ASSESSMENT METHODS FOR SPATIAL DEVELOPMENT AND INFRASTRUCTURE PLANNING

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1. INTRODUCTION

The continuous development of a sustainable and integrated transport system is essential for a good functioning society, economy and environment. Infrastructure development takes place at different spatial scales involving many stakeholders making it a complex process.

Infrastructure planners have various strategies at their disposal to build high quality infrastructure with high satisfaction among stakeholders. Recent developments in guidelines for transportation appraisal and planning, involves improvements in quantification and treatment of impacts related to infrastructure development. In particular, advancements are made with regards to methodologies for measuring the wider impacts. There is also an untapped potential for improving the planning process through collaborating planning, which involves the anchoring the process among stakeholders and utilizing their knowledge at equalized terms.

Different instruments and methods already exist to carry out transport appraisals. Some are tailor made, while other instruments and methods have a wider range of application. Often these are part of guidelines for infrastructure development and comprise topics such as cost-benefit analysis or multi-criteria-analysis. Yet, these guidelines might not capture or focus on all impacts that stakeholders are worried about, particularly when it comes to the social impacts and distributional concerns. Also, collaborative planning is usually not part of these guidelines.

Hence there is a need to further improve methodologies to carry out assessments for infrastructure development. To obtain optimal strategies, more knowledge on broader impacts is required, as well as a collaborative planning of infrastructure and spatial development. The development of such an inclusive methodology comprises various challenges:

- How to gain a better understanding of the relation between spatial and multimodal infrastructure development?
- How to assess the societal value of combined multimodal infrastructure and spatial development for decision making on investments?

- How to capture the added value from combined infrastructure and spatial development?
- How to provide an inclusive assessment on consequences of infrastructure development?
- How to utilize stakeholder information without suffering from information skewness?
- How to identify and distinguish between vested interests and the interests of society?

Given these challenges, the Conference of European Directors of Road (CEDR) raised the question '*How to achieve integrated project development of infrastructure and its spatial surroundings?* To answer this, CEDR has asked for holistic methods for assessing costs and benefits of combined infrastructure and spatial development in way that adheres to the principles of collaborative planning. This should lead to the development of an assessment tool that (i) assesses the predicted impacts of integrated infrastructure development and (ii) includes relevant stakeholders directly in the assessment process. In doing so, CEDR offers planners a tool to make integrated infrastructure more inclusive and collaborative.

The SPADE project (Assessing the added value from **SPA**tial **DE**velopment as a factor in infrastructure planning) – project refers to this central question. The project relates to the assessment of an integrated spatial and infrastructure development, which focusses upon the assessment of the added value of the integrated plans and designs, in order to get an insight in the societal relevance of collaborative planning.

For developing of an improved method, an extensive literature review has been undertaken to identify the needs for such a method. The review comprises both theory, empirics and practice in the different topics related to assessment methods in the transportation sector.

In our literature review, we have used several mapping techniques. These include search for relevant key words on Google Scholar, literature tips from experts on each topic and review of literature referred to by the public appraisal guidelines, as well as snowballing techniques. Articles were prioritized according to their age, publication quality, thematically precision and practical influence on spatial appraisal. In addition, we have mapped a set of 20 spatial appraisal guidelines from North America, Europe and Oceania.

This paper starts by providing an overview over theoretical and empirical foundation of wider impacts, including economic, social and environmental impacts in chapter 2. The theoretical part further explores the relevance of collaborative planning in chapter 3. Then the associated assessment methods that makes planning more collaborative, such as including aspects such as wider impacts in a cost-benefit analysis (CBA), the use of (multi-actor) multi-criteria analysis (MCA), the combination of CBA and MCA, discussion methods, other assessment methods are discussed in chapter 4. The practical part looks into the state-of-the art of national guidelines on assessment methods in Europe, North America and Oceania. We give an overview of how the different guidelines treat wider economic and non-economic impacts and which assessment methods are suggested in chapter 5. The literature review forms the base for an assessment method for spatial development and infrastructure planning.

This paper summarizes the first deliverable produced under the SPADE project (see Holmen et al. 2019). The paper provides an outline of the literature review and a preview of the assessment method that will be developed.

2. IMPACTS OF SPATIAL MEASURES

Impacts included in appraisal of spatial measures build on a large volume of scientific literature. Yet, few earlier studies map these impacts systematically. In the SPADE project, we have reviewed both empirical and theoretical research on impacts of spatial measures with focus on transport-related measures. We refer to Holmen & Hansen (2019) for the full survey. Table 1 provides an overview of the classification of impacts from transport investments and measures based on our mapping. In the following, we will summarize the key points of this review. Our focus is on efficiency impacts (i.e. impacts on total social welfare), valuation and the largest impacts excluded from conventional CBA.

Table 1: Classification of impacts from transport investments based on our mapping

Impacts	Conventional impacts	Unconventional impacts
Economic	Construction, maintenance, time saving for business trips, net income for transport providers and driving costs	Production agglomeration, reduced misuse of market power, factor market impacts,
Environmental	Local air pollution, global air pollution and noise	Landscape, townscape, biodiversity, heritage and water environment, land contamination and solid waste
Social	Accidents, journey quality, physical activities and time savings for commuting and leisure trips	Security, severance, option and non-option values, service accessibility, affordability, risk of accidents and stress of congestion
Public budget	Tax financing, public income	Tax income related to change in economic activity

Earlier mappings have classified impacts from spatial measures (e.g. Oosterhaven and Knaap 2003 and Department for Transport 2019). The review of impacts is based on impact recipients (i.e. producers, consumers, others or public funding), where the delimitation between impact groups lies close to the practice in public appraisal guidelines. Other important impact dimensions include market attachment (i.e. direct, indirect and externalities), operative usage (i.e. inclusion in conventional CBA or not) and duration (permanent or temporary).

Economic impacts are defined in a narrow sense, only to include impacts on the production sector. Direct economic impacts include scheme costs and user and provider benefits, and are generally well understood and measured. Economic impacts in secondary markets, so-called 'wider economic impacts', distinguish themselves from other impacts excluded from conventional CBA with relative large value estimates. Particularly important are productivity and labor market effects related to increased competition and agglomeration synergies. Key contributions include Duranton and Puga (2003) and Venables (2007). Recent progress in the literature have been made on causal measurement of impacts under various circumstances, such as Combes et al (2016) on addressing housing production or Bernard et al (2019) on the improvement of firms performance due to the introduction of high speed rail services.

Environmental impacts involve externalities of the transport system. Pollution is included in the standard CBA, but valuation remains under constant development, especially for emission of climate gases. Geographic environmental impacts are more challenging to estimate. Important valuation methods include contingent valuation, choice experiments, travel cost method, hedonic prices and production and cost-function techniques. For environmental user goods, revealed preference methods are most common, while stated-based preference methods are most common for environmental non-user goods (Garrod and Willis 1999 and Perman et al. 2003).

Social impacts are impacts concerning households except socio-environmental impacts. These impacts are generally well understood, but this scientific literature does not draw much attention towards valuation. Some additional impacts are proposed by Geurs, Boon and Van Wee (2009). In principle, valuation methodology for indirect environmental impacts would often be suited also for indirect social impacts. For some impacts such as affordability and social cohesion, the borderline between social efficiency impacts and distributional impacts are somewhat blurry.

Public impacts are impacts related to distortions related to tax collection and public provision of goods. Costs of public funds are relatively well understood and straight forward to include in CBA, although value estimates vary quite a bit (e.g. Fridstrøm et al. 2000 and Levinson 2010). In contrary, the literature on spatial impacts on provision of other public measure are limited, although policy integration plays an increasingly important role in transport planning.

To conclude, the impacts in transport appraisal guidelines are well founded in a large, but fragmented, scientific literature. Still, the magnitude of several impacts in secondary markets remain uncertain and dependent on many contextual factors, making the inclusion in CBA problematic.

3. COLLABORATIVE PLANNING AND COLLABORATIVE PLANNING TOOLS

In addition to knowledge on the expected impacts, another contributor to the success of infrastructure development is the inclusion of stakeholders into the planning process. Therefore we consider the usage of these impacts in the planning process from the theory of collaborative planning. According to this planning method, there is more to decision making in planning than choosing the policy measure(s) with the most benefits compared to the lowest cost. Reality has shown that deciding on a policy measure or package of measures is vastly more ambiguous (De Roo & Voogd, 2007; Healey, 2003; Innes, 1998). A typical planning exercise results in a wide range of impacts that are felt and perceived differently by each individual. What constitute a cost and benefit, and the magnitude thereof, is often contested by stakeholders. This changes the way how the expected impacts are to be determined. Therefore, we need to consider methods that take into account this multi-interpretable nature of impacts into the planning process.

Literature on collaborative planning methods is not conclusive on the methods that work best to capture the multi-interpretable nature of impacts. The literature mainly consist of authors describing single use cases of a particular method and conclude on highlighting various components that seem to be advantageous of that particular method. An empirical analysis of collaborative methods with large sample sizes is absent, making it difficult to conclude on the requirements for collaborative planning methods on a high level of detail. However, a meta-comparison of various collaborative planning methods reveals the general features of these methods. Vacik et al. (2014) analyse 43 collaborative planning methods used in natural resources planning and find that most of them share similar features with no single method being universally the ‘best’. In addition, we have reviewed several collaborative planning tools which promise to enhance sensibly transparency and agreement, which, in other words, are means to reduce ignorance, disinformation, and biases of experts and stakeholders. The main the tools and the methods findings with their advantages and shortcomings are summarized in table 2.

Based on the conclusions from by Vacik et al. (2014) and our review, we conclude that a successful collaborative planning tool consists of the following features:

- A form of stakeholder interaction (physical such as focus group or online such as e-participation) that facilitates trust-building, face-to-face dialogue, and developing a shared understanding;
- Is relatively simple to understand and apply;
- Includes technological support systems (such as computer-based systems such as GIS-technology or web-applications or physical tools such as maps or models);

- Involves decision support systems (such as soft-systems methodology, SWOT-analysis the Vroom-Yetton method or the Four Rs framework); and/or
- Uses basic statistical analysis methods (such as MCA and its variants or Q methodology).

Table 2: Assessment of selected collaborative planning tools

Tool	Description	Advantages	Shortcomings
Future Search	Principle-based meeting to discover common ground and foster cooperation between stakeholders	Structured	Slow
Participatory GIS	Map-based interaction to attach qualitative or quantitative values to an area	Visualization	Confusing on large scale evaluations
e-Participation	Online forums for discussing relevant topics, petitioning, making surveys, exchanging information and more.	Multi-purpose	Crowded participation
Bayesian Causal Map	Statistical method to identify causal relationships based on econometric tools and Artificial Neural Networks	Statistically consistent	Complex
Soft System Method	Simple models of purposeful actions are built by each actor to discover their view and create a unique model.	Accounts for different viewpoints	Subject to interpretation
Fuzzy MA	Method to facilitate the understanding of trends and scenarios	Simplification	Fuzzy definition
KonSULT	Innovative tool for generating alter-native solutions and scores in trans-port planning based on experience	Awareness of options	Determination of scores
Joint Gains	Method for negotiating contrasting items and pursue a Pareto-efficient solution between stakeholders	Pareto-efficiency	Hard to apply
Delphi Method	Usually considered as a method for generating consensus, the questionnaires' technique allows feedback and deeper understanding of tacit viewpoints.	Structures discussion	Possible bias

The collaborative planning method provides the *institutional design* of the planning process. The institutional design involves the main rules and protocols that shape the collaborative process and is one of the major components for a successful collaborative planning process. Having reviews 137 empirical cases of situations in which collaborative governance is applied, Ansell and Gash (2007) conclude that other determents for successful collaborative planning are the starting conditions and facilitative leadership. *The starting conditions* refer to the initial situation with which the collaborative process starts. Factors such as the background of the actors, their relationship and their attitude towards the planning issue impacts the collaborative process. *Facilitative leadership* is another major component that is widely considered to be crucial to a collaborative process. The main tasks for such a mediator is setting out clear rules, guide the dialogue, build trust and explore mutual interest, so that the collaborative process is structured and efficient while making sure the principles of collaborative planning are adhered to.

4. ASSESSMENT METHODS FOR PROJECTS AND POLICY MEASURES

Although there is no scientific consensus on how to quantify wider economic effects in a CBA, there are two main branches of research.

The *first method* is based on calculations based on estimated agglomeration elasticity values and the expected change in effective density. This method is recommended in the UK guidelines for transport appraisal and extended in Graham and Gibbons (2019). It follows a three-step method consisting of the calculation of the access to economic mass via effective densities, estimation of agglomeration elasticities and quantification how the proposed transport scheme is expected to change productivity. Although this method excels in its simplicity, the needed estimation could be challenging.

The *second method* is based on spatial models such as Land-Use Transport Interaction (LUTI) and Spatial Computable General Equilibrium (SCGE) models. These models link transport with land-use (e.g., where people live and work) models aiming to model system dynamics. An overview of operational LUTI models is given in Kii, Nakanishi, Nakamura and Doi (2016) and Wegener (2004, 2014). Johansen and Hansen (2015) find LUTI models to be suitable to predict the changes in urban systems over time. Oosterhaven and Knaap (2003) give an overview of different approaches using LUTI models to estimate wider economic effects of investments in transport infrastructure.

Some well-known reservations exists against the use of CBA methods, such as understating the economic development benefits of certain investments, favouring some user groups at the expense of others, failing to incorporate all external effects into account (such as environmental or social impacts), and failing to deal with distributional effects (OECD, 2002). Therefore, we also consider MCA as complimentary method to overcome some of these limitations.

Multi-criteria Assessment methods are generally recommended for measuring impacts that are hard to value or measure precisely, e.g., environmental impacts like landscape and other qualitative effects. Therefore, most public guidelines for transport appraisal and planning include a framework of (partial) MCA as supplement for CBA. General reviews of MCA methods applied to transport appraisal can be found in Pérez, et al. (2014) and Deluka-Tibljaš et al (2013). A prominent example for a variant of a MCA method is the Multi-Actor Multi-Criteria Analysis (MAMCA) introduced in Macharis et al. (2008) and Macharis et al. (2012). In an MAMCA, stakeholders are grouped in homogenous groups. Each group performs an MCA with criteria relevant for that specific group. This approach enables the planners to identify differences in wishes between the groups and also allows for adding weights to the groups in the final results. Results can be presented as a set of different scoring matrices for each stakeholder group.

We further identified and classified Multi-Criteria Decision-Making (MCDM) methods in the following types based on Velasquez & Hester (2013) and Penadés-Plà et al. (2016):

- *Goal-orientation methods* based on predetermined goals, e.g., by deducing objectives set by the government (see Transport for NSW (2018) for methods like a Goal Achievement Matrix (GAM) and a Strategic Merit Test (SMT)).
- *Utility and valuation methods* based on assigning a utility value to each consequence which could consider uncertainties and preferences. Examples are methods based on Multi-Attribute Utility/Value Theory (MAUT / MAVT) and Analytical Hierarchy Process (AHP).
- *Mathematical programming mathematical methods* based on maximizing or minimizing a set of objectives respecting a set of constraints. Examples are Goal Programming (GP) or methods based on fuzzy set theory.
- *Distance-based comparisons methods* based on comparing each alternative to the best and worst alternative in each criterion. Examples are Technique for order preferences by similarity to ideal solutions (TOPSIS) and Multi-criteria optimization and compromise solution (VIKOR).
- *Outranking methods* based on pairwise comparisons of each criterion between each pair of measures to identify a ranking for all measures from best to worse. Examples are methods based on Elimination and Choice Expressing Reality (ELECTRE) and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE).

Using an MCA based method is particularly useful in including qualitative and non-monetized effects and in including different stakeholder views in planning appraisal. The method, however, is prone to subjective bias towards the views of the participants of the scoring process. MCA is also sensitive to the choice of criteria and weights and the many MCA methods described above show that there is a lack of an agreed upon theoretical framework.

To overcome the challenges using a CBA or MCA, we also looked at the benefits of combining CBA and MCA. The literature on integrated assessment methods combining CBA and MCA is rather sparse because the results of both methods are usually considered separately. In general, we identified two types of integrated CBA/MCA combinations. *First*, the results of a CBA evaluating the public costs and monetizable user benefits are used as an additional criterion in a MCA. *Second*, the results of a MCA are used within a CBA using a monetization method. An application of the first type is presented by Sijtsma (2006) in form of a tool for sustainable project evaluation called Multi-Criteria Cost Benefit Analysis (MCCBA). It is strongly based on stakeholder involvement since the aggregation of monetary and non-monetary scores is based on consensus among the stakeholders. The second method type is used, e.g., in an approach name Strategic Option Assessment (SOA) presented in Prosser, et al., 2015. The main idea of SOA is to monetize all impacts like in a CBA and then apply a weighting (e.g., temporal, spatial, or cost) of the costs and benefits. Then, the weighted cost benefit performance is compared between the options. Another integrated is the AMDTM as presented by Kiel, Muizer and Taale (2015). In this method, monetized and other quantifiable and unquantifiable values are considered in a weighted manner to determine cost-efficiency.

Overall, there is a large volume of literature on assessment methods for infrastructure development based on either CBA or MCA. When taking a deeper look towards methods that combine CBA and MCA, we observe potential for further research. Especially when the inclusion of non-monetizable and non-quantifiable impacts as well as stakeholder involvement is needed while at the same time keeping the objectivity of the method is a requirement, the development of assessment methods are getting challenging. Especially for reducing the subjective bias of the involved parties of the assessment process, tools and techniques from collaborative planning approaches should be used.

5. IMPACT COVERAGE IN PUBLIC APPRAISAL GUIDELINES

The theoretical base as described in the previous chapters have found their ways into practice. Several appraisal guidelines are available which have their theoretical foundations in the literature as described before.

National appraisal guidelines are important for the prioritization of spatial measures. Nevertheless, impact coverage and appraisal tools vary substantially over countries. In the SPADE project, we have reviewed the impact coverage in a set of 20 national and regional appraisal guidelines. We refer to Holmen et al. (2019) for the full survey. Here, we will account for the main points.

The guidelines were identified through websites of relevant government agencies and review of earlier mappings. Table 3 shows the reviewed spatial appraisal guidelines. Annex A includes the full citation of the guidelines. For a detailed description we refer to Holmen and Hansen (2019)

In a mapping of 25 European national appraisal guidelines, Odgaard et al. (2006) find that all countries use CBA and that nine of them at the time also used MCA. Their results suggest better impact coverage in Northern and Western Europe than in Eastern Europe, which in turn had better impact coverage than Southern European countries. Mackie and Worsley (2013) summarize a mapping of guidelines in Northern and Western Europe, North America and Oceania. Their mapping reveals that Oceanian guidelines also are among the most advanced. All countries assessed used CBA in combination with various non-monetized assessments. They point out wider economic impacts and reliability as the most important topics for progress at the time. Wangsness, Rødseth and Hansen (2017) find substantial progress in the coverage of wider economic impacts in the appraisal guidelines.

Table 3: Reviewed spatial appraisal guidelines

Country	Guideline
Australia	Australian Transport (2017), Bureau of Infrastructure, Transport and Regional Economics (2014)
Australia (New South Wales)	Transport for NSW (2018)
Austria	Bundesministerium für Verkehr, Innovation und Technologie (2010)
Belgium	Rebel Group Advisory (2013 and 2014) and De Lijn (2015)
Canada	Transport Canada (1994) and Treasury Board of Canada Secretariat (2007)
Canada (British Colombia)	Ministry of Transportation and Infrastructure in British Colombia (2014)
Denmark	Transportministeriet (2015)
European Union	European Commission (2014)
Germany	Federal Ministry of Transport and Digital Infrastructure (2016)
Ireland	Department for Transport, Tourism and Sport (2016)
Netherlands	Centraal Planbureau (2013, 2018a and 2018b), Rijkswaterstaat (2018) and Romijn and Renes (2013)
New Zealand	NZ Transport Agency (2018)
Norway	Jernbanedirektoratet (2018) and Statens vegvesen (2018)
Sweden	Trafikverket (2018)
Switzerland	Federal Roads Office FEDRO
United Kingdom	Department for Transport (2019)
United Kingdom (Scotland)	Transport Scotland (2018)
United States	US Department of Transportation (2018)

The national appraisal guidelines apply many dimensions to classify impacts. In the chapter on impacts' scientific foundation, we accentuated impact recipients, persistency, operative usage and market attachment as important dimension for impact classification. Other dimensions used for classification in the guidelines include geography, infrastructure, size and sign. We review guidelines with an Anglo-Saxon background. This selection captures the countries that were recognized to have best practice by earlier mappings (e.g. Odgaard et al. 2006 and Mackie and Worsley 2013). We map 34 impacts, including 11 environmental, 9 pure economic, 6 pure social, 4 economic and social and 3 public (defined as impacts on public funds and measures). The level of detail for which each impact is defined varies, so results should be interpreted as indications and not be taken too literally.

Overall, the impact coverage in public appraisal guidelines are higher for economic and environmental impacts, than for social and public impacts, but the differences are not large. Yet, environmental impacts have the poorest CBA coverage. Moreover, MCA are commonly recommended as assessment tool for geographic environmental impacts. Supplementary quantitative estimations are mostly used on wider economic impacts. Although the potential magnitude of these impacts suggest that they should be included in CBA, uncertainty about the magnitude and possible overlap between impacts makes it difficult in practice. In addition, estimation of impacts from spatial measures often assume no market failures in secondary markets, whereas wider economic impacts are caused by such market failures. Maintenance and construction costs, air pollution, noise and direct journey costs are included in all guidelines, while affordability and urban consumer variety are seldom included.

The widest impact coverages overall are found in Anglo-Saxon countries, while the poorest coverage are found in North America and small Continental European countries. The widest CBA coverage are found in the guidelines of European Union and New Zealand, while Australia and United States have the poorest coverage. Of course, it is not all about quantifying all impacts in CBA, considering the reasons for MCA and supplementary quantitative analyses often are applied due to uncertainty in the quantitative estimates. Moreover, the countries with poor impact coverage are generally less focused on environmental and social impacts.

Although impact coverage is decent in most countries under investigation, the weight put upon spatial appraisal in decision-making varies quite a lot. For instance, ranking projects according to cost-benefit rankings constitute a starting point for selection of transport projects in Germany and United Kingdom (e.g. Mackie, Worsley and Eliasson 2014). To the contrary, CBA plays a less important role for decision-making in Netherlands, Norway and Sweden, where other political interests are more influential (Eliasson et al. 2015 and Annema et al. 2016). Considering the amount of research conducted on wider economic impacts, more frequent future inclusion of these impacts in CBA seems likely. This requires higher estimation precision, handling of potential overlaps with other impacts and revision of assumptions on market failures in secondary markets. High focus on public policy integration suggest that impacts on policy measures will receive more attention in the years to come.

6. CONCLUSIONS AND RECOMMENDATIONS

The SPADE project looks into the challenges as set out in a central question by CEDR, '*How to achieve integrated project development of infrastructure and its spatial surroundings?'* The paper gives a brief overview of the status on research into the impacts of measures, collaborative planning, assessment methods and national guidelines. In this literature review we showed the potential and need of improved assessment methods for transport appraisal based on existing methods. Based on our review, we identified a set of requirements for new transport appraisal methodologies.

First, scientific literature on impacts from spatial measures is large, but fragmented. Still, valuation of impacts in secondary markets are often complex and uncertain, and therefore often not included in the CBA. Judged by the size of their value estimates, wider economic impacts might be particularly important in this regard. Impacts on other public measures constitute the impact group that have received least attention in the literature, although it remains central in spatial planning.

Second, earlier mappings of national appraisal guidelines for spatial measures suggest that the widest impact coverage are found in Northern and Western European and Oceania. We found that currently the widest coverage overall is found in the guidelines of Anglo-Saxon countries, while New Zealand and European Union have the widest CBA coverage. Impact coverage is relatively even over types of impacts. Likely future progress in the guidelines includes more frequent inclusion of wider economic impacts in CBA and improved assessment tools for policy integration.

Third, we showed the need for improving current CBA methods in theory and practice. However, better CBA methods does not address all shortcomings observed in current infrastructure development practices. CBA deals insufficiently with the political reality of which infrastructure development projects are subject to. After all, infrastructure development is a political process in which trade-offs between stakeholders and the democratic nature of the process should be considered together with the magnitude of an effect.

Fourth, while MCA is better equipped in capturing trade-offs between stakeholders and the subjective nature of impacts, it does not reflect the political process of consensus building process in an iterative manner (Turner, 2006). In this regard, collaborative planning methods are needed to further improve current methodology. Therefore, in addition to CBA and MCA. An integrated assessment methodology should also include methodologies for stakeholder involvement. This should follow an institutional design that supports stakeholder interaction aided by a facilitator, technological support systems, decision support systems and a method for basic statistical analysis.

These requirements provide future research directions and development possibilities for an integrated assessment tool. The SPADE method is likely to further build on the findings from the literature. The SPADE method will integrate the different impacts by means of a combination of CBA and MCA using new techniques to include stakeholders in the planning process.

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Annex A

An overview of the reviewed transport appraisal guidelines in this research are provided below.

Country	Guideline
Australia	Australian Transport (2017): Australian Transport Assessment and Planning Bureau of Infrastructure, Transport and Regional Economics, Department of Infrastructure and regional development (2014): *Overview of project appraisal for land transport*
Australia (New South Wales)	Transport for NSW (2018): Principle and Guidelines for Economic Appraisal of Transport Investments and Initiatives
Austria	Bundesministerium für Verkehr, Innovation und Technologie (2010): *Nutzen-Kosten-Untersuchungen im Verkehrswesen (RVS 02.01.22)*
Belgium	Rebel Advisory Group 2014: Maatschappelijke kosten-batenanalyse van een derde Scheldekruising te Antwerpen Rebel Advisory Group (2013): Standaardmethodiek voor MKBA van transportinfrastructuurprojecten. Aanvulling: Infrastructuurprojecten voor vrachtvervoer over land (weg, spoor en binnenvaart) De Lijn (2015): MKBA van de vertramming busbundel 7 tussen sint-denijs-westrem en gent dampoort
Canada	Treasury Board of Canada Secretariat (2007): 'Canadian Cost-Benefit Analysis Guide: Regulatory Proposals'. Transport Canada (1994), 'Guide To Benefit-Cost Analysis In Transport Canada'.
Canada (British Colombia)	Ministry of Transportation and Infrastructure (2014): *Benefit Cost Analysis Guidebook*
Denmark	Danish Ministry of Transport (2015): Manual for samfundsøkonomisk analyse på transportområdet
European Union, spatial	European Commission (2014): Guide to Cost-Benefit Analysis of investment projects
Germany	Federal Ministry of Transport and Digital Infrastructure (2016): *The 2030 Federal Transport Infrastructure Plan*
Ireland	Department for Transport, Tourism and Sport (2016): Common appraisal framework for transport projects and programmes
Netherlands, spatial	Centraal Planbureau (2018): Ruimtelijke- én mobiliteitsprojecten in de stad: wat en hoe groot zijn de effecten? Centraal Planbureau (2013): Plannen voor de stad - Een multidisciplinaire verkenning van de effecten van verstedelijkingsprojecten op het functioneren van een stad Romijn and Renes (2013): Plannen voor de stad - Een multidisciplinaire verkenning van de effecten van

	verstedelijkingsprojecten op het functioneren van een stad, Centraal Planbureau.
Netherlands, transport	Rijkswaterstaat (2018): Werkwijzer MKBA bij MIRT-verkenningen Centraal Planbureau (2018): MKBA-methoden en bereikbaarheid: Hoe omgaan met niet-infrastructurele maatregelen, zoals wegbenuttingsmaatregelen? Romijn and Renes (2013): Plannen voor de stad - Een multidisciplinaire verkenning van de effecten van verstedelijkingsprojecten op het functioneren van een stad, Centraal Planbureau.
New Zealand	NZ Transport Agency (2018): *Economic Evaluation Manual*
Norway, road	Norwegian Public Roads Administration (2018): Konsekvensanalyser, veiledning, Håndbok V712, Vegdirektoratet 2018.
Norway, rail	Norwegian Railway Directorate (2018): Veileder i samfunnsøkonomiske analyser
Sweden	Trafikverket (2018): Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.1
Switzerland	Bundesamt für Strassen, ASTRA (2010): Handbuch eNISTRA – ein Tool für zwei sich ergänzende Methoden zur Bewertung von Strasseninfrastrukturprojekten: NISTRA – Nachhaltigkeitsindikatoren für Strasseninfrastrukturprojekte
UK	Department for Transport (2018): *Distributional Impacts Appraisal* Department for Transport (2018): *Social Impacts Appraisal* Environment Agency (2007): Addressing environmental inequalities: cumulative environmental impacts
UK (Scotland)	Transport Scotland (2018): Scottish Transport Appraisal Guidance (STAG)
USA	U.S. Department of Transportation 2018: Benefit-Cost Analysis Guidance for Discretionary Grant programs