Further development of these tools does not guarantee that sustainability is achieved (Sheate, 2012). Moreover, the practical implementation is determined not only by the design of the tool itself but also by the context in which assessment takes place (Marsden, 1998).

Recently, SA of road projects has been implemented in the Global South. Diaz-Sarachaga, Jato-Espino, and Castro-Fresno (2017), for example, developed SIRSDEC to facilitate the selection of sustainability indicators for road projects based on countries' and location-specific needs. Tsai and Chang (2012) propose a framework

to evaluate sustainability items of road construction and design in Taiwan. Furthermore, Kokkaew and Rudjanakanoknad (2017) designed a Green Growth Index as an ex-post evaluation for sustainability performance of highway projects in Thailand. This research mostly concerns ex-post evaluation with a strong focus on the technical development of the tool. Fewer concerns are given to the role of the context that determines effective implementation. For the implementation, the tool has to integrate all sustainability dimensions (Eggenberger & Partidário, 2000; Fischer, 2006), the techniques (De Ridder et al., 2007; Hacking and Guthrie, 2008), and the stakeholders' interests (Bueno et al., 2015). Little evidence is available on how SA for road project planning is implemented in practice in the Global South. This investigation may inform the specific barriers that impede tool implementation.

Scholars have already reported several barriers in implementing impact and policy assessments from the perspective of decision-makers and policy-makers in the Global North context (e.g., Nykvist and Nilsson, 2009; Turnpenny et al., 2008). The reports identified some deficits in departments' capacities, such as skilled personnel, funds, and time. However, the perspective of practitioners is still missing in the analysis. Although these stakeholders are essential, practitioners are at the forefront of tool adoption and early implementation. Practitioners here constitute those who apply the tool as part of planning processes both as government officials and external experts. In the Global South countries, a new assessment tool for road projects is often developed by adopting international guidelines for environmental assessments and investments in infrastructure projects (ADB, 2006; OECD, 2012). Practitioners play significant roles in 'trial and error' efforts during early adoption and in meetings with stakeholders, such as government officials, NGOs, local people, and university experts.

This paper aims to identify the institutional barriers that potentially impede the implementation of a SA tool in Indonesia. The study emphasizes the development of strategies that are suited to a specific context of an assessment practice (Alexander 2016). A context here refers to "the organisational and institutional location of the decision-making processes which are themselves situated within and influenced by a given society and its broader social, cultural, and political values" (Bina, 2008, p. 719). The research question is: *What barriers are encountered by practitioners in implementing a SA tool for road project planning in the Indonesian context, and in what ways can these barriers be unraveled based on the findings?*

A combined approach to data collection is applied. First, based on literature, a list of barriers in the Indonesian context is constructed. Second, the study confirms the presence of these barriers in practice through a series of interviews with road planners/engineers, decision-makers, project managers, and experts. Based on these findings, the perceptions of the barriers were obtained from the practitioners in two professional associations. Consequently, the structure of this paper is as follows. The next section sheds light on the institutions that potentially function as constraints for

the implementation. The approach and methods used for data collection and analysis are then discussed. The presentation of the results follows with the identification of the most influential barriers found in the Indonesian context. Finally, the discussion and conclusions are presented.

4.2 An Institutional Perspective on Barriers to Implementing a SA Tool

4.2.1 Contexts and barriers

The role of context has gained considerable attention among scholars to enhance the effectiveness of assessment tools for at least four reasons (e.g., Gazzola et al. (2011), Sala et al. (2015)). First, sensitive cultural circumstances, such as the values and beliefs of stakeholders, frame and legitimize the decision-making process (e.g., Gibson (2013)). Second, the dynamics of power within an institution determine issues, alternatives, expected results, and solutions. Third, different legal and administrative approaches and mechanisms influence how decision-making is carried out (e.g., Gazzola et al. (2011)). Lastly, the context defines stakeholders' aspirations and practices as a result of resources, training, and political commitment (Turnpenny et al., 2008).

Institutions here can be regarded as sets of rules constructing dynamic interaction in a given context. Institutions are 'rules of the game' that arrange behavior and interaction processes through formal and informal constraints (North, 2009, p. 3). North (2009) argued that formal and informal rules could be distinguished. Formal rules include legal instruments and are a product of a formal institution, typically written in law and legislation. On the other hand, informal rules are dynamic and usually unwritten (Helmke & Levitsky, 2004; Rodrik et al., 2004). The informal rules typically imply a social sanction that is affecting people who share a similar worldview. Nykvist and Nilsson (2009) clarify institutions as "*who gets to participate, on what grounds, how is a decision being taken, and where*" (Nykvist & Nilsson, 2009, p. 18). In institutions, rules (structure) and agency (actor, individual, or group who participate in decision-making) can be distinguished. The dynamic interaction between both involves a continuous process of reproduction. Giddens (1984) calls the interaction as the duality of structure.

This paper adopts the "new institutionalism" approach to view barriers to implementing a SA tool. It addresses interaction in institutions that continuously change as they respond to internal factors (agency, rules, etc.) and external factors (culture, social norms, etc.) (Stephen Bell, 2011; Peters, 2012). The approach has extensive coverage; it not only focuses on formal rules as structure, instead of informal rules (Koelble, 1995; Peters, 2012). March and Olsen (1989) elaborate that the approach focuses on organizational structures and interactions, routines and procedures, norms and conventions of behaviors, habits and belief systems, as well as the formal elements of the state. Therefore, institutions are concerned with

relations of works, hierarchies, lines of command, responsibilities, and channels of communication. Routines and operating procedures explain the 'inertia' of institutions which are relatively stable and tend to be difficult, but possible, to change (March & Olsen, 1989). Therefore, institutions here are analyzed to understand to what extent the context is responsive to the implementation and how responsible departments can gain acceptance and legitimacy.

4.2.2 The Indonesian context as a case

In Indonesia, sustainability has been increasingly understood as a strategic policy objective in transportation (Munawar, 2007) and infrastructure development (MPWH, 2015). However, it is still treated as a sectoral issue. In the infrastructure sector, the concept of sustainability is advanced to strengthen environmental consideration in the policies of public work departments. For example, The Ministry of Public Works and Housing (MPWH) emphasizes minimizing adverse impacts of roads on the environment, such as reduction of pavement material and energy use in construction. The Ministry of Transportation has concerns the contribution of road traffic to the production of greenhouse gases and particulates. The 'silos' characters of the sectors need to coordinate sufficiently to obtain an integrated policy. Since the 'big-bang' in decentralization in 2001, road infrastructure development has become highly fragmented (Darmoyono, 2019). Multiple agencies, such as the spatial planning, public works, environment, and the transportation departments at different jurisdictional levels, are involved in the design of road development policies and plans (Miharja & Woltjer, 2010). The Local Government Act of 2014 reflects this 'complexity' of the bureaucratic structure. The situation complicates integrated decision-making.

In integrating environmental considerations into road projects, practitioners apply Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA). SEA is regulated under the Environmental Act of 2009. The public works or the spatial planning department prepare it to evaluate the socio-environmental impacts of spatial development plans, programs, and policies. At the project level, EIA is prepared to mitigate negative impacts and include the measures in final designs (MPW, 2011). However, EIA seems ineffective for a project planning purpose. First, it generally tends to be adopted late in the planning processes (see Soria-Lara et al. (2015) for the Spanish example). Second, there is generally little room available to reflect on the selected road project. Thus, the results only legitimize the project actualization. Moreover, the integration of socio-economic dimensions is still weak in the implementation of both tools (see Fischer (1999) for the case of SEA of transportation projects).

With regards to the deployment of SA of road projects, a rating system tool has been applied by MPWH since 2014 (Suprayoga & Lawalata, 2015). The purpose of it

is to develop best practices that further improve the sustainability performance of road projects. The application of this tool follows efforts worldwide to assess the sustainability of highway projects, such as Greenroads, I-LAST, Envision, and BE2ST-In-Highways (Bueno et al., 2015; Griffiths et al., 2018). In Indonesia, the early development of the rating system tool mainly focused on assessing the physical elements of road projects, such as material and energy use during construction and technology utilization for impact mitigation (Lawalata et al., 2013), with a little support to road project planning.

In 2015, MPWH published a guideline to integrate sustainability concept into infrastructure projects throughout the project life cycle (i.e., planning, design, construction, maintenance, and demolition). The guideline encourages the implementation of SA aimed at assisting decision-making and evaluation performance of the projects. For road project planning, practitioners deploy combined evaluation techniques for project feasibility studies (i.e., CBA and MCDM) that are modified to cover more strategic and comprehensive sustainability dimensions. Such an initiative has also been elaborated in other research (e.g., Sijtsma (2006), Barfod et al. (2011), Gühnemann et al. (2012)). This paper will identify barriers that impede the implementation of the initiative in the Indonesian context.

4.2.3 An analytical framework for identifying barriers

From a new institutionalism approach, Turnpenny et al. (2008) define and simplify an examination of an integrated assessment by "examining activities at different institutional levels". Three distinct categories of institutional levels: viz. the micro, meso-, and macro-level (Table 4.1). On the micro-level, researchers focus on the availability of required resources (e.g., time, funds, and personnel) at the user level. This level category provides information about the deficit model of the tool implementation, where the resource capacities mainly contribute to the barriers. On the meso-level, organizational procedures and management systems of knowledge transfer are pointed out as primary concerns. The broader context of the implementation is presented in the macro-level. This level includes linkages between the implementation of, in this case, SA, with the broader values, norms, and societal goals, and the connections with the broader policy network of the stakeholders (Nykvist & Nilsson, 2009). Several barriers are also presented in Table 4.1, derived from research in the Indonesia context.

Table 4.1 An evaluation framework to explore the barriers to implementing a SA tool

No.	Level	Description *	The Indonesian context**
1.	Micro (individual)	• Resources (time, funds, personnel) available to the tool implementation with a focus on human resource capacities (levels and types of expertise and skills of responsible desk officers and the developers and users of the assessment).	• An integrated assessment is new to the implementing departments (e.g., lack of knowledge, awareness, and skilled expertise). • Resources are limited to scoping all key sustainability dimensions. • Fewer technical capacities and necessary resources (e.g., funding, skilled personnel) are found at the lower jurisdiction.
2.	Meso (organization)	• Organizational norms and culture in terms of attitudes towards sustainability issues and the role of knowledge. • Formal and informal decision rules that guide decision-making, including incentives and reward structures as well as rules that guide treatment and the use of knowledge. • Coordination procedures for preparing the assessment; use of knowledge/data/evidence in the coordination process within and between organizations for reaching decisions and follow-ups, such as institutional memory, databases, and communication channels for external and internal consultations. • Leadership: commitment and vision of appointed leaders and their lines of command, organizational motivation and informal leadership, special skills, or resources.	• A multitude of stakeholders' involvement presents without clear responsibilities of who is doing what, where, when, and how. • No formal guidance is available to assist in the detailed implementation. • National policies are available, but the political commitment (including leadership) of each department is lacking. • Governmental regulations and guidelines are too generalized to reflect local conditions and too rigid to promote innovation.
3.	Macro (policy network of the stakeholders)	• The network of stakeholders concerned with the process; their interests, goals, concerns and strategies considering both formal and de facto relationships, and the role of knowledge/data/evidence in the strategies of stakeholders aiming to influence the decision-making.	• The involvement of multiple departments results in coordination difficulties and conflicting interests. • National policies are unclear to assist in the integration of all sustainability dimensions across departments. • Unbalanced development priorities occur, and public

No.	Level	Description *	The Indonesian context**
		• The administrative/legal context of the process: including objectives set by governments as well as formal restrictions, laws, regulations, and procedures concerning the use of knowledge/data/evidence.	awareness is lacking in making sustainability considerations integrated into plans. • Linkages between the assessment procedure with the planning process are still unclear.

* Based on Turnpenny et al. (2008) and Nykvist & Nilsson (2009)
** Based on Giovanna et al. (2006) and Darmoyono (2019) about the implementation of impact assessment procedures for road projects in Indonesia

The SA tool procedure for road project planning in Indonesia is illustrated in Figure 4.1. First, all sustainability dimensions (i.e., social, economic, and environment) are screened and scoped in the preparation phase. The alternatives of road projects are also identified, including an option without a project. Next, the practitioners conduct the survey, baseline studies, and analysis in the investigation phase. In this phase, by using CBA techniques, the economic benefits (also costs) are calculated by monetizing as many impacts as possible (MPW 2005). For those impacts which are difficult to monetize, the practitioners apply MCDM, such as for landscape degradation, habitat fragmentation, community disruption, and species habitat fragmentation. The identified impacts are then transformed into evaluation criteria with specific weights. In the last phase, the alternatives are ranked according to the total scores of impacts. The alternative with the highest 'sustainability' impact is selected.

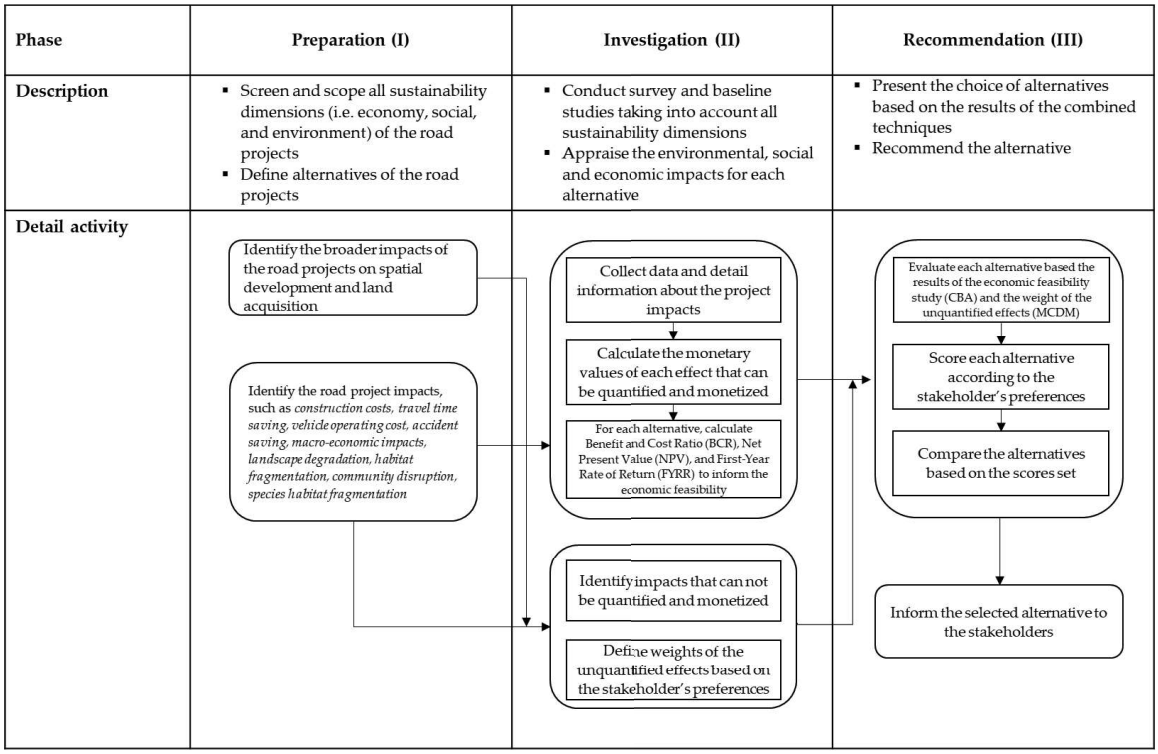

Figure 4.1 An evaluation framework to explore the barriers to implementing a SA tool

This paper argues that the barriers to implementing a SA tool have various degrees of influence in each phase (I-III). For example, stakeholders' knowledge of sustainability dimensions can act as a barrier in the preparation phase (I). Skilled personnel and funding seem more influential during the investigation phase (II). And in the latest phase (III), practitioners face unstructured involvement of stakeholders to obtain agreements on the selected alternative. Each phase often takes a long period to complete. It may exceed a single political cycle in which supports for project actualization can change (Priemus, 2010). Figure 4.1 illustrates the dynamics of the tool implementation, and barriers in one phase can influence barriers in the next phase. However, the outcomes of each phase may not strongly associate with the final decision. The next section elaborates on methods for the study.

4.3 Methods

A mixed-methods design, involving desk study, interviews, and an online survey, was used to achieve the aim. The research methodology is presented in Figure 4.2.

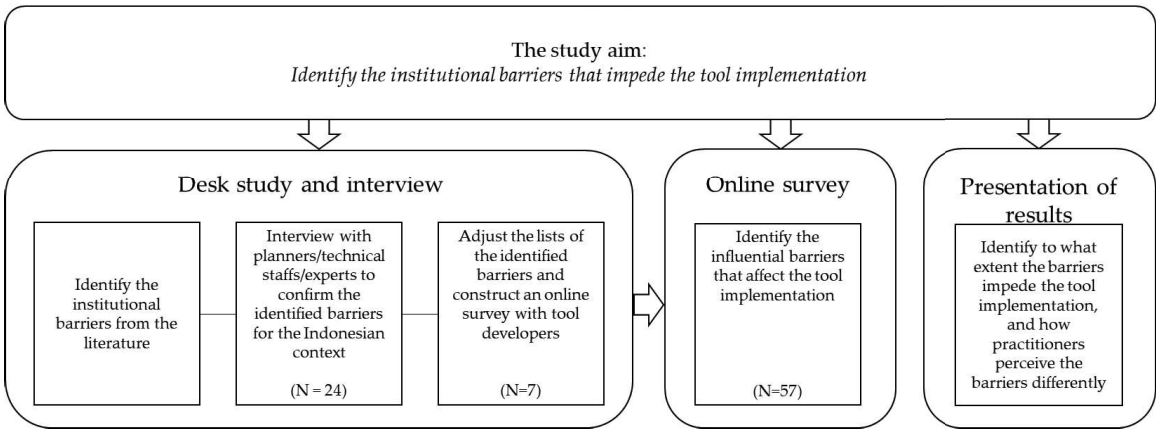

Figure 4.2 Research methods used in the study

4.3.1 Desk study and interviews

First, by using the lists in Table 4.1, the barriers that impede the implementation of a SA tool in Indonesia were explored. The lists were cross-checked by doing semi-structured interviews with 24 interviewees, including road planners/engineers, decision-makers, project managers, and experts. The interviews were conducted from August 2017 to December 2017 and resulted in 21 main institutional and political aspects that hinder or support sustainability assessment of road infrastructure development. Based on the results, some barriers were identified, including integration with existing planning processes, cooperation and coordination between departments, funding, awareness, and knowledge, commitment, leadership, transparency, etc. These results were then transformed into an online questionnaire form.

The initial draft of the form was sent to seven tool developers, including two university experts, two practitioners, and three researchers. They were involved in developing guidelines for road project feasibilities (MPW 2005) and a road rating system tool (Lawalata et al. 2013). Three of these developers are actively involved as members of a working group in The Ministry of Public Works and Housing who are responsible for making road guidelines, manuals, and standards. Individual short interviews were conducted to evaluate whether the earlier results of the interviews had adequately captured the barriers encountered. Additions and modifications were then made to the questionnaire form. The questionnaire content was finally assessed in terms of structure, readability, format, and appropriateness. The final version of the questionnaire was distributed online (see Appendix C).

4.3.2 Online survey

From August 2018 to October 2018, respondents were selected to participate in the online survey. Contact lists of two professional associations were used for the selection: Indonesia Association of Planners (IAP) and Indonesia Road Development Association (IRDA). The respondents received an e-mail and online messages with the invitation to fill out the online questionnaire form. A total of 57 respondents gave their feedback. Other respondents refused to respond because of the lack of experience in using assessment techniques for road project planning. Figure 4.3 shows the composition of the respondents based on a) primary work domains, b) length of professional experience and c) scope of the professional services (i.e., national, regional, or local level). The majority of the respondents were senior practitioners who had more than ten years of working experience (61%). Moreover, the vast majority of respondents (49 respondents) provided expertise for the national authorities.

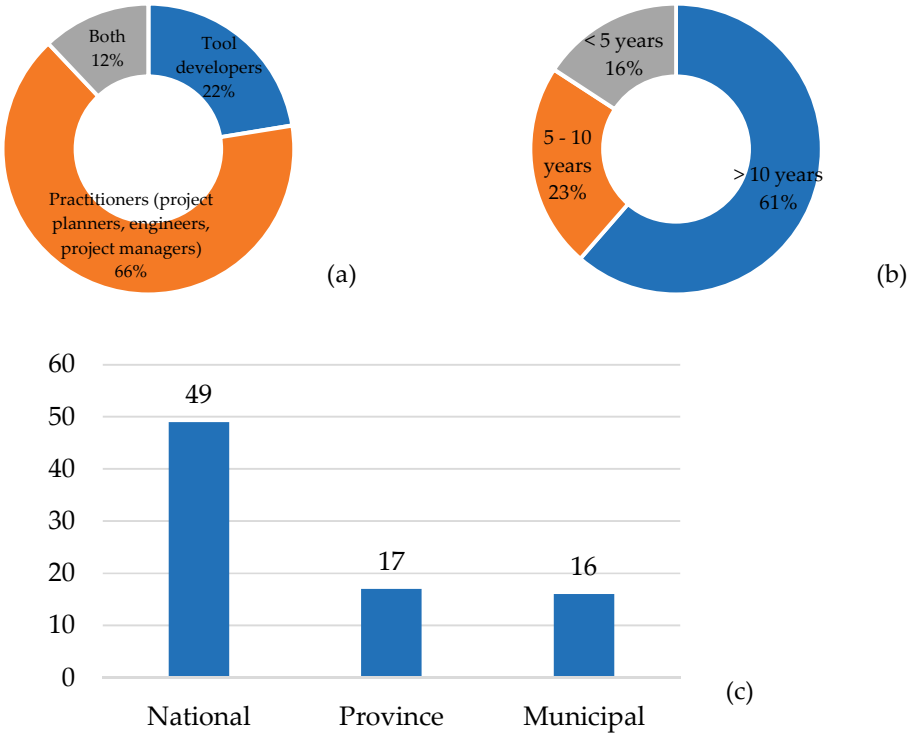

Figure 4.3 (a) Primary work domains; (b) Length of professional experience; and (c) Scope of professional service

The survey responses were processed as follows. The multiple-choice responses to the given statements were analyzed and presented. Based on this result, the existence and the intensity of the identified barriers were estimated from the

percentages of respondents. If the respondents chose more than one option, the aggregate was counted as the percentage. An analysis based on Kruskal-Wallis (KW) tests (i.e., one-way analysis of variance by rank) was then conducted to identify the differences of the perceptions based on the practitioners' backgrounds. This type of analysis is suitable for non-parametrical tests using a categorical independent variable, as shown in Figure 4.3 (see Field 2013). The differences were considered significant at p-values of <0.05 and <0.10. In the rest of the survey, the respondents were asked about their opinions regarding the most critical changes necessary to improve the implementation. The results are discussed below.

4.4 Institutional Barriers to Implementing a SA tool in the Indonesian Context

4.4.1 Perceptions of the barriers

The survey results were structured into three analysis blocks: i) perceptions of the barriers; ii) perceptions of the barriers found in each assessment phase; and iii) significant differences of the perceived barriers based on the practitioners' professional backgrounds. The examined barriers explored are presented into three levels: micro-level (I), meso-level (II); and macro-level (III). Overall, 24 barriers were identified and examined.

In the micro-level category, five of out eight barriers were considered as extremely influential (Figure 4.4). *Insufficient funding support* was the most influential barrier, with 61% of the practitioners that referred to its presence. A total of 54% and 53% of the practitioners perceived *unavailability of data and information* and *limited skilled personnel in using the tool* as among the most influential barriers. Moreover, 51% of the practitioners confirmed that *multi-disciplinary expertise* was needed to work with the tool. The figure on the expertise was almost similar to the rate of responses on *lack of users' understanding of the tool use* with 49% of the practitioners. Compared with this understanding, only 35% of the practitioners responded that the users have a *lack of knowledge of the integrative character of sustainability* and *a lack of knowledge of the assigned personnel in the technique use*.

Among the most influential barriers in the meso-level category was the *unavailability of top-down policies as guidance* with 53% of the practitioners responding to its presence. Furthermore, 51% of the practitioners perceived the barrier *about the difficulty to recognize the involvement of relevant stakeholders* as extremely influential. Also, 46% of the practitioners indicated a barrier to *arranging a structured involvement process*. Next, 46% of practitioners gave the response of the high importance of the *guideline in implementation*. This number was similar to their response to the *unavailability of specific procedures/manuals that guide the assessment and the decision-making processes*.

Furthermore, a *lack of the main department's leadership capability* was also mentioned by 44% of the practitioners. In the literature on sustainability assessment, this capacity might be able to direct processes and provides vision and motivation to perform the assessment (e.g., Turnpenny et al. (2008)). The result shows that 40% of the practitioners responded to *ineffective coordination among the departments* as extremely influential. Two other barriers were mentioned as moderately influential, including *low stakeholders' commitment to participate in the process/follow-up*, and *passive stakeholders' involvement in the processes*. This study recorded that 32% and 28% of the practitioners responded to these barriers, respectively.

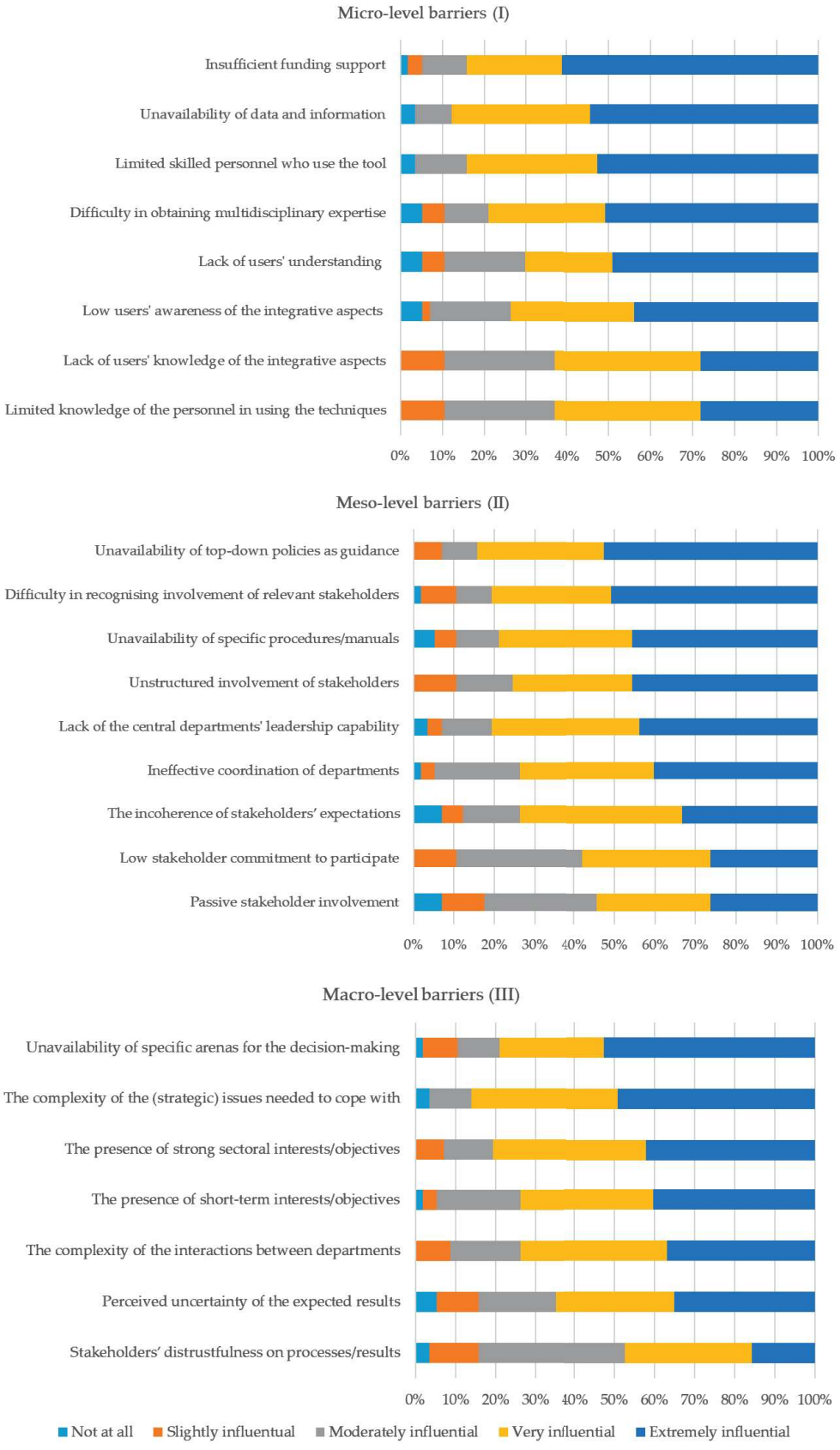

Figure 4.4 Perceptions of the institutional barriers based on the rank of influence

Figure 4.4 shows that five out of seven barriers were extremely influential at the macro-level. The *unavailability of a specific arena for decision-making* was considered as the most influential barrier, as perceived by 51% of the practitioners. The *complexity of the strategic issues needed to cope with* followed, according to 49% of the practitioners. This complexity also related to the *interaction of stakeholders working in various departments*, since 37% of the practitioners perceived that this interaction was very influential as a barrier. The *presence of strong-sectoral interests* was indicated by 42% of the practitioners. The findings on the perception of the complexity of issues and stakeholders involved might correspond to the missing specific procedures/manuals that guided the process. Two barriers were evaluated as moderately influential and very influential: i) *stakeholders' distrustfulness on the process/result,* and ii) *the incoherence of stakeholders' expectations upon the process/result* with responses 16% and 33% of the practitioners respectively. To sum up, the barriers identified in Table 4.1 were confirmed in the survey with various degrees of influence. Next, these barriers are studied in further detail at each assessment phase.

4.4.2 Perception of the barriers in different assessment phases

This study surveyed the practitioners' perceptions of the barriers in three assessment phases, as illustrated in Figure 4.1: i) preparation, ii) investigation, and iii) recommendation. Figure 4.5 shows that the practitioners perceived the barriers in all phases; however, some of them are more prominent than others. In the preparation phase, four barriers were considered influential. First, the most influential is the *low stakeholder commitment to participate*, as indicated by 48% of practitioners. Second, 40% of practitioners perceived two main barriers for the tool implementation, including *difficulty in obtaining multidisciplinary expertise* and *the complexity of the (strategic) issues*. Figure 4.5 also illustrates that 39% of practitioners signaled that the *unavailability of specific procedures/manuals* had hindered the implementation.

In the investigation phase, practitioners perceived some influential barriers, mostly related to technique deployment. Figure 4.5 shows that 45% of practitioners signaled that the *availability of the data and information* and *limited skilled personnel who use the tool* were two main barriers in this phase. Next, 42% of practitioners indicated *the complexity of the interactions between departments* was also influential. Moreover, 41% of practitioners recognized the four barriers to the tool implementation: i) *difficulty in obtaining multidisciplinary expertise*, ii) *lack of users' understanding of the tool use*, iii) *low users' awareness of the integrative aspects of the tool*, and iv) *insufficient funding support*.

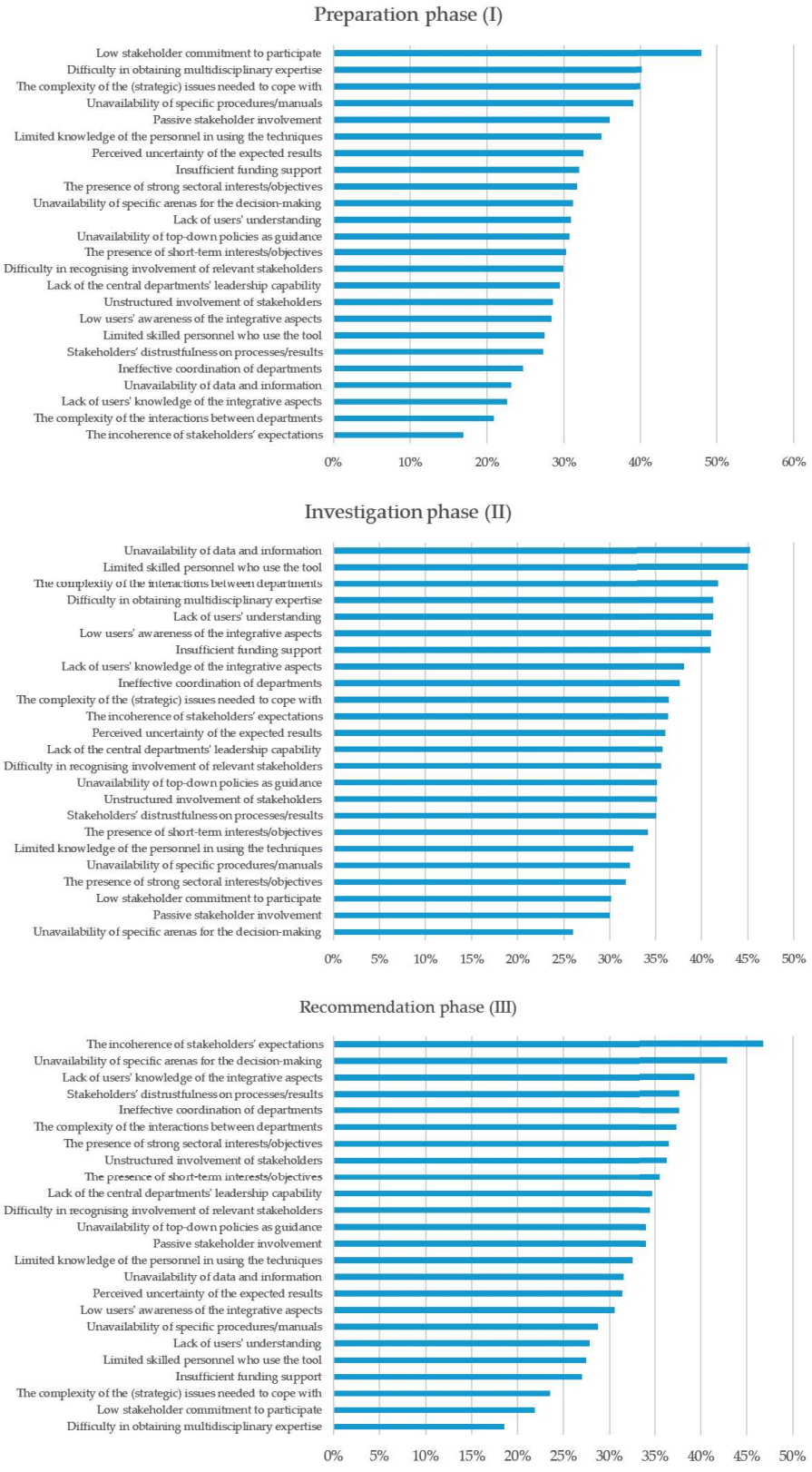

Figure 4.5 Perceptions of the institutional barriers in three assessment phases

Furthermore, we discovered that five barriers are more influential than the others in the recommendation phase. First, 47% of the practitioners perceived *the incoherence of stakeholders' expectations* as the most prominent. Two other barriers follow the previous, namely i) *unavailability of specific arenas for the decision-making* (43% of the practitioners) and ii) *lack of users' knowledge of the integrated dimensions* (39%). Next, 38% of practitioners pointed out two problems concerning i) *stakeholders' distrustfulness on decision-making processes/results* and ii) *ineffective coordination of departments*.

This study reveals that the barriers are found in all phases. However, the practitioners perceived the degree of barriers differently. In the preparation phase, the most influential barriers are typically located at the meso-level. In the investigation phase, the most prominent barriers are generally embedded at the micro-level. Furthermore, the most influential barriers in the recommendation phase are mainly concentrated at the macro-level. These findings imply that the prominent barriers are spread out in all phases. Figure 4.5 can help the stakeholders to strategically identify barriers in specific phases to advance the implementation.

4.4.3 Differences in practitioners' perceptions of the barriers

Overall, only a few test values were statistically significant at the 0.05 level, yet some agreements can be found among the practitioners. First, there were no differences between the practitioners' perceptions according to working domains, both at the significance level of 0.05 (*) and 0.10 (**) (Table 4.2). The result indicates that the working domains are less influential in differentiating the perceptions of the barriers. The second comparison (the length of the experience) shows only one barrier (*unstructured involvement of stakeholders*) as statistically significant at 0.10, indicating that an experienced (senior) practitioner seems more able to manage multiple stakeholders' involvement as compared to junior practitioners.

Table 4.2 The influence of the practitioners' working domain, length of experience, and scope of the professional service on the barriers at different institutional levels

No.	Identified barrier	Working domain	Length of experience	Scopes of the professional service
1.	**Micro-level**			
a.	Limited knowledge of the personnel in using the techniques	0,441	0,409	0,248*
b.	Lack of users' knowledge of the sustainability dimensions	0,241	0,386	0.048
c.	Low users' awareness of the integrative aspects of the tool	0,160	0,957	0.038*
d.	Lack of users' understanding of the tool use	0,600	0,235	0,168
e.	Difficulty in obtaining multidisciplinary expertise	0,771	0,489	0,947
f.	Limited skilled personnel who use the tool	0,950	0,651	0,760
g.	Unavailability of data and information	0,492	0,908	0,710
h.	Insufficient funding supports	0,109	0,574	0,714

No.	Identified barrier	Working domain	Length of experience	Scopes of the professional service
2.	**Meso-level**			
a.	Passive stakeholder involvement	0,971	0,323	0,161
b.	Low stakeholder commitment to participate	0,886	0,100	0,814
c.	The incoherence of stakeholders' expectations	0,464	0,404	0,192
d.	Ineffective coordination of departments	0,730	0,160	0,418
e.	Lack of the central departments' leadership capability	0,523	0,394	0,089**
f.	Unstructured involvement of stakeholders	0,882	0,074**	0,077**
g.	Unavailability of specific procedures/manuals	0,493	0,948	0,534
h.	Difficulty in recognizing involvement of relevant stakeholders	0,197	0,471	0,136
i.	Unavailability of top-down policies as guidance	0,563	0,591	0.023*
3.	**Macro-level**			
a.	Stakeholders' distrustfulness on decision-making processes/results	0,689	0,995	0,246
b.	Perceived uncertainty of the expected results	0,293	0,454	0,133
c.	The complexity of the interactions between departments	0,666	0,630	0,335
d.	The presence of short-term interests/objectives	0,463	0,889	0,077
e.	The presence of strong sectoral interests/objectives	0,527	0,863	0,077
f.	The complexity of the (strategic) issues needed to cope with	0,598	0,609	0,651
g.	Unavailability of specific arenas for the decision-making	0,861	0,867	0,249

Significance level of 0.05 (*) and 0.10 (**)

The third comparison relates to the scope of professional service. For 3 out of 24 investigated barriers, the test values showed differences at the p-level of 0.05: i) *low user awareness on the integrative aspects of the tool*, ii) *limited knowledge of the personnel in the technique use*, and iii) *unavailability of top-down policies as guidance*. First, the findings of the respondents indicate problems with resource capacities, at which a lower level of authorities, such as municipality, have fewer capacities (e.g., funds, skilled personnel, data availability) than an upper jurisdiction, such as central government. In the Indonesian context, municipal authorities still depend to a large extent on the allocation of funding transfers from the central government. In such a situation, the lower authorities will wait for policy guidance to use resources. Two out of 24 barriers were statistically significant at the level of 0.10: i) *unstructured involvement of stakeholders* and ii) *lack of the central departments' leadership capability*. On a smaller scale of implementation, such as streets and local roads, a more structured involvement of stakeholders can easily be attained as a limited number of stakeholders is involved in decision-making. Regarding the leadership, it seems that different authorities have shown a variety of ways they demonstrate capability in guiding implementation through visioning and coordination.

4.5 Discussion

This paper is aimed at answering the research question: *What barriers are encountered by practitioners in implementing a SA tool for road project planning in the Indonesian*

context, and in what ways can these barriers be unraveled based on the findings? By using an online survey, five barriers were found as the most influential across all levels, including i) *insufficient funding supports*, ii) *limited skilled personnel who use the tool*, iii) *unavailability of data and information*, iv) *unavailability of a specific arena for decision-making*, and v) *unavailability of specific procedures/manuals*. Less influential barriers were also found, such as *stakeholders' distrustfulness in the process/results* and *the complexity of the interactions between departments*. This study confirms some barriers that impede the implementation of integrated assessment procedures in the Global North context (e.g., Nykvist and Nilsson (2009), Turnpenny et al. (2008)). The implications of these findings is discussed below.

4.5.1 The implications of the influential barriers found in each level

The study reveals that all institutional levels have played a role as barriers to implementing a SA tool in the Indonesian context. The most noticeable one is that the practitioners have a strong concern about the 'minimum' prerequisite for tool implementation. This requirement refers to the lack of resource capacity of personnel and organizations (the micro-level). This is due to insufficient funding to conduct a more comprehensive analysis than is commonly required as the tool has to cover all sustainability dimensions (i.e., economic, social, and environment). Thus, the implementation needs a considerable amount of funding support to meet such a requirement (e.g., Gudmundsson et al. (2016)). Second, the practitioners highlighted the availability of skilled personnel as the most influential concern. The practitioners who were interviewed stated that the deployment of a new tool had encouraged them to upgrade their skills to "*meet a very broad set of requirements for the assessment*" (Turnpenny et al. 2008, 765–6). Third, still within the micro-level of institutions, a comprehensive analysis that was conducted affects what the practitioners refer to as 'adequate data and information' both in quantity and quality. One of the surveyed practitioners stated: "*Professionally, the practitioners require collecting all data and information for a successful implementation. The data will depend on their availability within the departments, but its quality was often unknown."*

At the meso-level, the results show that practitioners demanded specific guidelines and manuals. One of the respondents shared that: "*We [practitioners] need a specific guideline aimed at assisting in tool implementation and informing how it should be implemented*." This finding shows a gap between conceptual and practical knowledge about the application of the tool. The practitioners demanded a more detailed implementation procedure than is currently available. Bond et al. (2013) argue that effective implementation needs procedures to inform on professional standards and outcome expectations. Practitioners often find information about good practices in their professional networks. However, as shown in the finding, they consider this information as still lacking.

At the macro-level, practitioners highlighted the problem caused by the fluid interactions of stakeholders who are involved. The practitioners were aware of the importance of participation from these stakeholders and pointed out that this interaction is difficult to manage without a specific arena for decision-making. Bueno et al. (2015) highlight that SA of road projects should follow a transparent process so that diverse interests of stakeholders can be sufficiently captured (Bond et al., 2013). Without the arenas, the practitioners find it to be difficult to manage the involvement of stakeholders, especially with stakeholders who operate outside the project's jurisdiction.

4.5.2 The implications of the influential barriers found in each assessment phase

The practitioners perceived the influence of implementing barriers differently in each of the assessment phases. In the preparation phase, practitioners point out that limited stakeholders' commitment to participate and multidisciplinary teams are the two most influential barriers. Bond et al. (2012) highlight that this participation is necessary to i) obtain inputs for supporting decisions, ii) share information with wider stakeholders, and iii) reconfigure the power structure. Such a commitment ensures that decision-making processes are inclusive, and the decisions produced are legitimate (Bond et al., 2013). Moreover, a multidisciplinary expert is required, so that different views about the problems and solutions can be captured earlier in this phase. These results substantiate the finding by Fischer (1999) that proper preparation can guarantee fully integrated sustainability dimensions.

In the investigation phase, the practitioners pointed out that the availability of resources (e.g., skilled personnel, data, and funds) acts as the main barrier. In Indonesia, or elsewhere, the individual capacities of personnel are still limited, affecting the successful integration of both short-term and long-term objectives in development projects (Othman, 2013). The awareness of integrated sustainability dimensions is also a significant concern in road transportation policies in most Asian countries (Regmi, 2014). In the recommendation phase, the complex interaction of governmental departments acts as barriers that influence the outcome expectations. The practitioners responded that they often have competing expectations, producing uncertainty in the decision outcomes (e.g., Van Bueren et al. (2003)). The discussions and negotiations about the project alternative occur in this phase. However, the decisions leading to the alternative selection are taken in multiple arenas, which challenge the coordination between departments and jurisdictions.

The identification of the most prominent barriers in different phases has at least two implications. First, practitioners can concentrate on handling barriers found to be more substantial in specific phases. The planning of road projects, especially the large ones, often takes a considerable amount of time to proceed (Priemus, 2010). Therefore, stakeholders can invest in the efforts and resources required to perform

the main activities in each phase. Second, practitioners can gradually anticipate the barriers in the next phase. Therefore, the practitioners and the responsible departments can strategically handle the influential barriers to more effectively move the implementation forward.

4.5.3 The overall implications of the context in implementing a SA tool

Barriers to implementing a SA tool for road project planning are embedded in the context in some ways. First, the political aspect plays a crucial role in defining the aim of the tool to integrate sustainability dimensions. The finding shows that the presence of strong sectoral interests determines how the tool can incorporate the sustainability dimensions. Reflecting on the case of developing worlds, Pojani and Stead (2015) explain that the vast separation of responsibility and control may hinder the integration. Such a condition also occurs in road project planning in Indonesia.

Second, the context informs about the cultural aspect of collective activities, such as the use of an administrative procedure and the nature of public participation, social trust, coordination, and leadership. One of the barriers to implementing a SA tool is the availability of a technical procedure/protocol. The tool requires the practitioners to use multiple techniques, and they found it difficult to apply the techniques without clear guidance on how to manage, process, present, and interpret the data obtained. The guideline may also be necessary to communicate results (Te Brömmelstroet & Bertolini, 2008). Other barriers come from the degree of public participation and social trust. In Indonesia, the Spatial Planning Act of 2006 guarantees that the general public can freely express their concerns. Rukmana (2015) shows that their voices are often unheard of by the government. Leadership can also be of importance, where resources are scarce in supporting 'risky' innovations, such as the deployment of SA. Leadership can give visions and 'interventions from above' that eliminate sectoral fragmentation, mediate diverse expectations, and improve coordination.

By reflecting on the context, this study identifies several barriers beyond its minimum 'technical' requirements for tool implementation. Sheate (2009) claims that it appears less useful to enhance the application without exploring the linkages between the knowledge about the tool and the actual practice in a specific context. Turnpenny et al. (2008) show that the micro-level barriers, such as in training and funding supports, are only parts of the problems because the complex interaction between stakeholders determines overall effectiveness. Table 4.2 shows that at the lower jurisdiction (i.e., municipality), the practitioners found it difficult to incorporate strategic issues, in which stakeholders from broader jurisdictions should be included in decision-making processes.

4.6 Conclusion

This paper has addressed the growing interest in deploying methodologies for assisting decision-making in moving towards sustainable development by examining, from an institutional perspective, how Indonesian practitioners deal with barriers to implementing a sustainability assessment (SA) tool for road project planning. It is found that in Indonesia, the challenge of the implementation is not about its usefulness. Rather, it is concerned with the 'messy world' of the decision-making processes and the integrative characters of the tool (e.g., combined techniques, comprehensive dimensions, and multidisciplinary expertise) (Hacking & Guthrie 2008).

Our analysis shows that practitioners cannot treat SA as merely a 'technical tool' to rationalize the choice of road project alternatives. There is more to the tool than the purely technical issues surrounding its 'rational' characteristics, that is the context in which the tool is implemented (Howlett, 2009). The practitioners should be able to structure the involvement of stakeholders with different interests and resources, including those who are located outside the project's jurisdiction. As the study shows, detailed guidance is missing to clarify the sustainability dimensions/themes covered. Heeres et al. (2018), for example, suggest additional instruments, such as Sustainability Check, in combination with CBA that guide the scoping of sustainability themes at the early phase of the assessment. Second, the guideline is necessary to inform the stakeholders that the implementation is also a political exercise (Turnpenny et al., 2008). Therefore, they can understand that various frames of sustainability may compete with each other, and institutional fragmentation should be overcome.

In developing countries, such as Indonesia, road projects have become a main national strategy aimed at enhancing economic growth (Diaz-Sarachaga et al., 2017). These countries have limited resources and political capacities to achieve sustainable road development (Pojani & Stead, 2015). The findings imply that tackling the micro-barrier level is necessary to get the users more familiar with the technical character of the tool (i.e., combined techniques). At the macro-level, more spaces for public engagement are needed (O'Faircheallaigh & Howitt, 2013; Sheate, 2009), and an honest and trustful communication is necessary (Nykvist & Nilsson, 2009). Therefore, stakeholders can share visions about tool purposes and strengthen networking for integrated decision-making, which is found to be lacking in Indonesia (Delphine et al., 2019).

The study has substantiated the findings that the lower jurisdiction, such as municipality, has fewer capacities (e.g., lacking in personnel's skills and knowledge) to promote a sustainable road project in Indonesia (Giovanna et al., 2006). Sectoral fragmentation also impedes the scoping and screening of strategic sustainability impacts. The fragmentation will be difficult to overcome if the policymakers fail to

integrate the tool into the planning process at the municipality (Darmoyono, 2019). Still, studies have little attention to the implementation at the lower jurisdiction.

This paper examines barriers to implementing a SA tool solely from the perspectives of practitioners. However, they often act based on task specifications given by clients or superiors. Therefore, practitioners alone have a limited role in pushing the tool implementation forward. The power relations between the stakeholders may also be imbalanced, which can only be observed in actual project cases. Such a relationship results in a situation in which powerful stakeholders often dominate the mobilization of specific interests on project effects and 'sustainable' alternatives. Moreover, the on-line questionnaire used here cannot capture how practitioners can experiment and innovate to advance the implementation and to improve the context. These limitations are matters of future research.

5. Coping with Strategic Ambiguity in Planning Sustainable Road Development: Balancing Economic and Environmental Interests in Two Highway Projects in Indonesia

Kelok-9 highway, Payakumbuh, Indonesia ©Maxiboydmaxi

Abstract

In planning regional road development, planners often face a challenge to reconcile various interests and interpretations on the ultimate goals which complicate the discussion decision-making processes. This situation is defined as strategic ambiguity. Standard procedures for impact assessment are mostly ineffective at offering solutions that satisfy all involved stakeholders. This paper analyses the situation by using a Multiple Stream Framework (MSF) approach. MSF identifies three factors, labelled "streams", i.e. the problems, the solutions, and the politics streams, that open sustainability 'windows' for integrating different interests. This paper investigates the opening of such windows in two highway projects in Indonesia. Both projects showed a high ambition for achieving environmental sustainability. In these cases, the window was opened through (i) recognition of the problems and the solutions by the active involvement of stakeholders, (ii) coalitions with influential stakeholders for political supports, and (iii) mobilization of resources and policy networks by the stakeholders. It is concluded that planners might influence the streams to outline decision-making processes and to implement environmental impact assessments effectively.

Keywords: *EIA, large-scale infrastructure projects, sustainability, Multiple Streams Framework, qualitative data analysis, Indonesia*

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5.1 Introduction

Since the 1980s, there has been growing attention to applying the sustainability concept in many areas, including transportation projects. In general, sustainability can be thought of as relating to the comprehensive consideration of environmental, economic, and social aspects, with a long-term perspective (Gudmundsson et al., 2016; Ramani et al., 2011). In this paper, a transportation project will be considered "sustainable" when it contributes to favor economic development and fulfil the transportation needs of the society in a manner consistent with environmental protection (Bueno et al., 2015).

By such a definition, a sustainable road project entails the integration of multiple, often conflicting, social, economic, and environmental interests. In developing countries, in particular, road development is intended to connect isolated regions and to enhance economic growth through better people mobility (Gartner, 2016). In contrast, environmental interests, such as species habitat loss and massive landscape change, are rarely considered at the heart of discussions in the planning phase. Several stakeholders, such as NGOs, local communities, and other affected people, have become increasingly engaged in decision-making so that their long-term interests are better secured (Howitt, 2013). Project developers often struggle to mediate conflicting interests to achieve project goals or missions. These interests can be conceptualized into three aspects or pillars: (i) economic growth, (ii) social equity, and (iii) environmental protection (Jeon et al., 2013). These dimensions are not isolated with each other. Frequently, they overlap, and trade-offs occur among them (Joumard & Nicolas, 2010), but their relation is often unclear in the actual application (Purvis et al., 2018).

This paper examines how the integration of economic and environmental aspects is possible in planning sustainable road development, and how environmental assessments carried out can be made effective. The most common model of decision-making is the rational (comprehensive) approach that informs all consequences, solutions, and available options. For example, EIA (Environmental Impact Assessment) is used as a routine part of decision-making by scoping and screening project impacts and define alternatives for a sustainable option (Stoeglehner & Neugebauer, 2013). Planners and policy-makers also frequently rely on SEA (Strategic Environmental Assessment) (Fischer, 2006; Hildén et al., 2004). In SEA of transportation projects, Fischer (1999) substantiates that the integration of interests requires more effort because actors from various jurisdictions are involved, and a lack of preparation is common. Sustainability assessment (SA) is advanced to ensure that decision-making is comprehensive, meaning that it covers all three categories or pillars of environmental, social, and economic effects as well as indirect effects (Hacking & Guthrie, 2008; Morrison-Saunders et al., 2015; Sala et al., 2015). Yet reviews on SA of transportation projects also show that methods and tools applied have only partly measured the project impacts (Bueno et al., 2015; Heeres et

al., 2018). As a result, a limited use appears in the implementation of such assessments, and their actual effects on decision-making are still questioned (Runhaar & Driessen, 2007). Powerful stakeholders having abundant political and organizational resources may also control the decision-making processes (Salling & Banister, 2009).

For the investigation, two highway projects in Indonesia are used as cases. Both were aimed at improving economic growth as the leading national development strategy (CMEA 2011). However, as found in the context of developing countries, the project developers had a limited capacity to integrate short- and long-term considerations (Delphine et al. 2019b) and to mitigate the project effects effectively (Othman, 2013). The planning of sustainable transportation infrastructure appears ineffective because of institutional barriers, such as lack of stakeholders' awareness and time and limited skilled personnel (Pojani & Stead, 2015; Regmi, 2014). Such a condition encourages an incremental change aimed at establishing sustainability considerations into policies through continuous seeking of a window of opportunity (Fischer, 2004). This paper, therefore, addresses the research question: "*To what extent can 'windows of opportunity' assist the integration of economic and environmental interests in planning sustainable road development?*"

This paper draws on theories about policy agenda-setting by using a Multiple-Stream Framework (MSF) and its further refinement (Béland, 2016; Béland & Howlett, 2016; Kingdon, 2014; Zahariadis, 2016). This approach helps to outline the process in three different streams (i.e., problems, policies, and politics). First, the sustainability 'window' is conceptualized as a moment in which the stakeholders reach a sustainability plan proposal and successfully match their conflicting interests. Second, different elements of the three streams are investigated in which the window presents itself by using two highway projects in Indonesia as cases. Finally, this study reflects on findings and conclusions and how environmental assessment helps to assist integration.

5.2 Conceptual Framework

In this section, the concept of strategic ambiguity will be introduced, then followed by an explanation of the Multiple-Stream Framework (MSF).

5.2.1 Strategic ambiguity in planning sustainable road development

Eisenberg (1984) initially uses the term 'strategic ambiguity' to describe instances in which language was deployed in such a way to accomplish organizational goals. In this paper, the concept is adopted to understand a situation in public planning and decision-making in which various interests present and complicate discussions about development project goals (Giezen et al., 2015). First, this situation occurs

because of the level of abstraction of project goals. Large-scale development projects start with an underlying sense of purpose reflected in the strategic project goals (Giezen, 2012b; Salet et al., 2013). However, different framings, meanings, and expectations towards these goals might arise. Second, agreements on specific goals or choices are often challenging to achieve because of conflicting and irreconciled interpretations of interests.

The inclusion of 'sustainability' or 'sustainable development' goal into policies and plans is without exception in this regard. This goal can be considered ambiguous. Stakeholders have different meanings, frames, and expectations on what it entails and applies in implementation (Gibson, 2013). The ambiguity also allows ways of creative interpretation, both as constraining and facilitating choices, which are reinterpreted continuously by the stakeholders involved in decision-making (Zahariadis, 2016). If the contested interpretations are not negotiated in one single decision, they return in a later stage until all stakeholders reach a final agreement (De Bruijn & Leijten, 2007). This agreement may take time to grasp. Otherwise, disagreement makes the projects fail to implement.

Three aspects reflect ambiguity in planning sustainable road development projects: (i) problematic preferences, (ii) complex decision-making processes, and (iii) fluid participation (see Zahariadis (2016) for a general explanation). First, road projects usually consist of conflicts over goals or ultimate ends. These goals are continually renegotiated in different decision arenas (Giezen, 2012b). Second, stakeholders rarely understand well how decision-making works, especially when it involves multiple agencies across sectors and jurisdictions (Zahariadis, 2016). Public debates, scientific studies, and environmental assessments are used to justify whether project goals are viable or whether mitigation is adequate to address the impacts. However, the results of such processes might not be satisfying to all stakeholders. Third, the participation of stakeholders varies across different decision arenas. Such a situation makes a presentation in all arenas unmanageable, and particular stakeholders might be unable to influence decisions.

5.2.2 Multiple-Streams Framework (MSF): An explanation

The Multiple-streams framework (MSF) was developed as an analytical device in policy or decision-making under an ambiguity condition (Zahariadis, 2016; Zohlnhöfer et al., 2015). In such a situation, different spheres of decision-making involve stakeholders, and policy networks and arenas affect how problems are identified and how particular solutions are preferred. Although scientific evidence is available, stakeholders might not instantly accept the offered solutions. Planning literature addresses this situation by stating that any decision-making is a bounded-rational process, in which actors have various perspectives and frames regarding the problems and the solutions (Healey, 2006; Hoch, 2008).

As early as 1984, Kingdon's work outlined MSF to investigate how actors involved in policy processes set agendas or proposals successfully. MSF helps to explain how a window of opportunity opens for actors to a successful set-up of the policy process. In Kingdon's MSF, three categories of independent (and interdependent) variables or elements that interact exist, namely: (i) the problems stream, (ii) the policy stream, and (iii) the politics stream. *The problems stream* pushes forward all significant issues that potentially receive attention. Some conditions cause this stream to occur, such as high-profile events (e.g., crisis events or natural disasters). Kingdon (2014, p. 114) highlights that *"for a condition to be a problem, people must become convinced that something should be done to change it*". The second element is the policy or the solutions stream. This stream pushes all accumulated knowledge about the problems and the alternatives attached to the issues that make the windows open. To make an alternative acceptable, Kingdon (2014) elaborates some circumstances, such as feasible technical proposals, fitted to societal values, high political support, and workable budgets. The third and last element is the politics stream. This stream consists of the administrative and political dimension of the intended policy, such as political election, pressures from interest groups, and new leaders in the office.

When all these streams join in a specific moment, a window of opportunity opens to attach an agenda or a proposal into a particular policy or decision to be made. The three streams flow and remain independently until a specific point in time. The window might then open to create an opportunity to advocate the agenda in a particular period (Howlett, 2018). Several reasons can explain the seeking of actors for such windows. First, stakeholders have bounded rationality and a short attention span to generate public action (Van Stigt et al., 2013). As a result, they have difficulty in keeping a problem as a public interest. Second, decision-making is a complex process as actors show diverse interests and interact in various policy networks (Van Bueren et al., 2003). These actors usually interact with each other over a relatively long period, operating within a climate of uncertainty caused by context and time-specific knowledge and information limitations (Howlett, 2014). Third, unrelated arenas of decision-making influence how expected outcomes are defined (Van Bueren et al., 2003; Van Bueren & Ten Heuvelhof, 2005). Moreover, some influential actors may actively drive the result (Reardon, 2018). This institutional complexity requires the stakeholders to reduce gaps in the governance context and the available policy instruments in defining problems and accepting solutions (Howlett, 2009). The next section will explain how the integration of interests is attained by structuring this complex process in the case of road projects.

5.2.3 Integrating interests by seizing a sustainability window

Decision-making of transportation infrastructure projects, specifically the large-scale ones, is an extremely complex process in which multiple stakeholders negotiate and

communicate goals or missions (Giezen, 2012a; W. Salet et al., 2013). Large sums of public money are frequently spent on research and environmental assessments, but the results often fail to drive an agreement. Planners often seek ways to hook up solutions in the assessments so that perceived problems can be resolved. In doing so, stakeholders often collaborate with others to receive support and to legitimize their solutions or selected alternatives (Scandelius & Cohen, 2016). For the streams to come together, Kingdon (2014, p. 165) states: *"A problem is recognized, a solution is developed and available in the policy community, a political change makes it the right time for policy change, and potential constraints are not severe"*. Planners recognize and match the problems and the solutions, while the political streams are supportive for the integration of competing interests.

Before this integration occurs, first, planners need to identify various elements in each stream that open the window of opportunity. Figure 5.1 elaborates the contributing elements of each stream as described above. Figure 5.1 also points out the role of an actor, called a 'policy entrepreneur', which is essential to couple the streams that open the window. This actor plays a vital role in attaching solutions to the recognized problems, overcoming the constraints in implementation, and taking advantages of future benefits (Hermansen, 2015). The 'entrepreneur' is willing to invest their resources, such as time, money, energy, and reputation, in return for anticipated future gain in the forms of material, purpose, or solidary benefits (Kingdon, 2014). The role of these actors has been investigated in many fields, including economic policy (Ackrill & Kay, 2011), climate change policy (Hermansen, 2015), and urban development planning (Van Stigt et al., 2013).

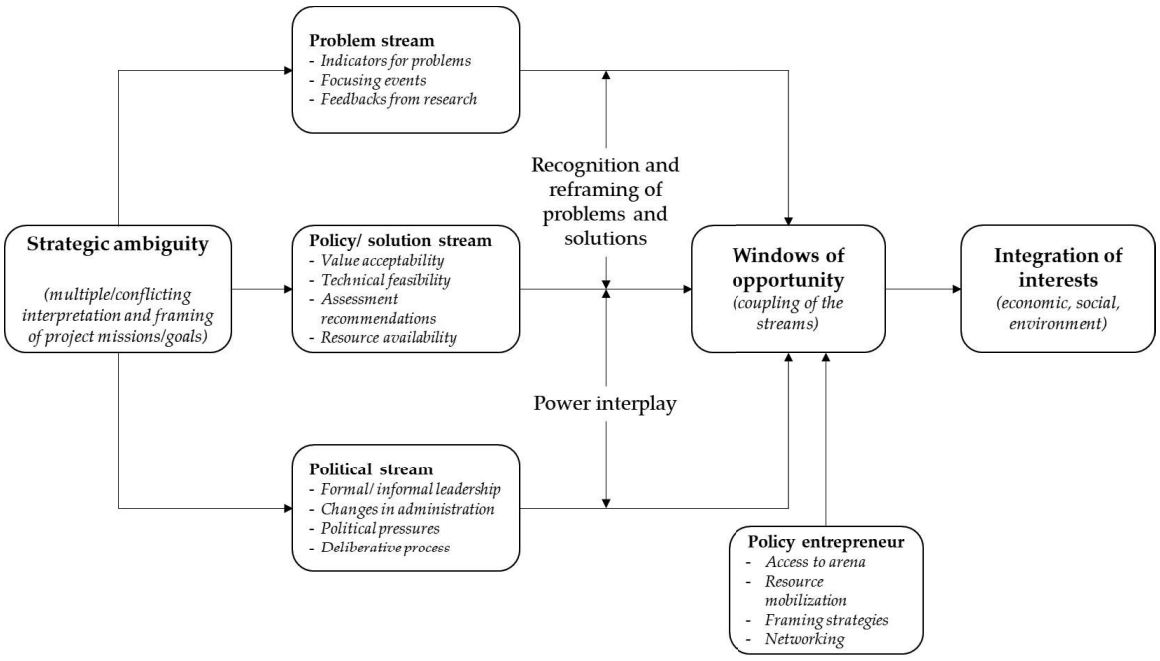

Figure 5.1 The analytical framework (based on interpretations of multiple sources, e.g., Kingdon, 2014; Zahariadis, 2016)

The convergence of the three streams with the contribution of the entrepreneur helps the presence of windows of opportunity. The windows allow a resolution of balanced interests between stakeholders. The next section will discuss the cases and methods used to identify elements in each stream (i.e., problems, policies/solutions, and politics) and the role of the entrepreneur that significantly contributes to the window opening.

5.3 Study Design and Case Selection

5.3.1 Case study design

This paper used an in-depth case study design to obtain information about the projects and to infer its broader development context (Yin, 2014). A single case is chosen as a way to 'understand the viewpoints and the behaviors, which characterize social actors' (Flyvbjerg, 2006, p. 236). By applying this design, we investigated how the concept of MSF enabled the presence of windows of opportunity for integrating multiple interests. The design allowed an examination of the underlying mechanisms that connect different and interdependent elements of three streams from the data gathered.

We first collected data consisting of assessment studies, monographs, policy and project reports, then performed in-depth interviews for two project cases in Indonesia. The first case is Bali Mandara Highway, located in Bali; the second is Kelok-9 in Sumatra (Figure 5.2). The interviewees were selected by using a purposive sampling technique (Kumar, 2014) based on active involvement in the project planning. In total, 21 potential interviewees were contacted, according to the project monographs and reports. In each case, five stakeholders agreed to be interviewed and included in the study, consisting of two governmental officials, a project manager, and two planning consultants (Table 5.1). One local leader and one NGO director were involved as interviewees for the Bali Mandara Highway case. No local organizations and NGOs were found actively participated in the Kelok-9 Highway project planning, based on the examined monographs and reports. This contrasting participation of interviewees can be explained, as the location of Kelok-9 Highway in a remote area, and public engagement was less reported.

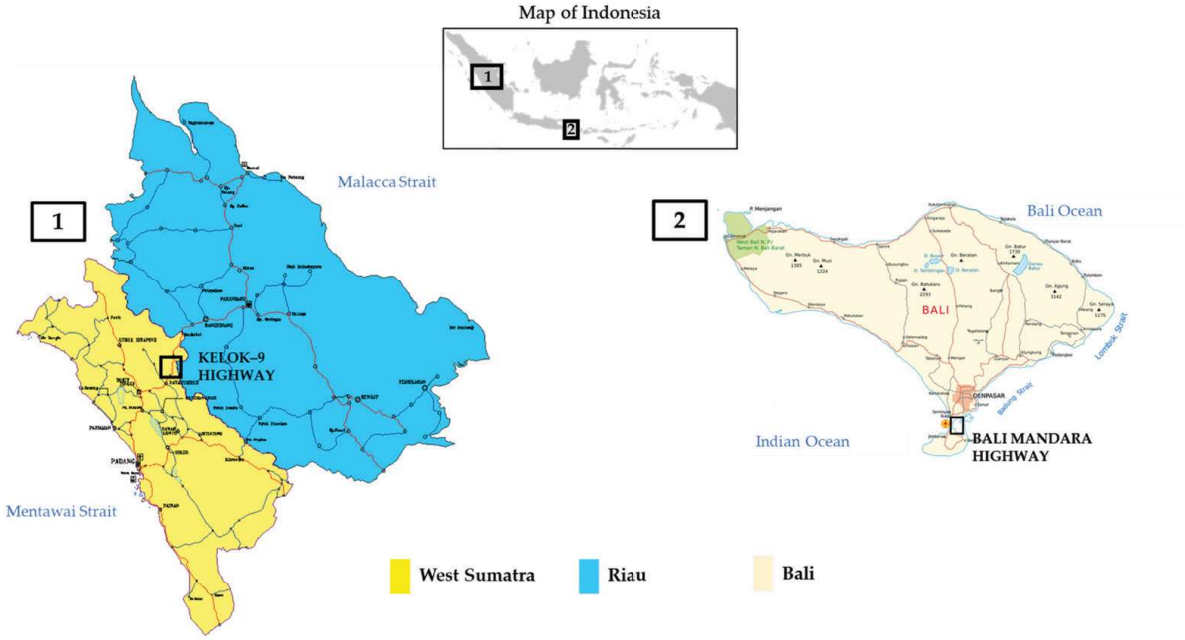

Figure 5.2 The location of the investigated projects (Kelok-9 and Bali Mandara Highway)

The series of interviews was performed from October 2017 to September 2018. In doing the interviews, a topic list guided the researchers to obtain data with regard to: (i) the project missions and the stakeholders' interests, (ii) processes carried out to resolve the competing interests, (iii) arenas and policy networks in which problems and solutions were discussed, and (iv) integration of interests achieved. All interviews were recorded by using an electronic device. Upon completion, written verbatims of the records were sent back to the interviewees for their comments and confirmation.

Table 5.1 The list of interviewees of the two project cases

No.	Project case	Interviewee	No. of interviewees	Interview code
1.	Bali Mandara Highway	Consortium representative (formerly the project manager)	1	A1
		Government official: - The Ministry of Agrarian Affairs and Spatial Planning - The Provincial Government of Bali	2	A2, A3
		Project consultant - Environmental consultant - Spatial planning consultant	2	A4, A3
		Local community leader	1	A6
		NGO director	1	A7

No.	Project case	Interviewee	No. of interviewees	Interview code
2.	Kelok-9	Project manager	1	B1
		Government official - The Ministry of Public Works and Housing - The Provincial Government of West Sumatera	2	B2, B3
		Project consultant - Landscape consultant and university expert - Road planning consultant	2	B4, B5

For the analysis, we explored 'meaningful units of information' (Silverman, 2014) in the data collected and coded the information to examine (i) the competing missions and interests; (ii) the detailed elements of the three streams (i.e., problem, policy, and politics), (iii) the elements opening the 'sustainability' window, and (iv) the traits of a 'policy entrepreneur' (Figure 5.1). Atlas.ti software was used for coding the information. The next section will present the cases and the empirical results in more detail.

5.3.2 Road development projects in Indonesia as cases

Since the 'big-bang' of decentralization in 2001, road infrastructure development in Indonesia has become highly fragmented (Darmoyono, 2019). Multiple agencies, such as the spatial planning, public works, environment, and transportation departments at different jurisdictional levels, are involved in the design of road development policies and plans (Miharja & Woltjer, 2010). The Local Government Act of 2014 reflects this 'complexity' of the bureaucratic structure that complicates integrated decision-making. In the Indonesian road development, sustainability is still considered a sectoral concern, which is the responsible agency for public works is mainly concerned with the mitigation of environmental impacts of the infrastructure construction (Lawalata et al., 2013).

In integrating environmental considerations into road projects, practitioners apply SEA and EIA. SEA is regulated under the Environmental Act of 2009. The public works or the spatial planning department prepares it to evaluate the socio-environmental impacts of spatial development plans, program, and policies. At the project level, EIA is prepared to mitigate adverse effects and include the measures in final designs (MPW, 2011a). However, EIA seems ineffective for a project planning purpose. First, it generally tends to be adopted late in the planning processes. Second, there is little room available to reflect on the selected road project; thus, the EIA results seem to legitimize the implementation, instead of adding value to the

project decisions (Giovanna et al., 2006). Moreover, public engagement in the assessments are relatively low (Delphine et al., 2019a).

Two highway projects that are selected as cases for this paper represent typical road projects in Indonesia, complicated by the involvement of agencies across different sectors and jurisdictions (Darmoyono, 2019).). In these projects, there are competing interests (i.e., regional economic growth [improving connectivity]) and environmental protection (preserving species habitats and ecosystem integrity). The projects are both situated in nature conservation areas. The competition made it difficult for the project developers to push the implementation forward. Without balancing the economic and environmental interests, the projects would not be delivered on time, and the delays would have caused additional economic costs (DGH, 2014; Lamade et al., 2014). The next section will explore the cases further.

5.4 A Tale of Two Highway Projects in Indonesia

This section elaborates the project cases: Bali Mandara Highway and Kelok-9. For each case, the emergence of windows of opportunity is explained through the convergence of the three streams (i.e., problem, policy, and politics).

5.4.1 Bali Mandara Highway: Project missions and competing interests

The central government enacted the highway project proposal in 2006. The project mission is to *"connect the activity centers located within the metropolitan region and support the regional growth as the national activity center that focuses mainly on tourism development"* (MPW, 2011, article 7). It is also aimed at improving national competitiveness by positioning the area where the highway is located as the main logistics center at the eastern part of Indonesia (CMEA, 2011). The highway connected three strategic locations, an international airport, an harbor, and a tourist resort, and was built above a sea-water. The government official told the reason: *"the local building code prohibited the overpass construction [on the main arterial road] because, in the design, the pillars had a height of more than 12 meters"* (*Interview A2*).

Despite the economic importance, competing interests emerged between the stakeholders. First, at that time, The Provincial Water Agency had reported a massive conversion of mangrove forest into commercial and public facilities. The government official explained that *"the [project] implementation would only fasten the speed of land conversion in the area" (Interview A3).* Second, the local communities noticed that the planned route displaced several religious sites. The community leader told that relocating these sites would have only *"undermined the sacral and cultural importance to the local people"* (*Interview A6*). The local communities and NGOs asked the appointed project consortium to delay the implementation unless the solutions were implemented regarding the site relocation.

Paving 'roads' to sustainability: problems, solutions, and the role of EIA

The enactment of the Metropolitan Spatial Plan 2011 consolidated the project implementation and established the vision for spatial development in the surrounding area. However, the planning consultant identified that *"there was a contradiction between the zoning in the [Metropolitan Spatial] Plan with the municipal spatial plan" (Interview A5)*. It appeared that the implementation sparked an argument about the mangrove forest protection. The project consortium thus signed a Memorandum of Understanding (MoU) with the Ministry of Forestry with an agreement to restore the forests affected by the project. To move the implementation forward, the project consortium conducted an EIA study.

After screening and scoping of the project effects, the hired consultant for the study announced the their recommendations in October 2011. The report identified fifteen important effects having priorities to mitigate, such as (i) changes in local culture and traditions, (ii) displacement of local fisheries, (iii) land-use changes, and (iv) forest mangrove removal (Jasa Marga et al., 2011). The consortium then held two public meetings to gather public opinions about these identifications in February 2012, involving parliamentary representatives, government officials (i.e., national, provincial, and local administration), local leaders, NGOs and the local media. Most stakeholders agreed the implementation could be carried out if the identified social and environmental impacts were mitigated. The local stakeholder demanded that social conflict should be avoided. Therefore, the local government demanded the consortium to *"allocate jobs for the local people during construction" (Interview A3)*. In the second meeting, the NGO identified an additional problem with: *"the displacement of local fisheries and community based tourism activities"* (*Interview A7*). These meetings turned out to be essential to define the problems and solutions before the proposal for the implementation was accepted. For the consortium, the meetings and the EIA helped them to translate the 'abstract' project mission into a detailed implementation plan that combined multiple interests of stakeholders.

Converged streams: the emergence of a 'sustainability' window

The governor approved the final version of EIA in September 2012 (JBT, 2013). As a follow-up with the local community leaders, the consortium identified the location of the religious sites and the fishery spot displaced by the project. To show concerns on the local needs, the consortium published a detailed highway design under the theme *"Strong, Green, and Beautiful" (Karim, 2016; Interview A1)*. From the publication, the consortium informed about the commitment to establish strict environmental standards in the implementation. The project manager explained that they deployed 'environmentally-friendly technologies to *"reduce the adverse [project] impacts on the landscape and to improve the pavement life-cycle" (Interview A1).* However, the environmental consultant was concerned that such a focus only moved the implementation away from ensuring its social commitment: *"the foreigners took most the [construction] jobs that should have been given to the local people" (Interview A4).*

In this case, the *problems stream* (mangrove forest protection and social conflict avoidance) and the *solutions stream* (conformance of high environmental standard and highway realignment) joined with the steady pressure from well-respected local leaders and NGOs in the opening of the sustainability window. In collaboration with the leaders, the consortium got legitimacy and helped to ease public resistance for the implementation (Lamade et al., 2014). This pressure can be categorized as a part of the *political stream*. The consortium acted as the main actor that linked both the *problem stream* and the *solution stream* and turned out to bring opportunities in term of (i) the reduction of construction costs from minimizing land acquisition and (ii) the attractiveness of the highway site as a tourist attraction because of its surrounding protected natural landscape (JBT, 2013). The project manager told the future benefit attained from: "*creating added social values from protecting the beautiful landscape around the highway"* (*Interview A1*).

In this case, the sustainability window caused the economic interest (connectivity improvement) to join with the socio-environmental interest (forest mangrove protection and land acquisition minimization). The window opened because local stakeholders participated in open discussions on the recognition of problems and solutions. Moreover, the collaboration between the consortium and the local leaders allowed joint-fact findings in the identification of displaced religious sites and the fishing grounds. The project manager successfully matched the problems and the solutions in the final plan and design, pushed by the local leader pressure in the political streams, and implemented the solutions.

5.4.2 Kelok-9 Highway: Project missions and competing interests

In 1990, the Ministry of Regional Infrastructure initiated the reconstruction project of Kelok-9 Highway with a mission to relieve a bottleneck segment between West Sumatra and Riau provinces (DGH, 2014). Moreover, fatal accidents frequently occurred because of its hilly location. The Provincial Highway Agency reported increasing traffic passing this segment (DPJ, 2001). This project consisted of three construction works: (i) road widening, (ii) bridge construction, and (iii) road re-alignment. The total length of the project is 5.0 km.

Some problems emerged before the actual implementation. First, the project was located in a protected forest, and national laws prohibited a land use change in the area. The change would have affected migration routes of native species, including seven mammals and four reptiles (DPJ, 2001). Some native trees needed to be cut down for the re-alignment work. The government official recalled*: "the function of the area was under a significant threat, and the implementation would have seriously offended several national laws' (Interview B2).* The provincial government faced a dilemma. First, if the project failed to implement, the West Sumatra province would have stayed economically uncompetitive and isolated. Tourist visits and foreign

investments would be below expectation (PSW, 2012). Second, in 1994, the central government was urged to accomplish the project in the meeting of IMS-GT, an international cooperation involving Indonesia, Malaysia, and Singapore. The project was aimed at enhancing economic growth in the bordering region of the three countries, also called the 'Growth Triangle' (DGH, 2014). The Kelok-9 Highway would connect West Sumatra with its abundant lands, labor, and natural resources with international harbors in Riau, transporting logistics and people to Johor (Malaysia) and Port of Singapore (Singapore). Two competing interests (environmental protection vs economic growth) thus complicated the project planning. The provincial government of West Sumatra hired a consultant to perform an EIA study.

Paving 'roads' to sustainability: problems, solutions, and the role of EIA

The governor approved the EIA in 2002, based on the recommendation of an independent committee. The report recommended the implementing agency mitigate adverse impacts in different phases. During the pre-construction and construction phase, the agency should address water quality degradation, species habitat threats, and landscape changes. It recommended that the agency transported water for the project from outside to avoid contamination and limit the number of lands occupied for the re-alignment. In the usage phase, the report warned about the expansion of illegal tree logging and degradation of air and water quality from increasing traffic. The agency was required to control land use changes along the new segment. However, the project manager explained that at the time *"the allocated budget was insufficient for following-up on the [EIA] recommendations" (Interview B3)*. In the same year, the provincial government published a feasibility study report to justify the economic importance of the project. This document reported economic benefits gained from the reduction of travel time and vehicle operating costs (DPJ 2002). It also pointed out the productivity growth of agriculture, tourism, and manufacturing sectors if the project was implemented. Still, the two reports were unable to push the implementation forward unless the status of the protected forest was changed to a construction site.

The Ministry of Forestry then issued permission to the Provincial Highway Agency to convert some lands as the project site (DPJ, 2004). In 2004, and the agency signed an MoU that, according to the government official, *"established an agreement [between parties] on the protection of species habitats from land-use changes because of the project implementation"* (*Interview B1*). With this establishment, the Ministry of Public Works handed over the project. The ministry specified four road and bridge routes as alternatives into an implementing plan (DGH 2005). Both the central and provincial agencies selected route alternatives and estimated the total construction cost. The Ministry of Public Works then revised the initial EIA.

Converged streams: the emergence of a 'sustainability' window

In this case, the *problems stream* concerns with the pressing issue of the status of the project site as the nature conservation area. This stream also comes from the pressing economic condition of the regions as reported in the feasibility study in 2002. The *solutions stream* originates from EIA in 2002 and the 2005 implementation plan. Both documents allowed the identification of the project effects. The 2005 plan also turned the project focus from merely infrastructure planning (connectivity improvement) to spatial planning (landscape protection and regional development). Based on this plan, the implementing agency successfully minimized 40% of the total area that could be converted according to MoU 2004. In 2009, a group of university experts were hired as landscape consultants to perform a thorough field investigation. They then published a highway landscape design in complement with the 2005 plan with the title *'Engineering and Landscape in Harmony'* (LBLL, 2009). According to the group leader, the design *"harmonized the massive structure of the new highway with its surrounding landscape by exploiting the touristic potentials" (Interview B4).*

From the *politics stream*, a change in project management, from the provincial government to the Ministry of Public Works, opened the sustainability window. This shift allowed the infusion of additional funding to implement the combined solutions, do fact-finding, and perform joint-research. In collaboration with Ministry of Forestry, the Ministry of Public Works monitored the project effects and restored the displaced landscape and habitats (BKSDA & DPJ, 2009). The involvement of the university experts also helped identification of touristic spots along the highway that became as assets of the local people. By coupling the three streams, the project manager seized an opportunity for balancing interests and allowed the implementation to start.

5.5 Reflecting on a Tale of Two Highways: Coping with Strategic Ambiguity in Planning Sustainable Road Development

5.5.1 Coping with strategic ambiguity by seizing 'sustainability' windows

Concerning strategic ambiguity, the Bali Mandara Highway case shows that the initial project mission of improving economic growth (regional connectivity and tourist attraction) conflicts with the interest of protecting the environment (mangrove forests and religious site preservation). In the Kelok-9 case, the project mission (improving regional connectivity) disputes with an interest of preserving the protected forest. Both cases illustrate that development project missions/goals often contain strategic ambiguity (Giezen et al., 2015) that can be resolved through reflection on the problems and the solutions (Salet et al., 2013). Such a process includes recognition of problems at a larger scale (international and national) and a lower spatial scale (local). In the Bali Mandara Highway case, the problems are

located at the national and regional level (regional connectivity) as well as at the local level (landscape protection). In the case of Kelok-9, the provincial government initially launched the mission of solving the bottleneck problem (at a regional scale), then recognized that the displaced species habitats (at a local scale) also required attention.

The opened sustainability windows illustrate moments when the stakeholders integrate competing interests by coupling the problems, solutions, and political streams. The case of Bali Mandara Highway shows that the problems were discussed in open discussion with the local stakeholders that allowed the solutions to emerge (conformance to high environmental standards and minimization of land acquisition) *(Interview A1).* In Kelok-9 Highway, the solutions consisted of mitigation measures that *"combined a technical solution (construction of high-pillar bridges to reduce land-use change and tree logging), and landscaping (slope prevention and tourist spots for sightseeing)" (Interview B1)*. It appears that the appearance of the windows also provided ways for the project leader/manager to innovate and create added value in coping with strategic ambiguity in large-scale infrastructure projects (Giezen et al., 2015).

The political stream comes from pressure groups (powerful stakeholders) and the change in administration and project management that gave supports for the windows to present themselves. Darmoyono (2019) explained that socio-cultural norm or *gotong royong* (collective works), encouraged continuous efforts of the stakeholders in the Indonesia road development to resolve their conflicts in an informal way. In the Bali Mandara Highway case, the inclusion of religious leaders into the project planning has proven effective as these stakeholders are well-respected in communities (Lamade et al., 2014). The seeking of the windows in both project cases here can be understood because of lack of formal actors' leadership and commitment, and time and fund limitation, which are commonly found in developing countries (Pojani & Stead, 2015). Top-down commitments from politicians or bureaucrats may also be inadequate to implement the recommendations (Fischer, 2004). At a given point in time, the stakeholders successfully matched their interests by using the windows available to them.

5.5.2 Mobilization of policy networks and the coupling of streams by the project manager

Both cases illustrate that policy networks can have a vital role to open the sustainability windows. These networks allow appreciation of each other's interests and collaboration in the seeking of appropriate solutions (Reardon, 2018). In the Bali Mandara Highway case, the interaction of the project consortium and the religious leaders reduced social tensions with the communities with interests of protecting their cultural sites. The Kelok-9 example shows that the network tie between the

public works and the forest authority encouraged resource sharing and collaboration for viable solutions. The project manager (the Ministry of Public Works) and the Nature Conservation Board collaboratively mitigated the displaced landscape through joint-monitoring and research. With the university experts, the project manager tailored solutions (highway re-alignment, landscape protection, and people empowerment).

The project managers working with the religious leader (Bali Mandara Highway) and the expert team (Kelok-9) have a vital role in coupling the streams. These actors show the qualities of being 'policy entrepreneurs'. First, they invested time to gain political support from other powerful parties and to remove any possible delays in implementing the solutions. In the Bali Mandara Highway case, the project manager earned immaterial paybacks from gaining a good reputation from *"delivering the project on time prior to the international APEC 2014 meeting held" (Interview A1).* The religious leaders were concerned about the sacral status of the project site and the improvement of people's livelihood from better connectivity (Lamade et al., 2014). Second, these actors also wanted to generate and test their solutions as prototypes for future projects with a similar challenge. In the case of Kelok-9, the project manager with the university experts linked up the problems and solutions into a detailed implementation plan that provided a showcase for future projects in nature conservation areas. These results, therefore, substantiate that policy entrepreneurs are *"more than just advocates of particular solutions; they are power brokers, coalition enablers, [and] manipulators of problematic preferences and unclear technology"* (Zahariadis, 2016: 35). These actors involved in several decision arenas that enabled them to connect problems and solutions (Van Stigt et al., 2013).

5.5.3 The effectiveness of the sustainability 'windows' and the use of EIA

In both cases, the 'windows' help to integrate interests with several reasons. First, the opening of the windows allows the stakeholders to deal with multiple options to complete the project mission. The Bali Mandara Highway case shows that the initial mission only (economic development) could not be fulfilled unless the local concerns with the social and landscape displacement were resolved. The mission is therefore expanded from connectivity improvement to community livelihood, mangrove protection, and cultural preservation (intra-generational equity and inter-generational equity). Second, the windows provide the implementing agencies with solutions that are financially viable and socially acceptable. In the Kelok-9 case, the final proposal includes a solution that minimizes land occupation for new bridges and roads. The solution expands opportunities for the local communities to manage sightseeing spots for tourists, obtaining long-term economic benefits (intra-generational equity).

The windows also allow the stakeholders to interact and establish collaboration through mobilizing their networks. The windows help these stakeholders to overcome limited capacities for integrated decision-making. In the Bali Mandara Highway case, the project manager approached the respectful local leaders who were concerned about social displacement to avoid social conflicts. The networks allow resource sharing, such as funding and skilled personnel. In the Kelok-9 case, the Ministry of Public Works funded joint-research and monitoring with the forestry authority to minimize adverse project effects.

The environmental assessments carried out in both cases are parts of the policies/solutions stream. By reviewing the EIA recommendations, the stakeholders identified the adverse effects and continuously refined the solutions for mitigation. Open discussions of the proposed recommendations helped the stakeholders involved to reflect on the project mission and to prepare for implementation with legitimate proposals/plans. The EIAs thus facilitate learning between the stakeholders, refinement of the problems and the solutions, and reflection of the project missions. In seizing the sustainability windows for integration, stakeholders expand their organizational capacities and mobilize networks to solve problems collaboratively (W. Salet et al., 2013; Scandelius & Cohen, 2016).

5.6 Conclusion

This paper demonstrated that the Multiple-Streams Framework (MSF) could be useful to structure decision-making processes in road infrastructure planning. The initial mission of the development projects often contains the element of strategic ambiguity that is characterized by multiple interpretations of the project goals, missions, or purposes. The concept of strategic ambiguity here is crucial in recognizing that there are many creative ways in which stakeholders can frame and reframe the project goals (De Bruijn & Leijten, 2007; Glasbergen & Driessen, 2005). The analysis of the multiple streams – problem, policy, and political streams – helps to account for strategic ambiguity by considering the complex decision-making processes that often complicate the planning processes. Strategic ambiguity is seen here as necessary to reassure viable solutions and seek added value (Giezen, 2013; Giezen et al., 2015; Priemus, 2007). This paper also substantiates that strategic ambiguity allows for reflection on what sustainability means to the stakeholders (Kemp & Martens, 2007) and mobilizes collaboration for implementation (Scandelius & Cohen, 2016).

This paper was inspired by the work of Kingdon (1984) and later advancement by other scholars (e.g., Hermansen, 2015; Zahariadis, 2016; Howlett, 2018; Reardon, 2018). MSF is applicable to investigate the streams leading to the presence of a 'sustainability window', in which strategic ambiguity of the projects are coped with, diverse interests are made balanced, and solutions become acceptable to all

stakeholders. Explicitly considering the dynamics of the decision-making in two highway projects in Indonesia, the integration of the interests consists of recognition of the problems and the solutions and associated with them within and across arenas, in which EIAs are informally discussed. EIA here becomes a vital element of the solution/policy stream that facilitates learning and joint fact-finding between stakeholders. Planners and decisions-makers therefore can link up the recommendation with the problems and expand the networks to support the implementation.

Pojani & Stead (2015) argue that most developing countries have a lack of resource and political capacities for implementing sustainable transportation infrastructure development. Recently, road projects have become a primary national strategy to improve economic growth in such countries (Diaz-Sarachaga et al., 2017). However, environment assessments, such as EIA and SEA, might be less compelling to assist the integration because the institutional context is often less supportive than mostly assumed (Nykvist & Nilsson, 2009). This paper substantiates that recommendations produced appear less effective in politicized situations (Fischer, 2004). As found in the empirical case, the lower jurisdiction showed limited funding to fulfill all recommendations (Kelok-9) and the external stakeholders could drive the commitment for implementation (Bali Mandara Highway). Rather than relying on detailed information on the effects, planners and decision-makers should be more aware of the various streams in which the interests at stake can be integrated into project proposals or plans.

In Indonesia, road infrastructure development is highly fragmented, involving various sectors operated in various jurisdictions. The sectoral fragmentation impedes the scoping and screening of the project impacts across the sectors and administrative levels (Darmoyono, 2019; Giovanna et al., 2006). Without formalizing the incorporation of the environmental assessments into the local planning process, the integration of sustainability aspects seems challenging to reach. Moreover, long-term objectives and targets are usually not portrayed as being at the heart of decision-making (Delphine et al., 2019b). Similar situations are found in the case of flood management in Indonesia, in which the national policymakers need not only well-defined articulations of problems, but also public pressure to implement the proposed solutions (Simanjuntak et al., 2012). The integration of interests needs a 'window' that presents itself through participation of wider stakeholders, political supports, and the role of policy entrepreneurs.

For future research, more cases are needed to substantiate how MSF can be effective in structuring complex decision-making processes and in coping with strategic ambiguity of project goals. Our study was located in a context of developing worlds in which road infrastructure projects have become a leading strategic for achieving economic competitiveness but political commitment can easily change in integrating environmental considerations (Regmi, 2014), and less

powerful stakeholders are often omitted from the discussion of development effects (Othman, 2013). Strategic ambiguity, therefore, may deepen conflicts between stakeholders, and they may constantly struggle to incorporate their interests in the project planning. More investigation on unbalanced power relations can inform how the integration of interests associated with sustainability needs not only "best technical solutions", but also continuous reflections of the project goals and better stakeholders' engagement.

6. Contestations over Scale Frames regarding the Sustainability of Mega-infrastructure Project Development: The Case of the Bali Mandara Highway

Bali Mandara highway, Badung, Indonesia ©Demosreg

Abstract

Although attention has been paid to scale in megaproject developments, little is known about how stakeholders frame problems and solutions associated with the sustainability of megaproject development on various scales, and what the effects of such framing are. The present research drew upon the politics of scale, focusing on various stakeholders' arguments about problems and solutions at different scales. We used a case study of the Bali Mandara Highway development project in Indonesia to examine the mixed and multiple scale frames regarding the sustainability of the project throughout the development phases, namely pre-construction, construction and post-construction. Our results show that the stakeholders used multiple scale frames, and that the mix of frames evolved over time. This paper provides insights into megaproject management in which scale should be not only used to structure the aspects of project decisions, but also extended to structure the problems and solutions at spatial, temporal and administrative scales.

Keywords: *megaprojects, impact assessment, spatial scale, qualitative data analysis, Indonesia*

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6.1 Introduction

In developing countries, infrastructure megaprojects have become a strategic delivery option for achieving sustainable development objectives (Othman, 2013). The projects can serve as drivers of economic growth and competitiveness (Mišić & Radujković, 2015). Megaprojects are defined as large-scale, complex ventures that typically cost US$ 100 million or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational and impact millions of people (Flyvbjerg, 2014; Van Marrewijk et al., 2008). Megaprojects attract a high level of public attention and political interest because of the substantial costs and the direct and indirect impacts on the community and the environment (Capka, 2004; Van Marrewijk et al., 2008). The planning and delivery of megaprojects require a high level of design knowledge and technical skills, competent human resources, professional–managerial capabilities and large-scale investments (Flyvbjerg, 2014; Sturup & Low, 2015). These sets of capabilities have been found to be lacking in developing countries (Mentis, 2015; Othman, 2013), which makes it challenging to align megaprojects with the sustainable development agenda.

Sustainability and megaprojects concern more than just the infrastructure scope itself. Sturup and Low (2019) argue that megaproject development should focus not only on what is built or not built, but also on the processes that surround decisions concerning and the impacts of construction (e.g., the social, environmental and economic impacts) in time and space. Here, sustainability means that the state of human and natural resource qualities remains the same or improves over time (Bell & Morse, 2010). The implementation of the concept is far from straightforward and is often contested (Gibson, 2013; Söderbaum, 2008). Project stakeholders have multiple interpretations of objectives and expected outcomes (Ward & Skayannis, 2019) and the multiple emerging interests are often difficult to reconcile (Clegg et al., 2017). Numerous interests influence the different frames of scale and different frames are used to refer to problems and solutions. Moreover, there is ambiguity about the scales at which the problems should be overcome or the solutions that should be delivered (Van Lieshout et al., 2011 for a mega-farm case). In project decision-making, these scale frames compete and affect the sustainability claims of megaproject development.

Studies on environmental impact assessment have shown the importance of scale to understand and address sustainability challenges (Cash et al., 2006; Gibson et al., 2000). Cumming et al. (2006), for example, show that road network development in a specific region may change social behaviors and ecological processes at different scale levels, such as farmers' access to markets (at the lower spatial level) and species habitat fragmentation (at a higher level). In the literature on megaproject management, scale often refers to the scope (or the ‘big’ size of the project). Ansar et al. (2017) expand this discussion of scale into a prescribed place (spatial), a prescribed time (temporal), and the number of actors involved

(relational). Concerning megaproject infrastructure development, some scholars studied scale and refer to it on the spatial scale (e.g., Xu, 2017) or the temporal scale (e.g., Stoffle et al., 2013). Scale is explored regarding the contested claims between project stakeholders over the benefits and costs of the development on a spatial and temporal scale (e.g., Howitt, 2013; Stoffle et al., 2013; Xu, 2017).

Scale is often discussed in relation to the structure of project decision-making, for example regarding strategic or tactical decisions (Salet et al., 2013; Samset, 2008). At a strategic level, decisions are framed in such a way as to keep a vital and shared mission in mind and to inform day-to-day decisions on problems and solutions. At a tactical level, concrete decisions are framed along a controlled but relatively open, step-by-step trajectory, offering more technical solutions to the problems. In most megaproject developments, these decisions tend to be insensitive to new information and knowledge (De Bruijn & Leijten, 2007), making the presentation of problems and solutions contested.

Despite the growing attention to scale in megaproject development, little is known about how stakeholders frame problems and solutions at various scales, and what the effects of these frames are on the sustainability of megaproject development. Our research question therefore was: How do stakeholders use scales to frame problems and solutions in mega-infrastructure project development? To answer this question, we drew upon the central practice of frames as a means to mobilize arguments about problems and solutions at various scales (e.g., Kurtz, 2003; Sadler & Kurtz, 2014). Second, we examined the mixed and multiple scale frames regarding sustainability in each development phase, namely pre-construction, construction and usage. Third, we explored how the strategic use of scale frames affects the sustainability of megaproject development.

For the investigation, Bali Mandara Highway – a road infrastructure megaproject in Bali, Indonesia – was used as a case study. This project is a typical example of a megaproject in a developing country, one that is intended to spur economic growth and competitiveness. However, as commonly found in the developing countries, the project developers had limited capacity to integrate short- and long-term objectives and useful measures of impacts (Othman, 2013). Part of the problem was that broader stakeholder engagement was rare (Clegg et al., 2017) and project successes were defined only in terms of costs, schedule and scope accomplishment (Flyvbjerg, 2017; Lehtonen, 2014).

The rest of this paper is structured as follows. First, the theoretical framework, which is based on a review of the existing literature, is outlined. Second, the research design and methods are described. Third, the results section presents an analysis of the Bali Mandara Highway case. The paper ends with a discussion of the findings and a separate conclusion section.

6.2 Scale Framing regarding the Sustainability of Megaproject Development

A megaproject is considered a totally 'different breed' of project compared to a traditional one (Capka, 2004) because of its broader impacts in time and space. The 'big' or the 'large' scale of such a project may rapidly displace social and natural systems (Gellert & Lynch, 2003). The social complexity of megaprojects means that numerous stakeholders are affected (De Bruijn & Leijten, 2007; Giezen, 2012a; W. Salet et al., 2013). This complexity makes it challenging to manage project decision-making for achieving sustainability (Sturup & Low, 2019; Ward & Skayannis, 2019).

Sustainability here refers to impacts extending from the local level (in which the project takes place) to the wider region over a prolonged period (Howitt, 2013; Stoffle et al., 2013; Sturup & Low, 2019). However, the time and spatial scales of megaproject effects are often strategically defined by the stakeholders. Project developers, for example, tend to shorten the duration of adverse socioeconomic effects to give the impression of low financial risks (Flyvbjerg et al., 2003; Mentis, 2015). Most interested groups in environmental protection are concerned with the prolonged and much broader impacts (Priemus, 2010). The project owners and proponents often seem only interested in immediate economic returns (i.e., economic sustainability) (Stannard, 1990). Therefore, megaproject stakeholders think, articulate and frame sustainability issues at a specific scale in a variety of ways.

Scale is defined as 'the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon' (Gibson et al., 2000). A scale is categorized into units of analysis located at different positions – or levels – on a scale; for example, on a spatial scale, the units can be distinguished into global/international, national, regional and local levels (e.g., Wilbanks & Kates, 1999). A temporal scale can be divided into long-term, medium-term and short-term levels (e.g., Van Lieshout et al., 2011). The governmental jurisdictions, namely municipal, provincial and central government/state, suggest units within an administrative scale (e.g., Vervoort et al., 2012).

Gibson et al. (2000) and Buizer et al. (2011) present an overview of how scales are conceptualized in various disciplines. From their overview, scale can be distinguished as both a neutral construct (or physical entity) and a social construct. Because of the contested information in a megaproject development, scale (as adopted for this study) is conceptualized as a social construct rather than a physical entity (e.g., MacKinnon, 2010; Marston, 2000). This study followed Kurtz (2003, p. 894), who argues that scale 'is not a pre-given, but a way of framing conceptions of political-spatiality'. As a result, scales and social action are mutually constituted and socially produced. Swyngedouw (2000, p. 70) conceptualizes scale as a part of 'continuous reshuffling and reorganization of spatial scales' of social processes that perform as 'an integral part of social strategies and struggles for control and

empowerment'. In this context, scale issues are articulated to enhance the power of some while diminishing the power of others to produce new social outcomes and a different social organization. Moreover, people often manipulate power and authority by operating and situating themselves at different scales (Leitner, 2004).

Scale framing is a process that involves interactions among different actors/ stakeholders to justify a particular definition of a problem at a specific scale (or level) (Dewulf et al., 2011). Kurtz (2003, p. 254) conceptualizes scale frames as a central practice of politics of scale, a 'type of collective action frame that names a grievance, targets decision-makers, and makes claims for redress, all with central reference to and differentiation by particular geographic scales'. When a specific scale frame is deployed, one can respond with a counter-scale frame to undermine the other's scale frame. Furthermore, Kurtz (2002, p. 256) adds that counter-scale frames 'are not collective action per se, but work to counter or undermine one or more elements of scale frames by involving a competing scale of references for the problem at hand'. Through scale framing, actors construct meaningful and actionable linkages between the scales at which the actors encounter a social problem and propose the solution. In other words, scale frames can be perceived as a sense-making device that various actors/stakeholders use to structure socio-environmental problems (Dewulf et al., 2011). Van Lieshout et al. (2011, p. 40) refer to scale frames as 'a specific type of issue frame, i.e. framing the topic of concerns that actors use in different communicative contexts' relating to scale.

The size, duration and complexity of megaproject development give rise to complex processes of contested sensemaking (Clegg et al., 2017). At the time of decision-making, most of the crucial information can be contested, which produces different opinions and arguments about the outcomes and impacts. This contestation is dynamic and evolves throughout the development phases (De Bruijn & Leijten, 2007). From the early development phase onwards, the main stakeholders (e.g., project managers, government officers and consultants/experts) can manage this dynamic by including the opinions of other parties (e.g., NGOs and community representatives) (Priemus, 2010).

Megaprojects run through different development phases, in this case at least pre-construction, construction and usage, as found in formal impact assessment in Indonesia (e.g., Jasa Marga et al., 2011). Pinto and Mantel (1990) for instance, show that most strategic decisions are made during the pre-construction phase (and up-front planning activities), when a project is being developed. Such decisions are framed in terms of needs identification, the deployment of project specifications/standards, and budget and schedule planning. In the pre-construction phase, the stakeholders barely experience project impacts, and future expectations determine the frames about the problems and solutions. During construction, local stakeholders start to experience the development effects at a limited spatial scale, and frame problems concerning, for example, congestion at road junctions or on

feeder roads and traffic-related pollution (Priemus, 2007). In the usage phase, stakeholders may perceive the broader consequences in time and space, due to which the affected stakeholders frame the permanent effects of megaprojects (Delphine et al., 2019). In a series of decision-making processes, different parties operating at different jurisdictions (i.e., municipal, provincial, national) jointly frame and reframe the project missions and mobilize solutions with the necessary resources (Suprayoga et al., 2020) .

An analytical framework that elaborates on the scale frames and levels in the mentioned phases is presented in Figure 6.1. In this framework, different scale frames (or levels) regarding the project decisions, and the project impacts and outcomes in time and space, indicate that the development project itself is possibly contentious and exposed to mixed frames regarding the problems and solutions. The final development achievement is therefore the result of the multiple frames of outcomes and impacts in different phases. These phases are interrelated, which means that the decisions made during one phases will influence the decisions made in the following phases (Priemus, 2010).

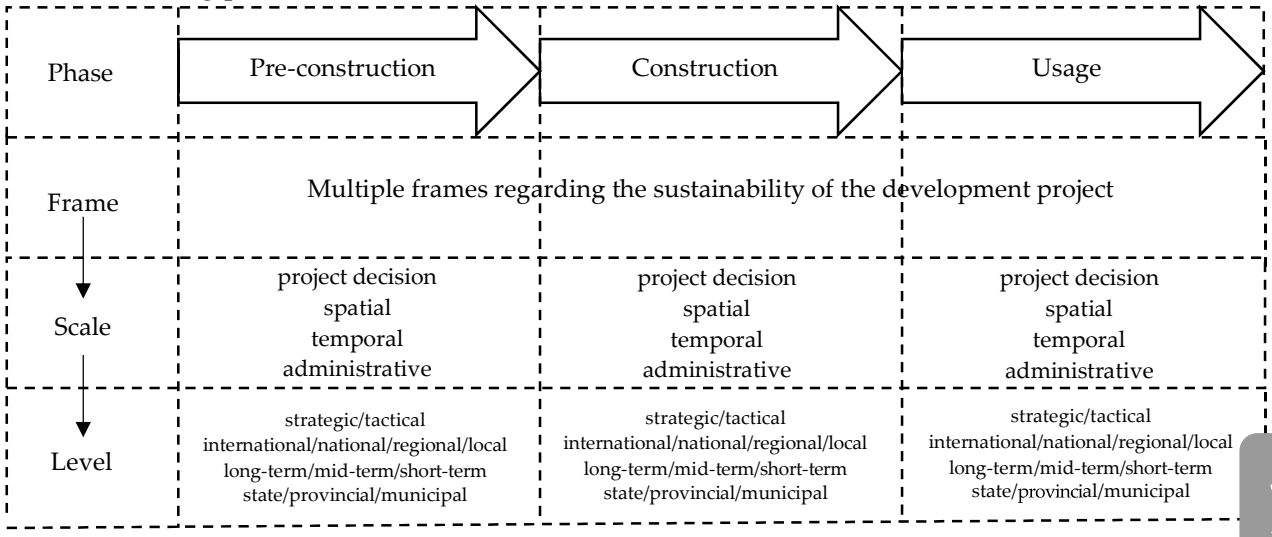


Figure 6.1 The analytical framework: scale framing

6.3 Research Design

6.3.1 Data collection and analysis

We applied a single case study approach because we wanted to examine how and why scale frames, as a social phenomenon, can occur and change (e.g., Yin, 2014). Following Flyvbjerg (2006, p. 236), we selected this approach to 'understand the viewpoints and behaviours, which characterise social actors' in a specific social context. In this study, the approach was used to explore concepts (i.e., scale frames and sustainability) in the Bali Mandara Highway development project, which served as a case study. The results of a single case study design can be useful before

performing a further detailed examination involving multiple cases (Yin, 2014). We also examined the underlying mechanisms that connect the framework presented in Figure 6.1 with multiple data gathered from both primary and secondary sources during the fieldwork (Thomas, 2011).

The Bali Mandara Highway was chosen as a case study for several reasons. First, the case is a megaproject regarding its budget and planning outlook and the number of involved stakeholders. Suprayoga et al. (2020) found that the planning process involved a series of decisions and that the framing and re-framing of the project mission was inevitable, as different stakeholders at various jurisdictions pushed forward their own interests. Second, the project was a complex one, with high inequality of involvement between stakeholders, large environmental impacts and wide-ranging effects on mobility and accessibility, including world-famous tourist sites in Bali. Third, the project sparked different arguments between stakeholders regarding the impacts of and outcomes from the up-front planning activities through to the usage phase, as recorded in public news media. Scale framing thus had exemplary effects on the sustainability of the megaproject. Finally, the access to data was high and the cultural circumstances were favorable.

Data were collected from policy documents, project reports, monographs and news articles to understand the issues around the case. The news articles were published by the popular media press with local and national coverage, and dated from the pre-construction phase (September 2012) to the early usage phase (October 2013). Thereafter, a series of semi-structured interviews were conducted with 20 interviewees selected through purposive sampling (Kumar, 2014). This type of sampling ensured the close involvement of stakeholders in one or more development phases. The interviewees therefore included governmental actors at all jurisdictions, project consortium representatives, environmental/ planning consultants, NGOs and local leaders (see Table 6.1). The interviews were carried out between September 2017 and August 2018. A list of questions guided the interviews about how the stakeholders framed the sustainability of the highway development, what they considered problems and solutions, and how and why the problems and solutions were framed as such. We therefore gained insights into the decisions taken, the situations faced and the impacts encountered in each phase. All interviews were audio-recorded. Upon completion, verbatim transcripts of the recordings were sent to the interviewees for comments and confirmation.

Table 6.1 The list of interviewees of the Bali Mandara Highway project

No.	Category	Number of interviewees	Code
1.	Project manager & engineering staff member (project consortium)	3	A1, A2, A3
2.	Municipal government official	4	BA1, BA2, B3, B4
3.	Provincial government official	2	C1, C2
4.	National government official	4	DA1, DA2, D3, D4
5.	Environmental and planning consultant/ expert	3	E1, E2, E3
6.	NGO director	2	F1, F2
7.	Local leader	2	G1, G2

As regards positionality (Schwartz-Shea & Yanow, 2012), the first author was involved in the auditing of the sustainability performance of the Bali Mandara Highway development project before conducting the present research. This involvement gave the researchers access to data on the project as well as the interviewees, and in-depth knowledge of the tensions and cultural issues related to the execution of the project. In addition, prior knowledge of the project setting provided a sense of the importance of how scale was involved in debates and how the technical project decisions (framed as strategic and tactical decisions) played a significant role in legitimizing planning and executing the project.

By analyzing the interviewees' responses, we constructed an overview of what the stakeholders framed as megaproject sustainability and on which scales these frames were located. Qualitative data analysis software (Atlas.ti) was used to bottom-up code the interview transcripts. The first step in our analysis was to read the interview transcripts looking for words and phrases related to scale-related issues or impacts (e.g., 'scale,' 'scale effect', 'large-scale' and 'administrative scale'), to time, to spatial or administrative areas, and to the size of the project. The second step was to code these based on the theoretical framework. In our third step, we constructed a timeline with framing of scales to trace the evolution, mixing and working of scale frames.

6.3.2 The case study: The Bali Mandara Highway

The Bali Mandara Highway is a 12.7 km toll road connecting three important locations in the southern part of Bali, namely (1) the tourist resort of Nusa Dua, (2) Ngurah Rai International Airport and (3) Benoa harbor (Figure 6.2). The highway entered the public domain in 2006 at the Indonesia Regional Investment Forum, during which the potential of infrastructure development to improve economic competitiveness was strategically explored (CMEA, 2011). The project remained

dormant, but was incorporated into various policy documents. For instance, The Metropolitan Spatial Plan 2011 states that this megaproject aims at 'connecting the activity centers located within the metropolitan region and supporting the regional growth as the national activity center that focuses mainly on tourism development' (MPW, 2011, Article 7). The highway spans Tanjung Benoa bay to comply with the local building code, which strictly prohibits the construction of an overpass with a height of more than 15 meters above the existing arterial road (Lamade et al., 2014).

The project consortium – consisting of five state-owned companies and one provincial and one municipal government – spent around €195 million on the design and construction, which at the time was Indonesia's largest infrastructure investment. Around 1,373 ha of mangrove forest was converted as the project site (Jasa Marga et al., 2011). More than 110,000 people lived in the area before the construction (BPS, 2012). In 2012, some 14 million international and domestic passengers passed through the airport. Benoa harbor is vital for the transportation of goods and people to less developed regions in the eastern part of Indonesia. There are 370 star-rated hotels in the Nusa Dua resort in the southern part of Bali, for which this highway is an important investment regarding transportation to and from the area.

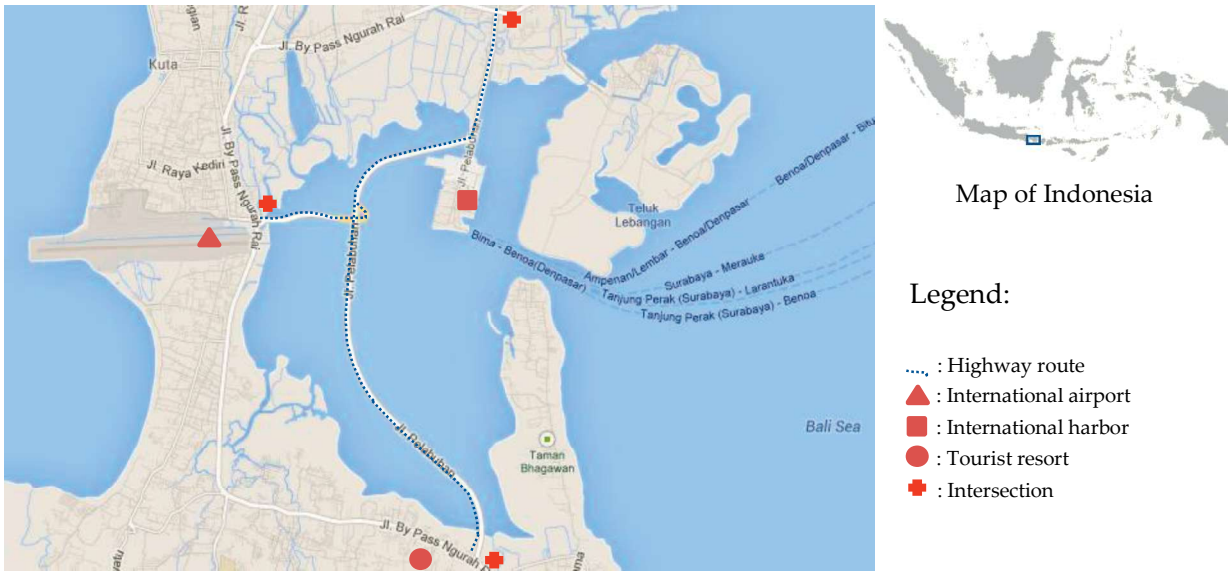


Figure 6.2 The location of the Bali Mandara Highway project

Different strategic perspectives on the sustainability of the megaproject development emerged during the decision-making processes. Three of these perspectives were pivotal. The first revolved around road network capacity expansion to improve the image of Bali as a competitive tourist destination by solving the acute traffic congestion in the area. The second perspective concentrated on mitigating the local impacts in general and preserving the natural and cultural

landscape of Tanjung Benoa bay, a large area of pristine mangrove forest that has several religious spots. Third, the strategic perspective focused predominantly on reinforcing the urban structure and transportation networks by improving connections with Denpasar (Bali's capital) and linking the southern and eastern parts of the Bali region to distribute regional mobility patterns and associated future developments.

As the project was about to be implemented, technical and social complexity emerged. First, the project contractors found flaws in the tide table, which affected the installation of the highway pillars. The NGOs found that the introduction of a new method aimed at resolving the problem increased the sedimentation rate and degraded the water quality in the surrounding area. Local fisheries also claimed that the project had reduced the number of fish and crustacean species in the bay area, and the rapid conversion of mangrove forests into business and settlement use was inevitable. Moreover, traffic congestion persisted, and three new highway junctions were identified as transportation bottlenecks (see Figure 6.2).

The development project was planned to be completed in 18 months. Nevertheless, the central government, which – through its five state-owned companies – had the largest investment share in the project, wanted to bring forward the completion to four months before the 25th Annual Meeting of Asia-Pacific Economic Cooperation (APEC) leaders in October 2013. Table 6.2 shows the project timeline and milestones.

Table 6.2 Project timeline and milestones of the Bali Mandara Highway project

Timeline	Phase	Project milestone
October 2011 – March 2012	Pre-construction	• Metropolitan Spatial Plan 2011 published • Public meetings on the environment impact assessment recommendations • Environmental impact assessment approved by the governor • Contractors and auditing consultants selected • Highway design finalized
April 2012 – June 2013	Construction	• Highway design revised • Construction work started • EIA revision approved • All construction works completed
June 2013 – October 2013	Early usage	• Operational and safety devices installed • Highway toll operation started • Metropolitan Spatial Plan 2011 revised • APEC Meeting 2013 held

6.4 Results: The Dynamics of Scale Frames concerning the Sustainability of the Bali Mandara Highway Development Project

This section outlines the results of the study concerning the scale frames and counter-scale frames used by the stakeholders of the Bali Mandara Highway development project in each development phase.

6.4.1 Pre-construction

In this phase, the project consortium used the project decision scale to frame the sustainability of the development. At a strategic level, the consortium argued that the development would cut travel time and reduce congestion in the area and thus benefit the economy. They explained that they opted for a route alignment to minimize the amount of land acquired from local people. They claimed that this option was necessary to reduce social tension amongst the local people.

> The highway […] helped to connect the harbor, the airport and the resort, and people could reach them in less than 15 minutes from each point. (A1)

> By selecting this [highway] alignment above the water, it avoided a social conflict caused by land acquisition. This option was therefore a win–win solution to resolve the interests between connectivity improvement and a reduction of tensions among the local people. (A1)

At a tactical level, the consortium managed to minimize the amount of land acquired for the construction site. By using these project decision scale-level frames, the consortium showed other stakeholders that sustainability was its primary concern.

Second, by using a spatial scale, the central government framed the sustainability in terms of maintaining Bali's position among other top international tourist destinations and relieving traffic congestion on a regional scale level. The central government also used the spatial scale frame to point out that the development was an implementation based on a higher (i.e., national) spatial plan.

> Bali is the leading tourist destination in Indonesia and is well known worldwide. […] The highway has a vital role in maintaining its image as a competitive tourist destination worldwide. (DA1)

> The highway [development], as the implementation of the Metropolitan Spatial Plan 2011, was aimed at strengthening the connectivity in the urban region as well as enhancing tourists' visits and distributing traffic concentration wisely. (DA1)

Thus, the municipal and provincial governments framed sustainability in terms of becoming a new touristic icon at the local level and as a means to accelerate regional economic growth.

> […] the highway would improve the tourism sector and other economic activities in Bali. Moreover, this [highway] could be a new tourist attraction because of its impressive structure and the beautiful landscape. (BA2)

> […] the highway would accelerate regional growth and create business and employment in Bali, particularly in its southern part. (C1)

Third, at a temporal scale, the central government argued for the economic sustainability in two ways: they argued that it would relieve the acute congestion in the medium term, and they framed the development as vital to support the APEC meeting in the short term. It appears that at this phase, the central authority only perceived benefits on a limited time scale.

Fourth, the administrative scale was used by an NGO to frame their dispute concerning the megaproject development plan with the provincial and municipal spatial plan. They claimed that the development plan came out of the blue and did not fit with the existing spatial plans.

> […] the highway should be built at another location. We believe that the government intentionally changed the location because it was built to support the implementation of the event [APEC gathering]. The [provincial] spatial plan should therefore be revised. (BA1)

Moreover, two of the interviewed experts claimed that, by using an administrative scale frame, the development seemed only to serve the interests of particular governmental levels. One of the experts suspected that the future enactment of the Metropolitan Spatial Plan 2011 by the central government merely legalized the development, allowing massive destruction of mangrove forest around the construction site. Another expert said that both the provincial and the municipal government had a conflict of interest in the project implementation, as they were also members of the consortium. Both experts admitted that the dispute had undermined the sustainability of the development project.

6.4.2 Construction

In this phase, the consortium argued that it had already acted appropriately to mitigate the project's effects. Referring to the tactical decisions made, it framed the project's sustainability with the success of complying with a stricter and higher environmental standard compared to other projects. They also argued that they were deploying what they called 'environment-friendly technologies' (e.g., recycled materials for pavement and bio-wastewater treatment) to protect the landscape quality. They also pointed out that the project construction included some measures to secure the surrounding species habitats.

> [Some technological] measures, such as material types and technologies, were applied to minimize the adverse consequences of the construction on the environment. (A2)

> The contractors installed wooden piles that allow sea birds to remain safe in their habitat. By this [effort], we already protected the landscape and the species' habitat from the displacement. (A1)

These claims all sound rather technical, but reveal decisions and actions taken to achieve the sustainability mission . The consortium also claimed that creating jobs for the local community during the construction work supported social sustainability. One of the interviewed experts backed the consortium's claim and said that local multiplier effects had indeed occurred for a limited period: 'The construction work created jobs for the local people and that generated multiplier effects in the area' (F1).

The NGO directors and the local leaders, however, disagreed with the claims of the consortium's representative. Contested scale frames started to emerge in this phase when the provincial government approved the revised document of the formal environmental impact assessment, which permitted the project contractors to change the construction method. It allowed them to use the material from the bore holes for the bridge's piles and from sources on land to raise the seabed along the route of the new road for the transport of equipment and personnel. It also solved the problem of tidal sea-level rise and made pile driving and other construction activities much easier. The consortium claimed that this change had no negative effects on the coastal environment. The NGOs and one local leader argued that the project had led to the destruction of mangrove forests at the local level. One of the experts claimed that the negative effects will last much longer than what is stated in the NGOs' studies.

> […] the new method for the construction should not be deployed. It potentially destroys the mangrove forest. It's turned out that some parts of the forest have become too difficult to restore. (F2)

> […] the soil materials deposited at the project site during construction have had a cumulative effect on the fragile landscape, such as a loss of biodiversity. (E1)

By using an administrative scale frame, an NGO and one of the experts framed the provincial government as the party responsible for causing adverse impacts. The expert also pointed out the inability of the provincial government to monitor these effects.

In this phase, the scale frame contestation over the sustainability of the development occurred when the project consortium thought that it had already taken some technical measures to mitigate the effects. However, the other stakeholders (NGOs and local leaders) disagreed, because the perceived adverse effects on the environment immediately materialized on site after the approval of the

revision. A part of the problem was the failure of the provincial government to incorporate the voices of the local people and the NGOs and have them check for and monitor these effects. Confronted with pressure due to the tight schedule, the project consortium continued the construction despite the protests.

6.4.3 Early Usage

The consortium completed the project in March 2013, four months ahead of schedule. It installed several devices to monitor traffic safety and reduce the energy consumption of the road lighting. Framing such actions in a tactical way, the consortium claimed it had contributed to mitigating the effects of the highway's operation. However, an NGO and one local leader disagreed that the measures were sufficient, and argued that there were persistent problems with the degraded landscape quality at the local and the regional scale level. One local leader even protested that an increase in biochemical oxygen demand (BOD) and chemical oxygen demand (COD) was evident, threatening the sustainability of the marine resources at the project site at a broader spatial level.

> BOD and COD have reached levels that are much higher than the minimum acceptable level. The local fisheries have seen a drop in the number marine animals that they catch. Crabs, for example, consume plankton, which is unable to grow naturally in such a polluted area. The residual materials from the project also block the circulation of seawater that brought the plankton. The fisheries have suffered economically from the low production of marine resources. (G2)

Despite this contestation, all stakeholders agreed that the spatial scope of the development was too small to solve the congestion problem. First, the rapid land-use change in the local area has become uncontrolled and generates more traffic than predicted. Second, three nearby intersections have become traffic bottlenecks. These bottlenecks worsened congestion and increased air pollution in the area. One of the experts said:

> The highway exits have become so dense with motorized traffic, especially during peak hours. It seemed that the project developers neglected failed to anticipate such a situation in the planning phase. Some of the land in the area has also been profoundly affected by this increased traffic. (E2)

By using the temporal scale, the consortium framed the benefits of the new highway in both the short and the medium term (e.g., travel time reduction between the airport and the tourist resorts, the reduction in congestion costs). In contrast, a director of one of the NGOs complained that the development had failed to deliver a permanent sustainable solution because the congestion persisted. The director claimed that the project actualisation only served a short-term interest (i.e., holding an international event) and did not have any prolonged benefits. The NGO director and the local leaders claimed that the development had produced unprecedented

long-term adverse events by threatening the people's natural and cultural resiliency. The director substantiated his argument by pointing out the massive transfer of property ownership to foreigners and the displacement of local fishing grounds:

> A demographic shift occurred as property ownership changed. The local people and big businesses compete to benefit from the development, and unbalanced competition has happened among both. (F1)

> The local communities and fisheries are affected by the highway. In the past, they could catch crabs and fish in the area. The massive highway structure has blocked the movement of their boats and reduced the number of marine species. (F1)

In this phase, the local leaders and the NGO directors framed the accumulated effects in time and space as undermining the consortium's claims regarding successes with planning, costs and technical scope. One of the local leaders, for example, said that:

> Most people were sceptical of the development plan in the area because their voices were often unheard. People already spoke about a delay in the project implementation and that the effects should be investigated thoroughly. However, the project was still carried out […] The people's concerns were considered unimportant. (G1)

The results of this study reveal that the stakeholders in the megaproject used mixed scale frames regarding the sustainability of the development. These scale frames evolved and were contested over time. Without active stakeholder engagement from the early phase, scale frames led to diverging opinions about the project's sustainability, in which scale frame mismatches occurred. These mismatches proved to be problematic for all stakeholders, and their cumulation also explains why the local people felt marginalised in the early usage phase.

6.5 Discussion

Our study shows that the key stakeholders in a megaproject development used different scales in their framing of the issues concerning the development they were involved in. The project consortium in Bali mainly used the project decision, and to a limited extent the spatial scale frames, in their arguments about the project's sustainability. They framed the development as improving connectivity and avoiding social conflict. Over the project development phases, the consortium used its decisions at the tactical level to argue that adverse impacts on the environment were mitigated through the application of strict environmental standards and environment-friendly technologies. This result substantiates the finding of Salet et al. (2013), namely that the strategic and tactical levels are often discussed to structure and frame actions and decisions in project management, while in this case the

government officials mainly used the spatial and temporal scale in their reasoning about the project's benefits.

Our results also show that local leaders mainly used temporal scale frames to argue about the cultural and natural resource efficiency, even though it threatened the future livelihood of the local people. The university experts, however, used diverse scale frames (i.e., spatial, temporal and administrative) to construct arguments about what constituted sustainability in the Mandara Highway case. They pointed out the coherence of the development plan with the existing spatial plan and highlighted some issues regarding the adverse project effects in time and space in all development phases.

Stakeholders therefore use multiple scale frames and level frames, not only in relation to the project decision as studied in megaproject literature (e.g., Clegg et al., 2017; De Bruijn & Leijten, 2007; Giezen, 2013; Salet et al., 2013), but also in other large-scale system decisions (Zandvoort et al., 2019). These frames can also represent the problems and solutions at a spatial, temporal and administrative scale. Following Kurtz (2003), the government's frames at higher spatial scale levels together with the NGOs' and the local leaders' frames at lower scale levels, relate to each other as scale frames and counter-scale frames. These scale frames and counter-scale frames consist of different scale dimensions (e.g., project decision, spatial, temporal and administrative) to highlight different elements of the issues related to the sustainability of megaproject development. The use of different mixed scales and levels enables more arguments and structures the arguments to push forward the stakeholders' interests (Van Lieshout et al., 2011). The use of multiple scale frames in this study shows that stakeholders have different perspectives on project outcomes and impacts (Howitt, 2013; Stoffle et al., 2013).

These scale frames evolved throughout the development phases. For example, during the pre-construction phase, the government authorities firmly believed that the development would deliver benefits in terms of supporting Bali as an established tourist destination, relieving congestion and distributing the economic development at a wider spatial scale level (i.e., the national and the regional level). On the contrary, NGOs and local leaders used the spatial scale frame to argue about the cumulative negative impacts on the landscape and the local inhabitants, such as water quality degradation and mangrove forest and fishing ground destruction during the construction and early usage phases. The local leaders pointed out the destruction of fishing grounds at the local level after the introduction of a new construction method. Contradicting this, at the early usage phase, the government stakeholders shifted the argument about the economic benefits to the regional level and at the same time excluded other arguments about the environmental costs at the local level – a clear example of a counter-frame based on different scales to win the debate leading up to a decision. This result also explains why strategic misrepresentation concerns not only the calculation of benefits and costs (Flyvbjerg

et al., 2003), but also the representation of these benefits and costs at particular scales or levels. Our results show that such strategic framing of issues at particular scales was common among the project proponents in order to control time and space impacts, and to assure others (especially the general public) of their ability to predict and mitigate the impacts (Stoffle et al., 2013). However, such behavior masks the inability of the project's opponents to do so (Adam, 1998).

Our results also show that the strategic use of scale can produce scale frame mismatches. Van Lieshout et al. (2011) state that such mismatches occur when the scale frames used by different stakeholders point in different directions, making decisions problematic. At the same time, specific stakeholders intentionally or unintentionally neglected other scale frames. For example, the project consortium continued to deploy the new construction method, even though NGOs and local leaders claimed that it was affecting the landscape quality and the fisheries. Such a situation is called a 'dialogue of the deaf' (Van Eeten, 1999), in which each party is unresponsive to what others say, creating a stagnating effect on collaboratively viewing and accepting problems in different times and spaces. As a result, problems can become intractable. Winch (2017) argues that megaprojects also entail the loss of natural capital and amenity for local stakeholders (and future generations). This study showed that the neglect of some stakeholders' scale frames made them feel excluded from the project decision-making and prevented them from obtaining future benefits from the development.

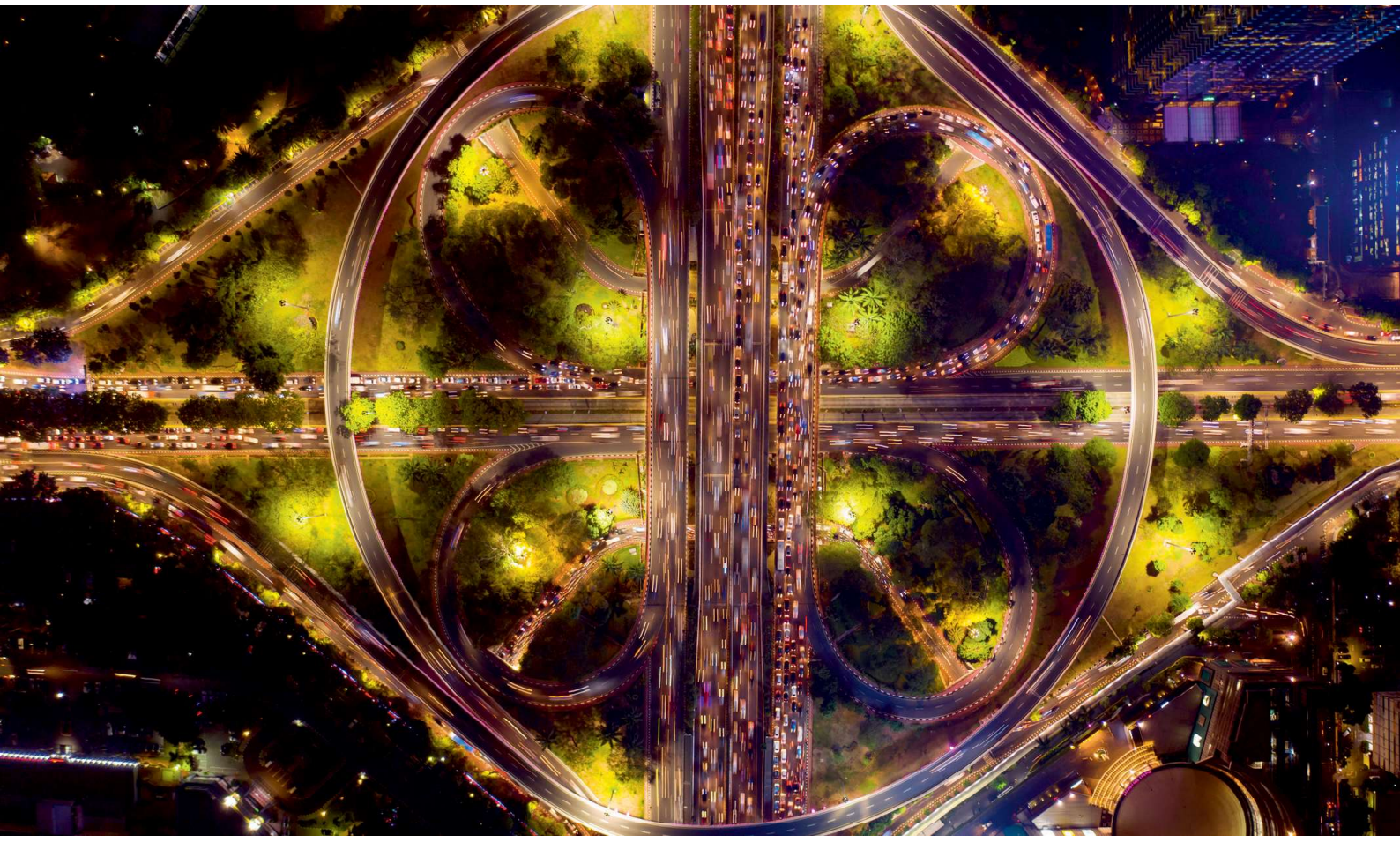
6.6 Conclusion

This study showed that stakeholders used various frames regarding issues surrounding the megaproject development of the Bali Mandara Highway in Indonesia. The limited use of scale failed to unfold multiple aspects associated with sustainability. Therefore, the planning and decision-making of megaproject development should include more aspects than the project management can provide to structure the problems and solutions. The study showed that different stakeholders tended to use specific scales (e.g., spatial, temporal and administrative scales) to structure the problems and the solutions. We conclude that scale frames were used to make sense of the complexity of the megaproject development, and were directed at both the problems at stake and the pathways along which the solutions should be sought. The framing of issues at particular scales and levels also made it possible to either consciously or unconsciously include or exclude arguments and other stakeholders. Debates, and who wins and who loses as the result of a decision, were largely determined by choices of scale and the scale levels to argue on. Our study drew on the changes of the identified scale frames and the inability to mediate the differences, which may bring disadvantages for the people and the landscape in the long term.

The politics of scale – in other words, the strategic use of scale frames – has several implications. First, scale frame differences can enrich discussions on outcomes and impacts at each phase and allow debates and fact checking that reduce strategic misrepresentations of benefits and costs at specific scales or levels (i.e., time and space). Second, scale frame mismatches contribute to conflict if negotiations and collaboration fail to overcome differences. In the Indonesian spatial planning procedure, inclusive participation in development planning and implementation is well recognized (Rukmana, 2015), but our study shows that stakeholder engagement is an issue that planners still need to work on. This study confirms that room for stakeholder engagement is still insufficient, as it is in most developing countries (Othman, 2013). The result is that the less powerful stakeholders tend to be marginalized (Delphine et al., 2019a). There is therefore a need for a greater emphasis on the sense-making and framing aspects of megaproject development, such as the understanding of multiple stakeholders' interests and the value of practicing stakeholder management. Educating marginalized stakeholders on the role of framing, scale issues and decision-making is therefore pivotal.

Megaproject development always involves politics of scale, a matter that is less considered in the literature, especially for its emancipating power for the poor and less developed, such as the fishing community in the Bali Mandara area. The results of this study add to the understanding of the complexity of megaproject development in terms of contested sense-making, in which scale frames are central to elucidate the power relations between stakeholders. Scale can relate to ethical concerns, including intergenerational equity and the evolution of the scale frames. Both are fundamental to keep megaprojects aligned with the sustainable development agenda.

7. Pathways to Sustainable Road Infrastructure Development



Semanggi flyover, Jakarta, Indonesia ©Ximagination

The introduction section of this dissertation highlighted the importance of integrating sustainability into planning road infrastructure development. In this, road infrastructure turns out to be a prominent spatial intervention by policymakers worldwide, aimed at improving regional connectivity and urban accessibility (Öberg et al., 2017; Bertolini et al., 2005; Spit, 1999). In developing countries, in particular, policymakers positioned road development at the top of their policy agendas, aiming at enhancing economic competitiveness through attracting foreign investment (Gartner, 2016). They mostly believe that new road construction is the main cure for traffic congestion (Pojani & Stead, 2015). However, they often fail to recognize the broader adverse effects on the environment and society. These effects may include landscape displacement and have prolonged consequences (Gellert & Lynch, 2003; Van der Ree et al., 2015; Delphine, 2019). Better integration will enable policymakers and planners to keep aligned with the international agenda on sustainable development.

The planning phase is suggested to be vital for advancing the integration of sustainability interests. In this phase, stakeholders prepare the resources required (e.g., funding, time, and personnel) to make the integration successful. Moreover, the process within this phase allows the exploration of ways to tackle adverse development impacts earlier than if it is done in later phases (i.e., the construction and operation phases) (Bueno et al., 2015; Reid et al., 2012; Tsai & Chang, 2012). But the difficulty remains. Stakeholders have different interpretations of what sustainability means and what can be expected of it (Bond & Morrison-Saunders, 2009; Gibson, 2013). Influential stakeholders often dominate project decision-making (Flyvbjerg, 2017; Salling & Banister, 2009) and shape the expected outcomes. It also appears that there is a lack of awareness of the integrative aspects of sustainable development (Pojani & Stead, 2015), such as time and space, and the three sustainability pillars (i.e., the social, economic, and environmental pillars). In developing countries, sectoral fragmentation frequently prevents stakeholders from effectively coordinating to achieve a collective goal (Mentis, 2015; Regmi, 2014). Research has shown that environmental considerations tend to be incorporated only later on in transportation projects (Soria-Lara et al., 2015) and that a lack of preparation is common (Fischer, 1999b). Therefore, the integration of sustainability into planning road infrastructure development is still facing several challenges.

This dissertation explored the features that affect the integration. Integration was viewed from a new institutional perspective, in which formal and informal rules jointly determine the successful or limited integration. Moreover, using this perspective, agency and structure interact with each other, and shape the societal outcomes (Hall & Taylor, 1996; Koelble, 1995; Peters, 2012). This dissertation argued that integration is determined not only by the content, but also by the quality of planning processes in a given societal context. Context plays an important role through institutional arrangements, power structure, and cultural embeddedness (Healey, 2007). In addition, there is a complex interplay between content and context

and between substance and process that co-determines planning outcomes (Healey, 2006, 2007). Therefore, planning for integration should be seen as more than just a rational decision-making process. Instead, it is also a political exercise to construct the social reality, in which institutions can act as both barriers and opportunities. Against this backdrop, the aim of the present research was to answer the following main research question:

> ***What features explain the successful or limited integration of sustainability into planning road infrastructure development, and what specific strategies can be revealed by this investigation into the particular case of Indonesia as a developing country?***

To examine the answers to this question, this chapter discusses the outcomes of the research from three perspectives, namely content, context, and process. The following section first offers conclusions based on the research findings. The chapter ends with a discussion and some final thoughts.

7.1 Synthesis of the Main Findings: Answering the Sub-Research Questions

The previous chapters provided insights that help to better understanding the different perspectives of integrating sustainability into planning road infrastructure development. This section first discusses the answers to the sub-research questions. The findings from the chapters are then related to the analytical framework presented in Chapter 1 to answer the main research question (Section 7.2).

7.1.1 To what extent have assessment tools incorporated sustainability in planning road infrastructure projects?

Chapter 2 started with a systematic review of indicators to assess the sustainability of road infrastructure projects. The contribution of this chapter is that it elucidated the various indicators that are included in the sustainability assessment of road infrastructure projects. The chapter also scrutinized which sustainability criteria/aspects were sufficiently or insufficiently covered as indicators, and in what ways the indicators could be further implemented in planning. Based on a systematic literature review, the findings show that there are some drawbacks to the application of sustainability assessment of road infrastructure projects.

First, none of the approaches identified in the literature is capable of incorporating all of the associated criteria/aspects as indicators. The "project appraisal methods" approach, for example, neglects the complete account of intangible impacts throughout a project's lifecycle. As for cost–benefit analysis (CBA), the method tends to emphasize only those impacts that can be transformed

into monetary values (Bueno et al., 2015). In addition, the "techniques for impact assessments" approach includes very few criteria/ aspects as indicators, and predominantly includes indicators concerning the efficient use of resources (materials and energy) (Hameed & Hancock, 2014; Stripple, 2001). In the "sustainability assessment methodologies" approach, many different indicators are used with limited criteria included. This finding confirms that a selective bias appears in the inclusion of indicators in the papers reviewed, out of either pragmatism or convenience (Bell & Morse, 2010).

The second drawback is that core sustainability criteria (i.e., intergenerational equity, and precaution and adaptation) are less covered as indicators. One of the possible reasons for this is that the reductionist paradigm dominates the deployment of assessment tools (Gasparatos et al., 2009). Gasparatos (2010) also argues that most sustainability assessment tools are concerned with only a limited time period and are unable to secure critical, human and natural resources (Thérivel et al., 2009). On the other hand, some indicators can be easily quantified or monetized (e.g., time saving, safety risk reduction, vehicle operating cost, macroeconomic development). All in all, an exhaustive inclusion of criteria is inherently tricky because of limited resource to capture the complex interaction of socio-ecological elements in the long run (Bueno et al., 2015).

In conclusion, sustainability is a vague concept and it has multi-interpretative meanings (e.g., Ashford & Hall, 2011; Kemp & Martens, 2007). From the content perspective, clarification of the concept in planning can be an initial step toward integration. This process can be stimulated by testing the assessment indicators used against the criteria provided in Chapter 2. Such a procedure may avoid representing favorable discourses, for example, economic development over environmental protection. Chapter 2 also suggests that any assessment tool has to prioritize the inclusion of indicators that reflect intergenerational equity considerations. Moreover, the findings of this chapter reflect, from the content perspective, the need for a balanced inclusion of indicators for successful sustainability integration.

7.1.2 How are time and space dimensions included in a sectoral and a comprehensive perspective on planning for sustainable road infrastructure development?

Chapter 3 identified multiple perspectives on the sustainability of road infrastructure development. It contributes to the construction of an integrated approach that includes considerations of space and time, which are often absent from current assessments. Based on the case of Trans-Java Road Network Corridors, the research shows that various sectoral elements constitute the sustainable outcomes. These elements can be located in an infrastructure, a spatial, a temporal, and a governance perspective. Each perspective can be elaborated in detailed

dimensions, in which the various sectoral elements are found. These dimensions are hardly separable from each other, showing that the sustainability of road development is cumulative to these sectoral elements, and a fragmented and sectoral view cannot secure the intended outcome.

The findings presented in this chapter show that a sectoral view, represented by the infrastructure perspective, is inadequate to capture all sustainability elements and their interactions. As investigated in the case study, this infrastructure perspective is also focused only on mitigating the adverse environmental effects of the physical construction and operation (Gudmundsson et al., 2016). It tends to focus on efficiency and reveals the inability of the respective agencies to capture broader development effects, both spatially and temporally (e.g., Litman, 2013). By bringing together all sectoral elements in a comprehensive perspective, the chapter shows that multiple sectoral elements contribute jointly to sustainable development.

When seen from a broader theoretical angle, these findings can be the starting point for a more nuanced approach to connecting and balancing both sectoral and comprehensive perspectives into planning for sustainable road development. The application of mixed perspectives allows policymakers and planners to select which sectoral elements are relevant for advancing integration (e.g., Ramani et al., 2011; Gudmundsson et al., 2016). For this purpose, a mixed-scanning methodology was introduced. The methodology aids the examination of sectoral elements and permits adjustments to these elements when decision environments continuously transform to adapt to new contexts (Ijeoma, 2007). The use of this methodology is suitable for developing countries, in which the political commitment can easily change and sectoral fragmentation hinders further integration (Pojani & Stead, 2015). The methodology also allows stakeholders to capture various sectoral perspectives and to sensitize the posture of other policy sectors and their relations at different scale levels (Etzioni, 1999). This finding also shows that institutions, as a feature of context, play a role in advancing integration (Ng et al., 2015).

7.1.3 What institutional barriers affect the integration of sustainability in road project planning?

Chapter 3 provided an analytical framework to investigate the role of context. According to Bina (2008, p. 719), context is "the organizational and institutional location of the decision-making processes which are themselves situated within and influenced by a given society and its broader social, cultural, and political values." Tennøy (2010) argues that contexts affect how policymakers make progress on sustainable development, in terms of political support, trust, and commitment, which is beyond what assessment tools and indicators can support. Moreover, context informs us about legal and administrative matters that have procedural and methodological implications (Gazzola et al., 2011); it also determines successful

integration by the adaptation and creation of tailored-made assessments (Hildén et al., 2004; Marsden, 1998).

The findings presented in this chapter confirm the role of institutions in limiting integration. The chapter examined the complexity of institutions by analyzing at three levels, viz. the micro-, the meso-, and the macro-level (e.g., Nykvist & Nilsson, 2009; Turnpenny et al., 2008). The micro-level explains the barriers that are related to individual aspects, such as skilled personnel, knowledge, awareness, and funding. However, this level is only part of the problem. The integration is also limited to the organizational capacity at the meso-level, such as leadership, procedures, and guiding policies. At the macro-level, the interaction of the networked organizations is highlighted, such as trust, broader participation of stakeholders, and the availability of specific decision arenas. Road infrastructure projects are often affected by political decisions that can change over time (Priemus, 2010). This chapter emphasized the merits of identifying barriers throughout the assessment phases, namely the preparation, investigation, and recommendation phases. Each barrier appears dominant in specific phases. This chapter showed that better preparation and inclusive decision-making helps to advance integration. From the research, policymakers and planners can anticipate which barriers are influential for making continuous progress for integration.

In sum, the findings contribute to extending the work of Bina (2008), Turnpenny et al. (2008), and Nykvist and Nilsson (2009) on the role of context in integrating assessment into the planning of sustainable development. The barriers identified capture the complexity of decision-making processes, embedded in context, which contributes to the limited integration. Multiple stakeholders in different sectors and jurisdictions join the processes, and they have different interests in the outcomes of the development project. Therefore, planners and policymakers have to create a supportive decision environment that facilitates the fluid interaction and effective engagement of stakeholders (O'Faircheallaigh & Howitt, 2013). This engagement is also vital, because different stakeholders have multiple interpretations of what sustainability means and how it can be incorporated in project planning.

7.1.4 How do stakeholders balance economic and environmental interests in planning sustainable road development?

Chapter 5 started with an explanation of some drawbacks to the use of impact assessment to integrate sustainability. The planning of large-scale road infrastructure projects is a complex process. Numerous stakeholders are involved and they have multiple interpretations of project goals and missions (Giezen, 2012; Giezen et al., 2015). When it comes to project planning, these stakeholders often do not understand how the project missions could be actualized, and as a result, the decision outcomes can be uncertain (Salet al., 2013). Such project missions contain an

element that is called ”strategic ambiguity” (Eisenberg, 1984). Here, strategic ambiguity refers to multiple interpretations of the project mission that are continuously redefined throughout the processes of decision-making (Giezen et al., 2015).

This chapter examined in what ways environmental and economic interests can be integrated under ambiguity. Using Kingdon’s (1984) framework, the chapter identified multiple elements within the three policy streams (i.e., problems, solutions, and politics) that open windows of opportunity so that both interests can be incorporated (Kingdon, 2014). These elements include assessment indicators and pressing concerns (the problems stream), as well as impact assessments and research studies (the solutions stream). From the politics stream, the elements consist of the deliberative decision-making process, changes in project management, and coalitions of multiple stakeholders. At a certain point, all these streams come together to open a window of opportunity to integrate different interests reflected in the sustainability pillars.

The empirical findings gathered here show that the incorporation of sustainability into planning road infrastructure development is an iterative process. It includes framing and reframing the problems and the solutions, and collaborating with other stakeholders to mobilize resources to implement the solutions (e.g., Knaggård, 2015; Salet et al., 2013; Van Stigt et al., 2013). Power relations also plays a role in the acceptance of the offered solution for integration. Policy entrepreneur enters the scene to connect the problems and the solutions in different decision arenas, motivated by future expected personal or much broader incentives (e.g., hired in other projects, social conflict avoidance). Stakeholders can therefore connect the identified problems and the solutions offered before the final decision for the integration is accepted. This finding supports the argument of Bond and Morrison-Saunders (2013) that pluralistic decision-making helps to capture stakeholders’ interests in time and space. The findings also show that the activation of an inclusive process including marginalized stakeholders increases opportunities for integration.

7.1.5 In what ways do the contested scale frames of the problems and solutions affect the prolonged sustainability outcomes?

Chapter 6 illustrated that the complexity of scale in the identification and management of road development impacts (Cumming et al., 2006; Flyvbjerg et al., 2003). The findings presented in this chapter enrich the discussions of scale in megaproject planning and decision-making. Scales in a megaproject are often referred to only in terms of scope (or size) (e.g., Ansar et al., 2017) and are limited to spatial impacts (Flyvbjerg et al., 2003; Giezen, 2013). Success is merely defined in terms of a project management-based perspective, including budget and schedule (Kardes et al., 2013; Lehtonen, 2014). As a result, megaprojects often fail to integrate

the broader effects of such projects over time and space in planning and decision-making. Instead of treating scale as a fixed entity, this chapter discussed scale as a social construct. In this, scale is explored as a framing concept to analyze how stakeholders encounter social and environmental problems (Howitt, 2013; Stoffle et al., 2013), and how different scale framing produces mismatches between the problems and the solutions by the stakeholders (Van Lieshout et al., 2011).

The chapter discussed in what ways scales contribute to the limited integration of sustainability into road infrastructure development. The findings also revealed a social conflict between the local communities and the project developer indicated by disagreement over the problems and the solutions on specific scales. Unless these differences are resolved, the different scale frames become scale frame mismatches, in which the problems and the solutions do not correlate (Van Lieshout et al., 2011). The mismatches also indicate that power relations between stakeholders are often imbalanced. As a consequence, the development project turns out to be disruptive to the local stakeholders and affects their future livelihoods. This result confirms the displacing effects of mega-road infrastructure projects in time and space, as highlighted by Gellert and Lynch (2003) and Delphine (2019). In Indonesian spatial planning, an inclusive decision-making process is rare, and participation is still limited to information sharing and consultancy (Rukmana, 2015). With the limited scale used and the limited participation of stakeholders in decision-making processes, project developers fail to incorporate the wider and prolonged impacts of the project development. The result is that projects lose sight of sustainability considerations.

The findings presented in this chapter enrich the discussion about scale in megaprojects. The findings show that project developers should move beyond cost and time efficiency and scope accomplishment to define the project success (Flyvbjerg, 2014; Lehtonen, 2014). However, they should be able to incorporate scale in the identification of impacts and the mitigation efforts, and continuously frame and reframe the problems and the solutions in such a way that the diverse interests of stakeholders can be incorporated (Clegg et al., 2017). In terms of social relevance, the findings provide a stepping stone toward integrating scale issues in megaprojects and emphasizing the importance of inclusive decision-making. Because of the present deficit of such projects in this process, the chapter argued that much broader discussions of scales help policymakers and planners to identify the complexity of development effects. This finding shows that the limited use of scales is a result of imbalanced power structures affecting the accountability and transparency of decision-making (e.g., Flyvbjerg et al., 2003). Such a process, as this chapter showed, fails to integrate the long-term considerations of impacts that threaten intergenerational equity as the main principle of sustainable development (Sturup & Low, 2015, 2019).

7.2 Discussion

The main findings show that several features aid or constrain the integration of sustainability into road infrastructure development. These features can be pinpointed by using the content, context, and process perspectives. This section discusses the answer to the main research question by addressing two main emerging issues extracted from the findings, namely the need for a coherent conceptualization of sustainability (section 7.2.1) and the main features that explain successful/limited integration, with Indonesia as an example of a developing country (section 7.2.2). Finally, the answer to the main research question is given.

7.2.1 On the right track? Driving sustainability into road infrastructure development

This dissertation presents sustainability as a contested concept that has multiple interpretations (Gibson, 2013; Söderbaum, 2011) and shows that different stakeholders expect different things from it (Bond et al., 2013). It also shows that the assessment tools used to assist the planning of and decision-making around road infrastructure projects have failed to incorporate sustainability. As a consequence, the inclusion of indicators seems arbitrary, and those selected often seem to have been selected for pragmatic or biased reasons. Two related issues also reflect the limited integration.

First, the application of sustainability in the planning of and decision-making around road infrastructure projects tends to promote specific discourses of outcomes, as shown by the frequent use of particular indicators, such as the mitigation of negative impacts on landscape and society. Most of the papers reviewed acknowledge that these impacts should be overcome. Nevertheless, the currently practiced assessments have largely failed to integrate the *intergenerational equity* criterion as an indicator. This finding stresses the argument made elsewhere that most of the tools deployed tend to adopt a "weak" approach, meaning that the environmental costs being counted are unable to include the values of natural capital over a prolonged period (Gasparatos, 2010), particularly the critical ones in a specific context of application. The result can be confirmed by the persistent use of existing popular tools for evaluating the strategic impacts in space and time (e.g., cost–benefit analysis) to evaluate sustainable options.

The second issue is that the planning and decision-making related to road infrastructure projects tend to overlook specific outcomes, such as improved accessibility and connectivity, but omit the governance processes required to achieve integration. Such processes consist of the participation of broader stakeholders, cross-sectoral collaboration, transparency, and integrated impact interventions (Gibson, 2006, 2013; Gibson et al., 2005). This result also implies that both content and process features are equally crucial for achieving successful integration.

Therefore, the assessment tools practiced should not be seen as a technical endeavor only. The project cases presented in this dissertation show that power contestation between stakeholders shapes the rationality of the projects, in relation to development impacts and outcomes in a given temporal and spatial context (Clegg et al., 2017; Flyvbjerg, 1998). Influential stakeholders often steer the project reality and undermine the voice of indirectly affected stakeholders (Delphine, 2019).

To overcome such drawbacks, this dissertation presented an analytical framework that can help planners and policymakers to incorporate time, space, and process considerations into road development planning. The framework fills the gap in the existing range of frameworks, such as the Driver–State–Pressure–Impact–Response (DSPR) framework that feeds information to facilitate the development of indicators and measures for evaluating sustainability performance (e.g., European Conference of Ministers of Transport, 2004). As this study shows, the greatest weaknesses in such frameworks are the incomplete understanding of space and time dimensions in the practiced assessments. Such a limitation leads to failure to secure the critical human and natural capital in the long run (i.e., intergenerational equity) (Thérivel et al., 2009).

7.2.2 A dead-end street or a promising road? Features of integration

The present research investigated what features determine the integration of sustainability into road infrastructure development. Each empirical research chapter of this dissertation contributed to the explanation of the process, content, and context features. The discussion below systematically reflects on each of the features.

Content

From the content perspective, successful or limited integration is determined by the coherent use in practiced assessments of indicators aimed at assisting the planning of and decision-making around road infrastructure projects. Most papers reviewed in Chapter 2 discussed an aspect related to the inclusion of the three sustainability pillars (i.e., the social, economic, and environmental pillars). However, the inclusion

Box 7.1. Content features that contribute to integration

1. A coherent conception of sustainability, supported by criteria and requirements that reflect the main principles of sustainability and the application of multiple methods/tools to cover these criteria and requirements.
2. The representation of the cumulative development effects in given time and space through inclusive decision-making.

of the pillars is insufficient to ensure that sustainability is considered. This is for two reasons.

First, the representation of the sustainability pillars/circles may be imbalanced because of the contested nature of sustainability. Gibson et al. (2005) find that the use of the pillars/circles is convenient because they present the traditional fields of policymaking and specialized research. However, such a convenience makes the pillars less suitable for encouraging integration. The pillar-based approaches tend to concentrate on competing objectives, rather than the interrelations among social, economic, and environmental interests. They neglect the overlapping and shared concerns, which makes capturing the linkages and interdependencies of indicators in each pillar problematic (Gibson, 2013; Gibson et al., 2005). The presentation of these indicators is static, and sometimes indicators from specific interests (represented by a pillar) dominate the conceptualization of sustainability. A coherent conception is required, assisted by criteria and requirements that reflect the main principles of sustainability (Sala et al., 2015). In addressing the complete account of sustainability, the application of multiple methods/techniques may be required, as none of them is able to include all these criteria (Gasparatos et al., 2009).

Second, Chapter 2 showed that the cumulative development effects are rarely addressed as indicators, because the time and space dimensions are often omitted from the discussions. A part of the problem is that the pillar categorization neglects the importance of these temporal and spatial dimensions (Seghezzo, 2009). Without evaluating the indicators used against intergenerational equity and the context-sensitivity criterion, this finding shows that sound assessment practices are far from within reach. It also appears that power contestation shapes the expected outcomes of development projects (Clegg et al., 2017; Flyvbjerg, 1998; Flyvbjerg et al., 2003). As the project context is dynamic, and multiple stakeholders have different frames about the sustainability impacts and the outcomes (in space and time), the representation of these cumulative effects can only be achieved through inclusive decision-making. Box 7.1 summarizes the features that contribute to integration from the content perspective.

Context

The features derived from the context perspective concern the cultural, political, and social values that shape how decision-making takes place (Bina, 2008). The linkages between decision support tools for assisting sustainability and effective integration by those who use them is mediated by context (Howlett, 2014). Institutions can be either barriers to or opportunities for advancing integration. As institutions are complex, involving interactions between agency and structure, this dissertation analyzed institutions by categorizing them into levels, namely the micro-level (individuals), the meso-level (organizations), and the macro-level (networked stakeholders) (Nykvist & Nilsson, 2009; Turnpenny et al., 2008).

First, the findings indicate that the institutional capacity at the individual level is critical to integrate sustainability in Indonesia. To advance integration, combined methods/ techniques are proposed to include all sustainability considerations, namely social, economic, and environmental considerations (Beria et al., 2012; Hacking & Guthrie, 2008). As a consequence, it is necessary to build multidisciplinary and interdisciplinary teams to capture these considerations (Gasparatos et al., 2009; Sheate, 2009). By focusing on the context, the integration needs an institutional strengthening by putting "less focus on the actual tools and more on identifying the organisational and cultural prerequisites for developing processes that seek to build on the benefits of linking tools" (Sheate, 2009, p. 23). In other words, the context informs us about the capacity of the tool users applicants to achieve integration in many respects, including the methods/techniques used and sustainability considerations.

Second, at the meso- and the macro-level, integration relates to the interaction within and between the individual organizations. Institutions provide formal and informal rules that determine the form of interactions between these organizations. The findings show that some features have played a key role in advancing integration in Indonesia, such as leadership, guidelines/manuals, shared objectives, and broader participation. Leadership is required to mobilize limited resources (e.g., time, funding, and personnel) and to bring all sectors together. The guidelines/manuals can inform all stakeholders about the expected outcomes of the process (Bond et al., 2013; Te Brömmelstroet & Bertolini, 2008). Shared objectives and broader participation expand the area of tasks that usually hamper cross-sectoral thinking (Banister, 2012) and more integrated decision-making (Geerlings & Stead, 2003).

Lastly, institutions also introduce new opportunities for integration. The critical point here is that the meaning of "sustainability" or "sustainable development" is established in context. That "context matters" (Healey, 2007) was illustrated here by investigating the social, cultural, and institutional features. Road development in Indonesia entails a highly fragmented policy process (Miharja & Woltjer, 2010). Moreover, cultures can play a role in designing a better engagement of people in the planning process. Darmoyono (2019) concludes that Indonesian road development is constituted by a substantial cultural value—namely *gotong royong*—that continually seeks harmony within society. Different public organizations shape the sectoral

Box 7.2. Context features that contribute to integration

1. Improvement at the individual level of the capacity for integration.
2. The interaction within and between organizations, mediated by institutions through leadership, guiding manuals, broader participation, shared objectives, etc.
3. The actualisation of embedded local rules in context to resolve fragmented decision-making is resolved through, for example, *"gotong rotong"* in the Indonesian case.

policy objectives, which complicates integration. As shown by Chapter 5, such a condition can encourage formal and informal alliances that provide the underpinnings for achieving common "sustainability" objectives and justifying trade-offs between objectives and interests (Bond et al., 2012). Box 7.2 summarizes the features that contribute to integration from the context perspective.

Process

Integration cannot be reduced to a simple technical exercise that is only assisted by decision support tools. It appears that the tools alone are insufficient because of methodological and social complexity. First, political processes and power relations shape the objectives and the expected outcomes. Both can evolve over time, because new information is gathered and political commitment can change (De Bruijn & Leijten, 2007). Power relations between stakeholders also affect how the information is distributed and used. Second, extensive time-frames incorporated a tool deployed for sustainable decision-making means that points of follow-up and monitoring may not occur within a short time period (Bond et al., 2013). Planning has a central role in getting a decision right before implementation, requiring the stakeholders to reflect on the available options, often through the use of impact assessment procedures as decision support tools.

From this perspective, this dissertation shows that stakeholders frame sustainable outcomes in different ways. In addition, they point out the problems and the solutions on various scales. The consequence of this is twofold. First, a more pluralistic process is required to identify these frame differences. However, the existing planning practices in megaprojects have shown that the management often tends to exclude less powerful people from broader engagement (Clegg et al., 2017). Such practices expand differences and widen the mismatch between problems and solutions (Van Lieshout et al., 2011).

Second, the discussion about the frames of issues on multiple scales highlights a critical point in the impact assessment and project management of road infrastructure development. The socio-ecological interaction is complex in terms of scale (i.e., time and space) and is hardly captured on a single scale (Cash et al., 2006; Cumming et al., 2006; Stoffle et al., 2013). Chapter 5 showed that the identification of problems beyond the project scale has helped the stakeholders to acknowledge the broader project impacts in time and space. Such a process has also activated policy

Box 7.3. Process features that contribute to integration

1. Problem and solution identification efforts through framing and reframing and the use of problem-solving capacity, for example, impact assessment tools, in a collaborative way.
2. Activation of policy networks at multiple scales to capture all problems and solutions and to mobilize all necessary resources aimed at expanding problem-solving capacity.

networks and helped to involve stakeholders operating in different jurisdictions. It expands the problem-solving capacity by mobilizing the resources required for integration (e.g., personnel, funds) (Scandelius & Cohen, 2016). Moreover, the stakeholders deliberatively change the frames of the problems and solutions in time and space to secure long-term (intergenerational) considerations (Healey, 2006). Box 7.3 summarizes the features that contribute to integration from the context perspective.

7.2.3 Answering the main research question

This dissertation presents a new institutionalism approach to the integration of sustainability into road infrastructure development. In this approach, the content, the context, and the process contribute jointly and create areas of interaction that can further improve integration (Figure 7.1). First, the area in which content and context interrelate is the interface for the stakeholders to conceptualize sustainability as a common issue. This involves knowledge and cultural transformation. Stakeholders organize knowledge and institutional elements in such a way as to transform sustainability into common societal goals and effective achievements. The findings show that limited awareness of the integrative aspects of sustainability (e.g., time, tools, and expertise) affects how these stakeholders can advance integration. Some of the problems relate to incoherent and fragmented knowledge about sustainability across sectors and disciplines that are still embedded in the present institutional set-ups, for example, decentralized planning systems.

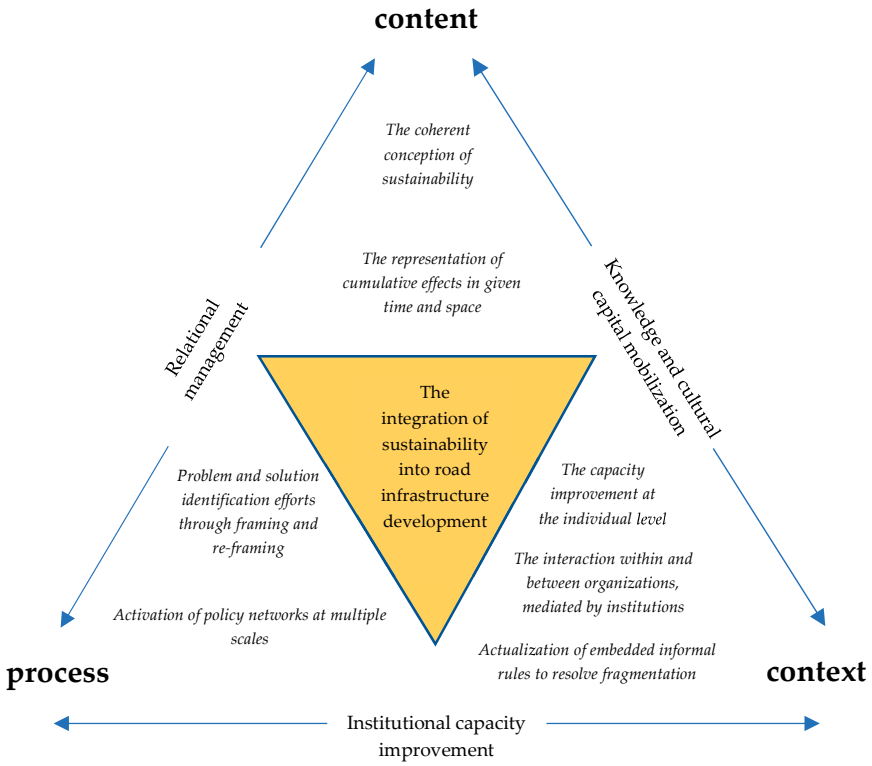


Figure 7.1 Features of integration

Second, relational and network management is needed to achieve integration between content and process. This is rooted in social relations with others, as each individual stakeholder distinguishes frames of references and systems of meanings. The active work of social construction is not undertaken in "neutral territory" as far as power relations are concerned (Healey, 2006). This dissertation shows that various stakeholders have different and evolving conceptions of what sustainability means in different spatial and temporal contexts. As a consequence, leading organizations should pay more attention to how the problems and the solutions are framed, and how policy networks can effectively transform power relations and establish a common basis of understanding.

Third, the interface between process and context has revealed the need to considerably improve institutional capacity. Institutional capacity refers to the overall quality of the totality of relational networks in an attempt to achieve collective sustainability goals. Chapter 4 showed that this quality is constituted from the awareness at the individual level of the status of interaction between organizations that build shared interests and trust at the macro-level. Chapter 5 demonstrated that the process itself creates opportunities to shape the building of the relations and knowledge frames, and the social and cultural capitals, through which connections are made to address shared concerns beyond the road projects themselves.

What has become clear overall is that context-specificity is important for the successful integration of sustainability into road infrastructure planning. For the case of Indonesia, this dissertation shows that significant barriers to achieving integration exist at all institutional levels, namely the micro-level, the meso-level, and the macro-level. Road development in Indonesia involves a complex set of institutions consisting of multiple governmental sectoral agencies in various administrative layers, which complicates the integration effort. It has proven to challenge the capacity of local government to integrate interests beyond the project's jurisdiction (Abidin, 2009). Chapter 3 showed that at this level, the capacity owned is limited in terms of skilled personnel and awareness. Despite these drawbacks, integration can potentially be achieved by mobilizing the social capital—or *gotong royong*—that is already embedded in the societal culture (Darmoyono, 2019). Darmoyono (2019) shows that such a cultural capital can be an asset when engaging in collaborative road management (i.e., new construction, maintenance, and financing).

Reflecting on the context of Indonesian road development leads to the conclusion that the way forward is along two pathways: (i) a continuous improvement of the institutions in order to deal with the deficit capacity for integration and (ii) the mapping of "external" available opportunities for wider stakeholders by setting up more inclusive decision-making. The first will take more time to realize, because of the limited capacity for a comprehensive account of sustainability, while the second will not guarantee that sustainability will be achieved in the long run. Where does this lead us?

7.3 Completing the journey: Final thoughts on Indonesian road development and routes for research ahead

In the global South, road infrastructure is a battlefield for sustainable development and there is still an unbalanced policy priority between economic development and environmental protection. Project developers, mostly public or governmental entities, have difficulty integrating short-term and long-term development objectives because of their limited awareness (Mentis, 2015; Othman, 2013). Although Indonesia as a vast developing country has a driving ambition to improve its economic growth and regional connectivity to compete globally (CMEA, 2011), planners and decision-makers do not know how to integrate sustainability from anything but a technical and engineering point of view, as is also the case in other parts of the world (Gartner, 2016).

In response to this dissertation's subtitle ("A dead-end street or a promising road?"), the findings indicate three ways ahead to promote the integration of sustainability into road infrastructure development. First, there is a lack of awareness among academics and policymakers of the content elements—that is, time and space—in the assessment tools practiced. Chapter 2 provided an

operationalization of how such considerations can be better included in indicators. Moreover, Chapter 3 provided an analytical framework that illustrates which time, space, and process elements should be included in planning and policymaking. This paves the way for future research into the integrated operationalization of sustainability indicators in sustainability assessment procedures.

Second, a comprehensive account of sustainability is difficult to obtain in road infrastructure development. By examining the application of sustainability assessment tools, the present research showed that context plays a vital role in directing the ways in which policymakers and planners can make use of these tools. Chapter 4 provided a systematic identification of barriers to implementing sustainability assessment tools that can be a starting point for collecting additional data to thoroughly examine a responsive institutional design. Such a design could help to overcome sectoral fragmentation and several contextual aspects, including the shared culture and the nature of communication, for instance, between project developers and local communities.

Third, from the process perspective, this dissertation shows that multiple stakeholders mobilize various frames about problems and solutions aimed at the sustainability of road development. A more integrated process of governance is, however, needed to deliver sustainable development. Chapter 6 showed that megaproject approaches often fail to achieve successful integration as they tend to limit the sustainability frames and scales on which the development effects are investigated. A part of the problem is that there is a power imbalance between the stakeholders involved, and the affected stakeholders are generally still the weakest parties. Therefore, future action-oriented research could provide an opportunity to restructure the imbalanced power structure and to facilitate a more accountable and transparent process, involving stakeholders in different jurisdictions. A more context-sensitive approach to integrating sustainability into road infrastructure development—taking into account not just an equal treatment of the social, economic, and environmental pillars, but also incorporating the intergenerational equity component—could thus contribute to turning many of the development projects that are in a dead-end street in terms of integrating sustainability, into more promising roads.

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Summary

The background to this dissertation lies in attempts to integrate sustainability into planning road infrastructure development. Around the globe, roads are built with the primary aim of easing the movement of people and goods for economic and social purposes. However, massive road development can lead to adverse impacts on the environment, with extended effects on society. Better integration of sustainability is necessary to ensure that all pillars of sustainable development (i.e., the economic, social, and environmental pillars) and the intergenerational equity principle are also considered in road investment. This dissertation focuses on the planning dimension of this, because more action spaces are available within the planning process than later in the project lifecycle. Past research has shown that the environmental pillar tends to be included only later in the development process. Moreover, the time, space, and governance dimensions are also less acknowledged in impact assessments due to methodological and social complexity. It appears that the integration of sustainability considerations into road infrastructure development faces several implementation limitations that need to be overcome.

This dissertation presents a systematic exploration of features that affect the successful or limited integration of sustainability into road infrastructure development. The integration is examined, from a spatial planning perspective, in terms of the *content* (i.e., the inclusion of time and space dimensions and environmental interests) through the planning *process* (including dynamic interactions and power relations of stakeholders) and within a specific *context* (in this case, that of a developing country), to identify institutional barriers and formulate context-specific recommendations. Indonesia was selected as a case study because it is a typical case of a developing country whose stakeholders have limited capacity for and awareness of integrated decision-making. In such countries, the pursuit of economic competitiveness may turn out to be so disruptive (e.g., in terms of social conflicts, natural resource losses, and pollutions) that they abandon the sustainable development agenda. The main research question was therefore:

What features explain the successful or limited integration of sustainability into planning road infrastructure development, and what specific strategies can be revealed by this investigation into the particular case of Indonesia as a developing country?

To answer the research question, Chapter 2 discusses the pitfalls of the methods and tools—such as cost–benefit analysis, lifecycle assessment, and rating systems—used to evaluate the sustainability of road infrastructure projects. First, the findings

presented in this chapter show that none of these approaches is capable of incorporating some associated sustainability criteria/aspects, namely time, space, and governance dimensions. As a result, some criteria, such as livelihood improvement and resource efficiency, appear to be more prominent than others, such as precaution & adaptation and intergenerational equity, both of which are also related to a time dimension. This result shows the imbalanced inclusion of indicators and sustainability discourses, for instance, the strong concerns about the mitigation of environmental effects taking precedence over the societal wellbeing of future generations. The findings also indicate that the intergenerational equity principle is still less covered in terms of indicators. For example, the rating system tool has a strong emphasis on evaluating the immediate impacts at a project scale, but neglects the prolonged impacts and the spatial scale of impacts. In addition, the lifecycle assessment tools for road projects are mostly seen as technical exercises without creating adequate room for inclusive decision-making in defining the indicators evaluated. These results show the integration is limited because time, space, and governance (process) dimensions are still less considered in current assessment tools.

Chapter 3 shows that the sectoral view on sustainable development is inadequate to capture the multiple and complex elements of road infrastructure in different times and spaces. An infrastructural perspective, for example, focuses only on the physical elements of roads (e.g., pavement structure and drainage systems) that contribute to adverse environmental effects (in the construction and operational phases). This chapter uses the case of Trans-Java Road Network Corridors to explore a more comprehensive understanding of the elements of sustainable road infrastructure development. This comprehensive perspective can better capture time, space, and governance elements, and their mutual interactions, that affect sustainability. A mixed-scanning methodology led to the conclusion that integration is made possible by including all relevant sectoral elements at both the strategic macro-level (i.e., corridors) and the micro-level (urban regions). The chapter suggests that integration can be achieved by zooming in and out to assess which elements contribute to sustainability at both levels. Such a framework eases the problem of the complexity of policy processes in countries in the global South, such as Indonesia, where no specific sectoral stakeholders can control the entire outcomes.

Chapter 4 identifies in detail several barriers to integrating sustainability into road project planning. From a practitioners' perspective, this chapter shows that these barriers exist at different institutional levels, namely the micro-level, meso-level, and macro-level. At the micro-level, some barriers—for example, a lack of skilled personnel, knowledge, awareness, and funding support—are hard to

overcome. At the meso-level, these barriers lie within the organizations involved in decision-making, including a specific procedure/ manual, a leadership role, and a guiding policy. At the macro-level, the empirical research performed for this chapter shows that communicative processes between stakeholders are absent, making it difficult for stakeholders to share expectations and objectives stemming from the integration. Indonesia is an example of a developing country with a less favorable setting for integrated decision-making. Sectoral fragmentation complicates the integration, and the lower jurisdiction level has difficulty capturing the wider spatial scale of project impacts. For this context, no single-level strategy can reduce this fragmentation. Therefore, the context can only be improved through a multilevel strategy focusing on: (i) the micro-level, such as personnel capacities (e.g., skill, knowledge, and awareness), (ii) the meso-level, such as leadership qualities of primary departments, and (iii) the macro-level, such as shared objectives and trust among stakeholders.

Chapter 5 provides an in-depth investigation into how the stakeholders involved in decision-making incorporate sustainability into road project planning. By using two highway projects as cases, this chapter reflects on the application of a multiple stream framework (MSF) to structure decision-making processes under ambiguity, in which stakeholders interpreted what sustainability means and how the interpretation of the project outcomes differs among stakeholders. The framework distinguishes three streams—problems, solutions, and politics—that come together at a certain moment, known as a sustainability "window." This window materializes after a series of decisions have been made during the planning process. From the findings, the pressing problems, such as landscape quality degradation, are insufficient to promote the integration because other interests are present, such as economic growth. Moreover, the availability of impact assessment results alone is less effective to deliver the solutions. In this chapter, the integration proves possible through (i) framing and reframing the problems and the solutions, (ii) collaboration with other stakeholders to gain resources, and (iii) political support through coalitions with different stakeholders. In such a process, the integration results from how the stakeholders connect the problems and the solutions at various spatial scales and mobilize the necessary resources, such as funds and personnel, to overcome the ambiguity of the project goals. This result also shows that the involvement of stakeholders from multiple spatial scales is necessary for successful integration.

Chapter 6 shows how project developers fail to take into account the time and space dimensions of road development projects. Sustainability here means that projects provide economic and environmental benefits at different times (in both the short and the long term) and at different spatial scales (i.e., local, regional, and

international). The concept of scale framing is used to investigate the complexity of the project impacts within and across these scales. Such complexity makes it difficult for stakeholders to intervene in the impacts effectively. This chapter shows that part of this difficulty is caused by stakeholders framing the problems and solutions differently at various scales (levels). However, in decision-making around megaprojects, specific stakeholders tend to dominate the definition of the problems and the solutions. Moreover, power contestation occurs between the stakeholders in the process. The result is that project success is often measured only in terms of time, budget, and scope, and that other sustainability considerations across time and space are not taken into account. The finding also shows that there are contested scale frames about the impacts. Because of the power imbalance, the influential stakeholders neglect this contestation from the early development phase, resulting in scale mismatches of the problems and solutions. This chapter shows that integration proves difficult if the involvement of stakeholders is lacking and the project developers are incapable of providing more accountable and transparent decision-making.

Chapters 2–6 collectively shape the conclusion on integration presented in Chapter 7. First, from the *content* viewpoint, integration is determined by the coherent use of indicators included in the practiced assessment. This means that the indicators incorporated reflect a full account of sustainability, evaluated against all associated criteria/aspects, such as socio-ecological system integrity, resource efficiency, precaution, and adaptation. Also, as the findings show, a balanced use of indicators must include the intergenerational equity criterion. This helps to secure the availability for future generations of critical natural resources, such as clean water and air, an aspect that is still less considered in terms of indicators. This dissertation thus proposes a framework that includes the time, space, and governance dimensions in considerations. Second, from the *context* viewpoint, institutions play a vital role in limiting integration. For example, the result show that there is a lack of personnel, knowledge, skills, awareness, and funding support to advance integration. However, the focus on the micro-level (i.e., individuals) is insufficient to reveal the barriers. The case of Indonesia shows that the improvement of the broader decision context—for example, leadership, shared interests, and the inclusive participation of stakeholders—is necessary to advance integration. Third, from the *process* perspective, integration is achieved through the framing and reframing of missions/goals and the effective use of environmental impact assessment, to cope with the identified problems in a collaborative setting. Moreover, the results show that better stakeholder engagement proves useful in restructuring the power relations between stakeholders, easing the problematic

trade-offs between interests, and activating policy networks for mobilizing all necessary resources.

To sum up, this dissertation proposes two pathways to successful integration. The first is the enhancement of the context at all institutional levels, namely the micro-level, the meso-level, and the macro-level. The aim is to facilitate a responsive context for integrated decision-making. However, it will be a long-term transformation because institutions tend to resist change. The second is the mapping of available opportunities through a more inclusive planning process by including a wider group of stakeholders at a larger spatial scale. This pathway provides opportunities for integration, despite a lack of institutional resources (e.g., personnel, time, and funds). It proves effective in some project cases but tends to be incremental and less systematic. The task of planners and policymakers is to navigate between both pathways to strengthen the governance of road infrastructure planning toward sustainable development.

Samenvatting

De achtergrond van dit proefschrift ligt in pogingen om duurzaamheid te integreren in de planning van de ontwikkeling van weginfrastructuur. Over de hele wereld worden wegen aangelegd met als voornaamste doel de verplaatsing van mensen en goederen, ten behoeve van economische en sociale doeleinden. Grootschalige wegenaanleg kan echter leiden tot nadelige gevolgen voor het milieu, met uitgebreide gevolgen voor de samenleving. Een betere integratie van duurzaamheid is nodig om ervoor te zorgen dat alle pijlers van duurzame ontwikkeling (d.w.z. de economische, sociale en ecologische pijlers) en het intergenerationele gelijkheidsbeginsel ook in wegeninvesteringen worden beschouwd. Dit proefschrift richt zich op de planningsdimensie hiervan omdat er binnen het planningsproces meer actieruimte beschikbaar is dan later in de project cyclus. Uit eerder onderzoek is gebleken dat de milieupijler pas later in het ontwikkelingsproces wordt opgenomen. Bovendien worden de dimensies van de tijd, ruimte en governance ook minder betrokken in effectbeoordelingen vanwege methodologische en sociale complexiteit. Het lijkt erop dat de integratie van duurzaamheidsoverwegingen in de ontwikkeling van weginfrastructuur te maken heeft met verschillende implementatiebeperkingen die moeten worden overwonnen.

Dit proefschrift presenteert een systematische verkenning van kenmerken die de succesvolle of beperkte integratie van duurzaamheid in de ontwikkeling van weginfrastructuur beïnvloeden. De integratie wordt vanuit een ruimtelijk planningsperspectief onderzocht in termen van de inhoud (d.w.z. de opname van tijd- en ruimtedimensies en milieubelangen) door het planningsproces (inclusief dynamische interacties en machtsverhoudingen van belanghebbenden) en binnen een specifieke context (in dit geval dat van een ontwikkelingsland), institutionele belemmeringen te identificeren en context specifieke aanbevelingen formuleren. Indonesië werd gekozen als casestudie omdat het een typisch geval is van een ontwikkelingsland waarvan de belanghebbenden een beperkte capaciteit hebben voor, en zich weinig bewust zijn van geïntegreerde besluitvorming. In dergelijke landen kan het streven naar economische ontwikkeling zo belemmerend blijken te zijn (bijv. in termen van sociale conflicten, verlies van natuurlijke hulpbronnen en vervuiling) dat ze de agenda voor duurzame ontwikkeling verlaten. De belangrijkste onderzoeksvraag was daarom:

Welke kenmerken verklaren de succesvolle of beperkte integratie van duurzaamheid in de planning van de ontwikkeling van weginfrastructuur, en welke specifieke strategieën kunnen

worden aangedragen door dit onderzoek voor het specifieke geval van Indonesië als ontwikkelingsland?

Om de onderzoeksvraag te beantwoorden bespreekt hoofdstuk 2 de valkuilen van de methoden en hulpmiddelen - zoals kosten-batenanalyse, levenscyclusanalyse en beoordelingssystemen - die worden gebruikt om de duurzaamheid van weginfrastructuurprojecten te evalueren. Ten eerste, de bevindingen in dit hoofdstuk laten zien dat geen van deze benaderingen in staat is om enkele bijbehorende duurzaamheidscriteria/-aspecten mee te nemen, namelijk tijd, ruimte en governance dimensies. Als gevolg hiervan lijken sommige criteria, zoals verbetering van het levensonderhoud en efficiënt gebruik van hulpbronnen, prominenter dan andere, zoals voorzorg & aanpassing en het intergenerationele gelijkheidsbeginsel, die beide ook verband houden met een tijdsdimensie. Dit resultaat toont de onevenwichtige opname van indicatoren en duurzaamheidsdiscoursen, bijvoorbeeld de grote aandacht voor het verminderen van de milieueffecten die voorrang hebben op het maatschappelijk welzijn van toekomstige generaties. De bevindingen geven ook aan dat het intergenerationele gelijkheidsbeginsel nog minder aan bod komt in termen van indicatoren. De beoordelingssystemen leggen bijvoorbeeld sterk de nadruk op het evalueren van de directe effecten op projectschaal, maar negeren de langdurige effecten en de ruimtelijke schaal van effecten. Bovendien worden de hulpmiddelen voor levenscyclusanalyse voor wegenprojecten meestal gezien als technische bezigheden zonder voldoende ruimte te creëren voor inclusieve besluitvorming bij het definiëren van de geëvalueerde indicatoren. Deze resultaten tonen aan dat de integratie beperkt is omdat tijd, ruimte en governance (proces) dimensies nog minder worden gewogen in de huidige beoordelingstools.

Hoofdstuk 3 laat zien dat de sectorale visie op duurzame ontwikkeling onvoldoende is om de veelvoudige en complexe elementen van weginfrastructuur in verschillende tijden en ruimtes vast te leggen. Een infrastructureel perspectief richt zich bijvoorbeeld alleen op de fysieke elementen van wegen (bijv. bestratingsconstructie en drainagesystemen) die bijdragen aan nadelige milieueffecten (in de bouw- en exploitatiefase). Dit hoofdstuk gebruikt de casus van Trans-Java Road Network Corridors om een uitgebreider begrip van de elementen van duurzame ontwikkeling van weginfrastructuur te verkennen. Dit uitgebreide perspectief kan de tijd-, ruimte- en governance-elementen en hun onderlinge interacties die van invloed zijn op duurzaamheid beter vastleggen. Een mixed-scanning methodologie leidde tot de conclusie dat integratie mogelijk wordt gemaakt door alle relevante sectorale elementen op te nemen op zowel het strategische macroniveau (d.w.z. corridors) als het microniveau (stedelijke regio's). Het hoofdstuk suggereert dat integratie kan worden bereikt door in en uit te zoomen

om te beoordelen welke elementen bijdragen aan duurzaamheid op beide niveaus. Een dergelijk kader verlicht het probleem van de complexiteit van beleidsprocessen in landen in het Zuidelijke halfrond, zoals Indonesië, waar geen specifieke sectorale belanghebbenden de volledige resultaten kunnen controleren.

Hoofdstuk 4 identificeert in detail verschillende belemmeringen om duurzaamheid te integreren in de planning van wegenprojecten. Vanuit het perspectief van de praktijk laat dit hoofdstuk zien dat deze belemmeringen bestaan op verschillende institutionele niveaus, namelijk op microniveau, mesoniveau en macroniveau. Op microniveau zijn sommige belemmeringen - bijvoorbeeld een gebrek aan bekwaam personeel, kennis, bewustzijn en financieringsondersteuning - moeilijk te overwinnen. Op mesoniveau liggen deze barrières bij de organisaties die betrokken zijn bij de besluitvorming, waaronder een specifieke procedure / handleiding, een leiderschapsrol en een sturend beleid. Op macroniveau laat het empirische onderzoek dat voor dit hoofdstuk is uitgevoerd, zien dat communicatieve processen tussen belanghebbenden ontbreken, waardoor het voor belanghebbenden moeilijk is om verwachtingen en doelstellingen die voortvloeien uit de integratie te delen. Indonesië is een voorbeeld van een ontwikkelingsland met een minder gunstige setting voor geïntegreerde besluitvorming. Sectorale fragmentatie bemoeilijkt de integratie en het lagere jurisdictieniveau heeft moeite om de bredere ruimtelijke schaal van projecteffecten vast te leggen. In deze context kan geen enkele strategie op één niveau deze versnippering verminderen. Daardoor kan de context alleen worden verbeterd door een strategie op meerdere niveaus die zich richt op: (i) het microniveau, zoals personeelscapaciteiten (bijv. vaardigheden, kennis en bewustzijn), (ii) het mesoniveau, zoals leiderschapskwaliteiten van primaire afdelingen, en (iii) het macroniveau, zoals gedeelde doelstellingen en vertrouwen tussen belanghebbenden.

Hoofdstuk 5 geeft een diepgaand onderzoek naar hoe de belanghebbenden die bij de besluitvorming betrokken zijn, duurzaamheid integreren in de planning van wegenprojecten. Door twee snelwegprojecten als casus te gebruiken, reflecteert dit hoofdstuk op de toepassing van een Multiple Stream Framework (MSF) om besluitvormingsprocessen onder dubbelzinnigheid te structureren, waarin belanghebbenden interpreteerden wat duurzaamheid betekent en hoe de interpretatie van de projectresultaten verschilt tussen belanghebbenden. Het raamwerk onderscheidt drie stromen - problemen, oplossingen en politiek - die op een bepaald moment samenkomen, bekend als een duurzaamheid 'venster'. Dit venster verschijnt nadat een reeks beslissingen is genomen tijdens het planningsproces. Uit de bevindingen blijkt dat dringende problemen, zoals aantasting van de landschapskwaliteit, onvoldoende zijn om de integratie te bevorderen omdat andere belangen aanwezig zijn, zoals economische groei.

Bovendien is de beschikbaarheid van alleen resultaten van effectbeoordeling minder effectief om de oplossingen te leveren. In dit hoofdstuk blijkt de integratie mogelijk door (i) de problemen en oplossingen in kaart te brengen en opnieuw in te kaderen, (ii) samenwerking met andere belanghebbenden om middelen te verwerven en (iii) politieke steun door coalities met verschillende belanghebbenden. In een dergelijk proces komt de integratie voort uit hoe de belanghebbenden de problemen en de oplossingen op verschillende ruimtelijke schalen met elkaar verbinden en de nodige middelen, zoals fondsen en personeel, mobiliseren om de ambiguïteit van de projectdoelstellingen te overwinnen. Dit resultaat laat ook zien dat de betrokkenheid van stakeholders uit meerdere ruimtelijke schalen noodzakelijk is voor succesvolle integratie.

Hoofdstuk 6 laat zien hoe projectontwikkelaars geen rekening houden met de tijd- en ruimte dimensies van wegontwikkelingsprojecten. Duurzaamheid betekent hier dat projecten op verschillende termijnen (zowel op korte als op lange termijn) en op verschillende ruimtelijke schalen (d.w.z. lokaal, regionaal en internationaal) economische en ecologische voordelen opleveren. Het concept van scale-framing wordt gebruikt om de complexiteit van de projecteffecten binnen en tussen deze schalen te onderzoeken. Een dergelijke complexiteit maakt het moeilijk voor belanghebbenden om effectief in te grijpen in de effecten. Dit hoofdstuk laat zien dat een deel van deze moeilijkheid wordt veroorzaakt doordat belanghebbenden de problemen en oplossingen op verschillende schalen (niveaus) anders beoordelen. Bij besluitvorming rond megaprojecten domineren specifieke belanghebbenden echter de definitie van de problemen en de oplossingen. Bovendien vindt in het proces een machtsstrijd plaats tussen de belanghebbenden. Het resultaat is dat projectsucces vaak alleen wordt gemeten in termen van tijd, budget en reikwijdte, en dat met die andere duurzaamheidsoverwegingen in tijd en ruimte geen rekening wordt gehouden. De bevinding toont ook aan dat er tegenstrijdige schaalframes zijn over de effecten. Vanwege de machtsonevenwichtigheid negeren de invloedrijke belanghebbenden deze disputatie vanaf de vroege ontwikkelingsfase, wat resulteert in tegenstrijdigheid van de problemen en oplossingen. Dit hoofdstuk laat zien dat integratie moeilijk is als de betrokkenheid van belanghebbenden ontbreekt en de projectontwikkelaars niet in staat zijn om meer verantwoordelijke en transparante besluitvorming te bieden.

De hoofdstukken 2–6 vormen samen de basis voor de conclusie over integratie die in hoofdstuk 7 wordt gepresenteerd. Ten eerste wordt integratie, inhoudelijk gezien, bepaald door het coherente gebruik van indicatoren die zijn opgenomen in de geoefende beoordeling. Dit betekent dat de opgenomen indicatoren een volledige weerslag van duurzaamheid weerspiegelen, geëvalueerd aan alle bijbehorende criteria /aspecten, zoals sociaal-ecologische systeemintegriteit, efficiënt gebruik van

hulpbronnen, voorzorg en aanpassing. Zoals de bevindingen aantonen, moet het evenwichtige gebruikt van indicatoren ook het intergenerationele gelijkheidscriterium omvatten. Dit helpt om de beschikbaarheid voor toekomstige generaties van belangrijke natuurlijke hulpbronnen, zoals schoon water en lucht, te waarborgen, een aspect dat nog minder wordt overwogen in termen van indicatoren. Dit proefschrift stelt dus een raamwerk voor dat de dimensies tijd, ruimte en governance in overwegingen te nemen. Ten tweede spelen instellingen vanuit contextueel oogpunt een cruciale rol bij het beperken van integratie. Het resultaat laat bijvoorbeeld zien dat er een gebrek is aan personeel, kennis, vaardigheden, bewustzijn en financieringsondersteuning om de integratie te bevorderen. De focus op microniveau (d.w.z. individuen) is echter onvoldoende om de belemmeringen bloot te leggen. Het geval van Indonesië laat zien dat verbetering van de bredere beslissingscontext - bijvoorbeeld leiderschap, gedeelde belangen en de inclusieve deelname van belanghebbenden - noodzakelijk is om de integratie te bevorderen. Ten derde, vanuit het procesperspectief, wordt integratie bereikt door het formuleren en herformuleren van missies / doelen en het effectieve gebruik van milieueffectbeoordeling, om de geïdentificeerde problemen in een samenwerkingsverband aan te pakken. Bovendien laten de resultaten zien dat een betere betrokkenheid van belanghebbenden nuttig blijkt te zijn bij het herstructureren van de machtsverhoudingen tussen belanghebbenden, het verlichten van de problematische afwegingen tussen belangen en het activeren van beleidsnetwerken voor het mobiliseren van alle noodzakelijke middelen.

Samenvattend stelt dit proefschrift twee trajecten voor tot succesvolle integratie. De eerste is het versterken van de context op alle institutionele niveaus, namelijk op microniveau, mesoniveau en macroniveau. Het doel is om een responsieve context voor geïntegreerde besluitvorming te faciliteren. Het zal echter een transformatie op lange termijn zijn omdat instellingen de neiging hebben zich tegen verandering te verzetten. De tweede is het in kaart brengen van beschikbare mogelijkheden via een meer inclusief planningsproces door het opnemen van een grotere groep belanghebbenden op een grotere ruimtelijke schaal. Deze weg biedt mogelijkheden voor integratie, ondanks een gebrek aan institutionele middelen (bijv. personeel, tijd en geld). Het blijkt in sommige projectgevallen effectief, maar is meestal incrementeel en minder systematisch. De taak van planners en beleidsmakers is om tussen beide paden te navigeren om de governance van de weginfrastructuurplanning naar duurzame ontwikkeling te versterken.

Appendix

Appendix A. List of the semi-structured interviewees

No.	Interviewee	Title	Organization
A.	*The Trans-Java Road Network Corridors (Java)*		
1.	Interview 1.1	Head of Infrastructure Sub Division	Development Planning Agency of West Java Province
2.	Interview 1.2	Head of Planning Sub Division	Highway Implementing Agency VIII, Ministry Public Works and Housing
3.	Interview 1.3	Head of Planning and Evaluation Division	Institute of Policy and Technology Implementation
4.	Interview 1.4	Director	Indonesia Road Development Association-West Java chapter
5.	Interview 1.5	Head of Land Transportation Sub Directorate	National Development Planning Agency/Ministry of Development Planning
6.	Interview 1.6	Social researcher	Institute of Policy and Technology Implementation
7.	Interview 1.7	Senior spatial planner of Infrastructure Division	Development Planning Board of Cirebon Regency
8.	Interview 1.8	Head of Infrastructure Division	Development Planning Agency of Purwakarta Regency
9.	Interview 1.9	Head of Regional Development and Infrastructure Division	Regional Development Planning Agency of Semarang City
10.	Interview 1.10	Head of Area Development Sub Directorate	Directorate of Area Arrangement, Ministry of Agrarian Affairs and Spatial Planning
11.	Interview 1.11	Senior consultant/ Traffic engineering (planning) expert	PT Jasa Marga (Indonesia Highway Corp.)
12.	Interview 1.12	Senior road environment researcher	Institute of Road Engineering
13.	Interview 1.13	Head of Planning and Evaluation Division	Institute of Road Engineering
14.	Interview 1.14	Senior traffic researcher	Institute of Road Engineering
15.	Interview 1.15	Head of Planning and Evaluation Section	Directorate of Spatial Planning, Ministry of Agrarian Affairs and Spatial Planning
16.	Interview 1.16	Head of Planning Division	Public Works Agency of East Java Province
17.	Interview 1.17	Traffic engineer (planner)/ Expert	Institute of Road Engineering

No.	Interviewee	Title	Organization
18.	Interview 1.18	Head of Spatial Planning and Environment Sub Division	Regional Development Planning Agency of Purwakarta Regency
19.	Interview 1.19	Head of Highway Network Integration Sub Directorate	Directorate General of Highway, Ministry of Public Works and Housing
20.	Interview 1.20	Senior transportation planner	Ministry of Transportation
21.	Interview 1.21	Head of Infrastructure Planning Division	Regional Infrastructure Development Agency, Ministry of Public Works and Housing
22.	Interview 1.22	Head of the Infrastructure Sub Division	Development Planning Agency of Surabaya Municipality
23.	Interview 1.23	Head of Planning Sub Division	Highway and Spatial Planning Agency of West Java Province
24.	Interview 1.24	Transportation researcher	Institute of Road Engineering
25.	Interview 1.25	Head of Transportation, Water Resources, and Utility Sub Division	Development Planning Agency of Surabaya Municipality
26.	Interview 1.26	Head of Programming Sub Division	Development Planning Agency of Surabaya Municipality
27.	Interview 1.27	City planner/ Expert	Bandung of Institute Technology
28.	Interview 1.28	Head of Programming Sub Division	Public Works Agency of Semarang Municipality
29.	Interview 1.29	Senior transportation planner of Transportation Directorate	National Development Planning Agency/Ministry of Development Planning
30.	Interview 1.30	Senior technical staff member	Highway Implementing Agency VIII, Ministry Public Works and Housing
31.	Interview 1.31	Head of Infrastructure Development Sub Division	Regional Development Planning Agency of Semarang Municipality
32.	Interview 1.32	Head of Land Acquisition Facilitation Division	Regional Infrastructure Development Agency, Ministry of Public Works and Housing
33.	Interview 1.33	Senior spatial planner of Infrastructure Division	Regional Development Planning Agency of Central Java Province
34.	Interview 1.34	Traffic planner/ Expert	Bandung of Institute Technology
35.	Interview 1.35	Head of Spatial Planning I Section	Directorate of Spatial Planning, Ministry of Agrarian Affairs and Spatial Planning

No.	Interviewee	Title	Organization
36.	Interview 1.36	Traffic planner/ Expert	Parahyangan Catholic University
37.	Interview 1.37	Head of Highway Environment Sub Directorate	Directorate General of Highway, Ministry of Public Works and Housing
B.	*The Bali Mandara Highway (Bali)*		
1.	Interview 2.1	Lead coordinator/ Traffic and road environment expert	Indonesia Green Road
2.	Interview 2.2	Engineering staff member	PT Jasamarga Bali Toll
3.	Interview 2.3	Project Control Manager	PT Jasamarga Bali Toll
4.	Interview 2.4	Senior spatial planner	Directorate General of Spatial Planning, Ministry of Agrarian Affairs and Spatial Planning
5.	Interview 2.5	Project Manager Section I for Bali Region	Directorate General of Highway, Ministry of Public and Housing
6.	Interview 2.6	Head of Construction Monitoring Sub Division	Toll Road Regulation Agency, Ministry of Public Works and Housing
7.	Interview 2.7	Senior engineering staff member	Highway and Spatial Planning Agency of Bali Province
8.	Interview 2.8	Head of Local Participation Division	Tanjung Benoa District
9.	Interview 2.9	Director	LPPM Udayana University
10.	Interview 2.10	Senior member	Tri Hita Karana Foundation
11.	Interview 2.11	Head of Spatial Planning for Strategic Regions (Java and Bali)	Directorate General of Spatial Planning, Ministry of Agrarian Affairs and Spatial Planning
12.	Interview 2.12	Head of Infrastructure and Technology Sub Division	Regional Secretary Agency of Badung Regency
13.	Interview 2.13	Head of Infrastructure Sub Division	Regional Development Planning Agency of Bali Province
14.	Interview 2.14	Head of Highway Division	Highway and Spatial Planning Agency of Badung Regency
15.	Interview 2.15	Confidential	-
16.	Interview 2.16	Confidential	-
17.	Interview 2.17	Head of Infrastructure and Spatial Planning Division	Regional Development Planning Board Agency of Badung Regency
18.	Interview 2.18	Director	Environmental Protection Foundation-Bali chapter
19.	Interview 2.19	Confidential	-

No.	Interviewee	Title	Organization
20.	Interview 2.20	Head of Infrastructure Sub Division	Regional Development Planning Board Agency of Badung Regency
C.	*Kelok-9 Highway (West Sumatra)*		
1.	Interview 3.1	Head of Area Development Sub Directorate	Directorate of Area Arrangement, Ministry of Agrarian Affairs and Spatial Planning
2.	Interview 3.2	Road design specialist	Indonesia Green Road
3.	Interview 3.3	Senior spatial planner	Regional Planning Board, West Sumatra Province
4.	Interview 3.4	Former Director/ Lecturer	Lembaga Bina Lingkungan dan Lansekap/ Trisakti University
5.	Interview 3.5	Senior engineering staff member/ Project manager Kelok-9	Highway Implementing Agency III, Ministry of Public and Housing

Appendix B.1 Semi-structured interview questions (Chapter 3)

1. What are the perceived project effects for both the whole corridor and the individual urban regions?
2. What policy goals/objectives are incorporated as sustainability goals/objectives according to your organizational missions, tasks, and mandates?
3. At what spatial level do you address such goals/objectives?
4. In what ways do you incorporate the abovementioned goals/objectives within the organizational responsibilities?
5. What are the main requirements for achieving the goals/objectives?
6. What attempts have been made so far to contribute to improving project sustainability?
7. What pieces of evidence support the contributions?

Appendix B.2 Semi-structured interview questions (Chapter 5)

1. What were the project's missions and the stakeholders' interests in the highway projects?
2. How did the purposes and the stakes evolve?
3. What processes were carried out to resolve competing interests?
4. Who were the leading stakeholders in such processes?
5. What problems and solutions were discussed in which arenas and policy networks?
6. What were the decision results of the arenas you were involved in that contributed to the definitions of problems and solutions?
7. In what ways was the integration of interests finally achieved? Could you describe how it was resolved?

Appendix B.3 Semi-structured interview questions (Chapter 6)

1. In what ways were you involved in the project? How long were you engaged in the project? What were your primary responsibilities?
2. What did you consider the main problems affecting the sustainability of the development project?
3. In what ways did such issues contribute to sustainability? At what stages did they apply? Could you give an example?
4. What locations were the most impacted by the project and at which development stages were they problematic? Could explain what the reasons are?
5. Did the duration of the project affect its sustainability? Later on, in what ways did the project end transform the pace and spatial development? At which stages did they apply? Could you give an example?
6. Could you explain which cultural values and natural resources were the most impacted by the project? At which development stages were they considered problematic? Could you give examples?
7. Could you elaborate who benefitted from the project? Which parties were responsible for achieving the sustainability of the development? In what ways and in which phases were they responsible?
8. What decisions do you consider as contributing to sustainability, and in which phases are these decisions made? Could you give an example?
9. What institutional arrangements are helping the project to achieve sustainable development? In which development phases were they problematic? Could you give an example?

Appendix C. Online-questionnaire form

A survey on the barriers to implementing an SA tool for road project planning

We thank you for your willingness to participate in completing the questionnaire. The aim of the questionnaire is to identify the degree of influence of the barriers to implementing an SA tool for road project planning. The main features of the implementation are the integration of sustainability aspects (i.e., social, economic, and environmental aspects), assessment techniques (e.g., CBA and MCDM), and the strategic scoping and screening of problems. We are targeting practitioners as our respondents because they have practical knowledge of the application of the guideline for Feasibility Studies for Road and Bridge Projects (MPW, 2005) that is adapted for an SA use by practitioners.

Based on a desk study and interviews with 24 decision-makers, project managers, university experts, and researchers, we categorized the implementing barriers into three institutional levels:

1. Micro-level: the individuals who are involved in producing the assessment, their behavior, and the constraints that bear upon them (such as a lack of skilled personnel, funds, and time).
2. Meso-level: the organizational level, namely organizational procedures and management structures, systems of knowledge transfer, norms and incentive structures.
3. Macro-level: the wider context, including linkages with broader values, norms, and societal goals, and connections with the larger policy network of stakeholders.

The questionnaire takes about 15 minutes to complete. If you have any queries about the questionnaire or the study, please contact the researcher through the email address provided on this form.

Respondent's details

1. I am working as a:
    - Freelancer
    - Other, please specify: ….
2. I am best described as a:
    - Tool developer (working as a researcher at a research institute/university)
    - Tool user (working as a spatial planner/road engineer/project manager)
    - Both
3. I have held my current position for:
    - Less than 5 years
    - 5 to 10 years
    - More than 10 years
4. In that period, I have been employed by (more than one option is possible):
    - National authority
    - Provincial authority
    - Municipal authority
    - Others, please specify: ….

Statements about barriers

We would like to gain an insight into the institutional barriers hampering implementation of SA tools for road planning through your responses to 24 statements regarding the micro-, meso-, and macro-levels. Please rate how influential each statement is concerning the identified barrier. The possible

ratings are: *"N.A. = not at all"*, *"S.I. = slightly influential"*, *"M.I. = moderately influential"*, *"V.I. = very influential"* and *"E.I. = extremely influential."*

Phases in which the possible barriers occurred
Please indicate the implementation phases during which the barriers were influential by selecting *"P = preparation"*, *"I = investigation"*, or *"R = recommendation."*

		N.A.	S.I.	M.I.	V.I.	E.I.	P	I	R
A	**Micro-level (8 statements)**								
1	Assigned personnel's limited knowledge of the use of the available techniques	○	○	○	○	○	□	□	□
2	Lack of users' knowledge of the integrative characteristics of sustainability aspects (i.e., social, economic, and environmental)	○	○	○	○	○	□	□	□
3	Low users' awareness of the integrative aspects of the tool (i.e., sustainability aspects, combined techniques, and interests)	○	○	○	○	○	□	□	□
4	Lack of users' understanding of the tool	○	○	○	○	○	□	□	□
5	Difficulty in obtaining multidisciplinary expertise in using the tool	○	○	○	○	○	□	□	□
6	Limited skills of the assigned personnel in using the tool	○	○	○	○	○	□	□	□
7	Unavailability of data and information to perform an integrated assessment (i.e., combined techniques)	○	○	○	○	○	□	□	□
8	Insufficient funding support in performing an integrated assessment	○	○	○	○	○	□	□	□
B	**Meso-level (9 statements)**								
1	Passive actors' involvement in decision-making processes	○	○	○	○	○	□	□	□
2	Low stakeholders' commitment to participate in the process/follow-up	○	○	○	○	○	□	□	□
3	Incoherence of stakeholders' expectations concerning the whole process/outcomes	○	○	○	○	○	□	□	□
4	Ineffective coordination of departments in decision-making processes	○	○	○	○	○	□	□	□
5	Lack of main departments' leadership capabilities to direct decision-making process	○	○	○	○	○	□	□	□
6	Unstructured involvement of stakeholders in decision-making processes	○	○	○	○	○	□	□	□
7	Unavailability of specific procedures/manuals to guide assessment and decision-making processes	○	○	○	○	○	□	□	□
8	Difficulty in recognizing involvement of relevant stakeholders	○	○	○	○	○	□	□	□
9	Unavailability of top-down policies to guide assessment and decision-making processes	○	○	○	○	○	□	□	□

		N.A.	S.I.	M.I.	V.I.	E.I.	P	I	R
C	**Macro-level (7 statements)**								
1	Stakeholders' distrust of assessment and decision-making processes/results	○	○	○	○	○	☐	☐	☐
2	Perceived uncertainty of the expected results	○	○	○	○	○	☐	☐	☐
3	The complexity of the interactions between departments at different administrative levels	○	○	○	○	○	☐	☐	☐
4	The presence of short-term interests characterizing decision-making processes	○	○	○	○	○	☐	☐	☐
5	The presence of strong sectoral interests determining the objectives and expected outcomes	○	○	○	○	○	☐	☐	☐
6	The complexity of the strategic issues beyond the project location that needed to be coped with	○	○	○	○	○	☐	☐	☐
7	Unavailability of specific arenas for performing the decision-making	○	○	○	○	○	☐	☐	☐

General comments (if needed): ……. (in a short paragraph)

Appendix D. The integrated indicator set to assess the sustainability of road infrastructure projects

No.	**Main group of indicators**/ *Indicators*
1.	**Mitigation of species habitat fragmentation and land use management**
	Reducing barrier effects on species; Avoiding species habitat fragmentation; Creating new species habitats beyond what the project is required; Protecting valuable habitats and natural (ecological) areas (e.g., wetlands, peat bogs, forest, semi-natural areas); Protecting endangered species and biodiversity; Protecting soil characteristics (e.g., mechanic, permeability, texture); Protecting green areas (e.g., avoiding deforestation and tree removal); Protecting landscape and human-made heritage; Avoiding irreversible damages to local ecosystems (e.g., fjord); Balancing earthwork quantities (cut and fill) during construction; Prioritizing native soils/materials for construction; Decreasing land-use changes (e.g., from forests to pavement areas); Avoiding productive land loss (e.g., best agricultural soils); Preserving water quality, capacity, and regime (e.g., keeping buffer between water body and road edge); Minimizing visual disturbance on surroundings.
2.	**Mobility and accessibility improvement**
	Reducing travel time; Decreasing road user's costs; Improving level of service; Improving accessibility to public services and other purposes (e.g., food shops, tourism, culture); Improving proximity to transits areas; Improving accessibility to disaster evacuation routes; Providing non-motorized transportation facilities for pedestrians and cyclists; Providing public transportation facilities (e.g., bus stops, train stations); Enhancing accessibility to public transportations; Enhancing goods and people movement (economic throughput and efficiency); Improving accessibility to employment in economic zones; Improving territorial cohesion and areal connectivity; Reducing impairments of traffic flow and driving comfort (e.g., congestion); Improving compatibility of diverse transportation modes.
3.	**Pollution (soil, water, air, light, noise) prevention**
	Reducing traffic emissions (NO_x, CO, PM > 10, CO_2)/improving local (and regional) air quality; Reducing light pollutions from traffics; Minimizing impacts on atmosphere (e.g., acidification potential (AP), eutrophication potential (EP), ozone depletion, smog); Minimizing/controlling noise, vibration, dust, and light trespassing; Reducing materials wasted in construction; Providing on-site recycling and waste collection; Protecting watercourses (e.g., lakes) in construction.
4.	**Climate change adaptation and resilient infrastructure**
	Reducing run-off quantity; Improving stormwater quality treated; Reducing urban heat island (UHI) effects; Reducing greenhouse gas (GHG) footprints; Selecting local climate-oriented plants/trees; Avoiding prone disaster areas (e.g. erosion, landslide, and hazardous susceptibility areas) in construction; Anticipating future traffic demands and disaster risk assessments; Reducing stormwater vaults through provision of natural drainage systems; Providing low impact development (LID) (e.g., basins in planters and rain gardens) to

No.	**Main group of indicators**/ *Indicators*
	manage infiltration of stormwater; Reducing heat gains (from pavement areas) through tree planting.
6.	**Community livability improvement**
	Avoiding natural and human capital losses because of traffic emissions; Providing/preserving views/scenery/vistas/scenic spots; Protecting archaeological and historic resources; Reducing accident risks in urban areas; Mitigating emission effects on human health (e.g. respiratory illness, cancer, premature deaths) and on urban ecosystem quality; Improving local perception on urban health quality (e.g., fine particulates and health-related emissions); Enhancing community cohesion; Increasing visual quality and art/culture/community values of neighborhoods; Avoiding on-street parking in urban areas.
7.	**Resource efficiency**
	Utilizing locally obtained materials for construction; Re-using pavement materials for construction; Selecting cost-effective design; Reducing space use for alignments; Reducing uses of non-renewable raw materials (e.g. fossil fuels); Utilizing non-renewable minerals (e.g., limestone, iron ore); Utilizing indigenous renewable energy (e.g., hydroelectricity); Improving energy efficiency in construction and operation; Reducing water uses in construction; Re-using stormwater for other purposes (e.g. irrigation).
8.	**Societal well-being and equity (both intrageneration and intergeneration)**
	Equitable environmental quality (from mitigating traffic emissions) in vulnerable groups of people (e.g., children, elderly, disabled); Enhancing regional growth and economic activities (e.g. business, jobs/employment, wages, property value); Enhancing fiscal impacts (e.g., public revenues); Reducing traffic injuries in vulnerable groups of people; Reducing pollution impacts to vulnerable groups of people (with their disproportionate effects in deprived areas); Promoting walking and cycling to improve general health; Improving perception on equity to decrease social tensions in resource allocation; Enhancing physical and social mobility for all people (to access, e.g., food, health care, friends, leisure, cultural, exercise); Reducing noise level to improve sleep quality and daytime sleepiness for children; Reducing travel costs to lower expenses for all households; Enhancing distributive effects of better connectivity to reduce spatial inequity; Providing transit and HOV access for all; Providing pedestrian and bicycle paths and dedicated access for vulnerable groups of people.
8.	**Integrative planning and decision-making**
	Applying road safety audit; Conformance with standards and requirements (e.g., technical, environmental, social); Disseminating information (public outreach) about the project sustainability (e.g., elements, technology); Participating/collaborating stakeholders and experts in the planning, construction, and usage phase (e.g., outcomes, strategic objectives, needs/mutual benefits, alternatives, facility upkeeps); Training personnel involved in the application of environmental sustainability programs; Educating public/personnel to increase awareness of sustainability; Hiring contractors having certified international standards in quality and environmental management systems; Providing contractors' warranty to ensure pavement durability; Integrating project funds in environmental impact

No.	**Main group of indicators**/ *Indicators*
	mitigation; Improving consistency and coordination between project planning and regional (spatial) objectives; Enhancing cross-institutional collaboration; Securing funds for maintenance; Integrating land use planning and environmental management; Integrating data, information, and models in planning and assessments; Improving individual and organizations' capacities to mitigate cross-scale impacts; Applying innovative delivery systems to incorporate sustainability.
9.	**Technological utilization for impact mitigation**
	Utilizing low impact development (LID) (e.g., permeable/porous pavement); Applying intelligent transportation system (ITS) solutions to manage traffic flows; Utilizing quiet pavement technology to reduce noise; Utilizing high-performance pavement (based on life-cycle assessment)/low-budget maintenance; Utilizing rapid and lean construction techniques; Utilizing precast/modular elements; Using low-energy lightings; Utilizing solar power sources in construction and usage; Applying climate-resistant designs and materials; Utilizing low-emission materials (e.g., warm mix asphalt); Utilizing low-emission equipment; Utilizing recycled materials; Utilizing data monitoring for water use in construction.
10.	**Context-sensitive development**
	Applying water-appropriate plantings to secure hydrological conditions; Applying context-sensitive landscape solutions (e.g., native vegetation and diverse plants); Applying context-sensitive & consistent designs to improve safety (e.g., traffic calming in residentials, safe streets in educational zones); Adopting regulations and standards to suit with local contexts and to apply user-oriented solutions; Integrating project plans with local concerns (e.g., aesthetic, environmental, art/culture/community values, senses of place).

Source: Own elaboration based on the examined papers. Note: All groups of indicators are extracted based on the indicators included in the papers reviewed. The detailed indicators are collected and compared. If indicators were found to be more or less the same, they were treated as the same indicator. Units of these indicators have been left out to allow the merging of the indicators without omitting the exact meanings.

Appendix E. Refined spatial levels of elements and distributions

Perspective	Dimension	Elements	Spatial level*			
			International	National	Regional	Local
Infrastructure (I)	Physical (A)	Efficient energy use		X		
		Use of local materials		X		
		Resilience to disasters		X	X	X
		Sufficient drainage capacity against early damage		X	X	
		Use of recycled pavement materials		X		X
		Reliable pavement design		X	X	X
		Pavement durability	X	X	X	X
	Operational (B)	Reduction of GHG release	X	X		X
		Enhancement of driving comfort		X		X
		Level of service (LOS) improvement (congestion relief)		X		X
		Multifunctional infrastructure design				X
		Multimodal infrastructure provision (walking, cycling)			X	X
		Mitigation of traffic noise and other polluting emissions	X	X	X	X
		Accident risk reduction		X	X	X
		Travel time saving				X
Spatial (II)	Functional (C)	Designs based on topographical limitations				X
		Provision of green features				X
		Formation of land-use patterns		X	X	X
		Improvement of access to urban centers and transportation hubs				X
		Aesthetic enhancement				X
		Locally sensitive street design				X
		Protection of agricultural lands		X	X	X
		Preservation of forests and species' habitats	X	X	X	X
	Structural (D)	Ending regional isolation		X	X	X
		Accessibility enhancement		X	X	X
		Connectivity improvement		X	X	X
		Distribution of spatial development		X	X	X
		Increased economic growth (and competitiveness)		X	X	X

Perspective	Dimension	Elements	Spatial level*			
			International	National	Regional	Local
Temporal (III)	Provisional (E)	Reduction of pollutant emissions during construction				X
		Just and proper land acquisition and community resettlement				X
		Monitored health and safety of the project's surroundings				X
		Allocation of jobs to local people				X
		Management of traffic delays (during construction)				X
		Water use efficiency				X
	Permanent (F)	The maintained ecosystem's carrying capacity	X	X	X	X
		Mitigation of damage to the ecosystem	X	X	X	X
		Minimization of changes to the landscape		X		X
		Minimization of social displacement	X	X	X	X
		Restructured transportation costs		X	X	X
Governance (IV)	Institutional (G)	Compliance with regulations and standards	X	X	X	X
		Continual monitoring of compliance		X	X	X
		Cooperation and coordination of agencies		X	X	X
		Implementation of best practices		X	X	
		Public participation				X
		Public-private partnerships		X		X
		Funding capacity		X	X	X
	Political (H)	Actors' awareness of integrative issues		X		X
		Shared vision		X	X	X
		Commitment to a long-term plan		X	X	X
		Actors' knowledge		X	X	X
		Actors' leadership		X	X	X
		Transparency and trust		X	X	X
		Presence of a long-term vision		X	X	X

Note: Distributions of the elements at various spatial levels (*stated by ≥4 referring sources [median=4])

About the Author

Gede Budi Suprayoga (1980, Bandung) studied City and Regional Planning at the Faculty of Civil Engineering and Planning, Bandung of Institute Technology (ITB). In 2005, he granted a scholarship by the institute to pursue his Master's degree in City and Regional Planning, specializing in Infrastructure Management and Development Planning. He worked at the Urban Planning and Design Research Group at ITB as a research and teaching assistant from 2005 to 2008. He taught Bachelor's and Master's students in city planning course and workshop. He started his career as a government employee at the Institute of Road Engineering (IRE), Indonesia's Ministry of Public Works, in 2009. He contributed to the formulation of strategic plans, Research and Development (R & D) programs, and the Climate Change Adaptation and Mitigation Plan in the road sub-sector. In 2014, he was appointed as the Head Section of R & D at the Traffic and Road Environment Laboratory of IRE. He organized several R & D activities in road safety, intelligent transportation systems, urban roads, and highway environments. He was also responsible for facilitating the development of standards and guidelines for road traffic engineering, planning, and road environments. He granted scholarships by International Urban Training Center (IUTC), Swedish International Development Cooperation (SIDA), and Studeren in Nederland (StuNed) to participate in courses, workshops, and seminars about sustainable transportation infrastructure, environmental management, and program evaluation for sustainable development. In 2016, he received funding from Indonesia Endowment Fund for Education (LPDP) to pursue his doctoral degree. He joined the Department of Environmental Sciences at Wageningen University and Research (2016-2019) and the Faculty of Geosciences at Utrecht University (2019-2020) to study and perform research about the integration of sustainability into spatial planning and infrastructure development projects. He is passionate about improving ways planners and engineers can collaborate to deliver physical infrastructure that improves people's well-being and protect the natural environment. In his education, research, and professions, he has interests in project appraisal, impact assessment, transportation infrastructure planning, and sustainability. He authored and co-authored scientific articles about the topics and books entitled *Jalan Hijau Indonesia*/ Indonesia Green Roads (2013) and *Sistem Pengadaan untuk Pembangunan Jalan*/ Procurement Systems for Road Construction (2014).