

**TOWARDS A MORE EFFECTIVE EIA IN TRANSPORT PLANNING: A LITERATURE
REVIEW TO DERIVE INTERVENTIONS AND MECHANISMS TO IMPROVE KNOWLEDGE
INTEGRATION**

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Abstract

A set of process-related barriers negatively determines the effectiveness of EIA in transport planning. Recent research highlights the unstructured stakeholder involvement and inefficient public participation in earlier phases of EIA as key bottlenecks. While the academic literature has produced promising theories for addressing these barriers, they have rarely been translated into solutions applicable and testable in practice. In order to bridge this theory–practice gap, we present a systematic literature review of interventions and mechanisms aimed at facilitating the integration of different sources and types of knowledge during the scoping phase of EIA. This review explores if and how interventions and mechanisms have been conducted in practice; if and why they worked or did not work; and how relevant they are for EIA in transport planning. Based on this review, we distil a set of three specific interventions and trigger mechanisms applicable in the context of EIA in transport planning.

Keywords: sustainability, scoping phase, stakeholders, public participation

1. Introduction

Significant changes are taking place in the context of transport planning. Instrumental rationality has come under attack (see Bertolini et al., 2008; Willson, 2001; Te Brömmelstroet and Bertolini, 2011), resulting in the emergence of new communicative approaches (Beukers et al., 2014; Curtis, 2011; Pfaffenbichler, 2011). This means “interactive processes rather than the deliberative process of a single actor or group of actors, emphasizing the design of planning processes, participation and learning, and a reconciliation of different ways of understanding planning opportunities” (Willson, 2001 p. 2).

The described altered context also limits the applicability of instruments grounded in instrumental rationality, namely Environmental Impact Assessment (EIA). Together with content and methodological problems associated with EIA in transport planning (i.e. the technical measurement of environmental effects) (Ma et al., 2012; Ortega et al., 2015), a wide number of process-related barriers (i.e. the dominant position of the certain professional groups that impedes the creation of constructive dialogue) seem to reduce EIA effectiveness in the emerging, more communicative planning context (Blicharska et al., 2011; Hildén et al., 2004; Lidskog and Soneryd, 2000; Mayer et al., 2012; Miralles-Guasch et al., 2014; Pinho et al., 2007; Sánchez and Morrison-Saunders, 2011; Soria-Lara, 2012; Tomlinson, 2011; Weston, 2000; Zhang et al., 2013; Zhou et al., 2011). In a recent survey where Spanish practitioners (transport planners and EIA developers) were asked to identify

the main process-related problems of EIA in transport planning, it was revealed that the integration of different sources and types of knowledge during the earlier phases of EIA was the biggest process-related barrier, highlighting the unstructured stakeholder involvement and ineffective public participation as the main culprits (Soria-Lara et al., 2015). The authors of this study concluded that a shift in how EIA actors are involved in the earlier phases of EIA in transport planning is strongly needed: “many times EIA implementation in transport planning is a set of disconnected steps where experts and stakeholders participate separately and feedbacks among them become nil” (Soria-Lara et al., 2015 p. 102). If this barrier persists the social value of projects will be inadequately addressed by the assessment, and as a result the assessment may become biased or subverted, with certain forms of knowledge unduly rising to the foreground (Richardson, 2005 p. 352). On the other hand, if this barrier is overcome EIA could recover its credibility as a collective process where different actors can deliberate and exchange their views on the goals and impacts of the proposed projects (Saarikoski, 2000 p. 682).

The abovementioned issues particularly affect the so-called scoping phase, the process of identifying the content and extent of the EIA. Affected by legal considerations and political systems, the scoping phase is usually completed in a relatively short period of time using existing information and consultations with stakeholders and the public. Its main objective is to provide all relevant information on the impacts to be assessed, system boundaries undertaken, potential mitigating and enhancing measures for project alternatives as well as recommendations for particular assessment methods (Lee, 2006). Generally, the considered participant checklist during the scoping phase includes environmental authorities (regional and local authorities, authorities responsible for air quality, nature and landscape preservation, spatial planning, etc.); other interested parties (sectorial governments, natural resource user groups like walkers, tourists, etc.) and the general public (landowners and residents, elected representatives and community figures, etc.). For this reason, interventions and mechanisms that integrate knowledge from multiple perspectives and stakeholders together during the scoping phase seem to be a crucial aspect.

Accordingly, this paper presents a systematic literature review centred on the following research question: *Which are the most relevant interventions and mechanisms for improving the integration of knowledge during the scoping phase of EIA in transport planning?* The review is focused on distilling a set of specific interventions and mechanisms for the particular context of transport planning, based on experiences from EIA practice, focusing on the EIA process rather than on its final product (the Environmental Impact Statement). The review is structured along the CIMO logic: *in a problematic Context (C), use this Intervention type (I) to invoke these generative Mechanisms (M), to deliver these Outcomes (O)* (Denyer

et al., 2008 p. 395-396). In our case, the “context” (C) is the set of factors affecting to the scoping phase of EIA, while the expected “outcomes” (O) is the improvement of knowledge integration during the scoping phase of EIA in transport planning. As indicated by the previous research question, the identification of “interventions” (I) and “mechanisms” (M) that bridge the “context” (C) and the expected “outcomes” (O) will be the main aim of the research.

Section 2 presents the research design for the literature review. This provides the basis for the discussion in Section 3 of the most relevant interventions and mechanisms proposed in the literature to overcome the described shortcomings. In Section 4 these interventions and mechanisms are distilled into an approach for improving knowledge integration between the various agents during the EIA scoping phase in transport planning.

2. Research method

The main objective of this paper is presenting a systematic literature review centred on identifying relevant interventions and mechanisms for improving the integration of knowledge during the scoping phase of EIA in transport planning. In order to achieve this objective, we reviewed relevant academic articles of EIA practice by conducting 5 searches of the Scopus database during December 2015, resulting in a total of 296 articles without double counting (see table 1 for keywords and results). The literature selection used two types of filters. First, based on the abstracts, articles focused on the integration of knowledge during the scoping phase of EIA were selected, resulting in a total of 65 articles. Second, these 65 articles were read in-depth, selecting those articles that provided specific interventions and mechanisms to improve knowledge integration, resulting in a total of 15 articles (see Appendixes A and B). The in-depth analyses were conducted by using a qualitative methodology. The identification of the 15 relevant articles was made by means of Content Analysis (Bryman, 2008). Next, the CIMO-logic was used to systematically process the information contained in these articles following according to the main objective of the research.

The CIMO logic was translated to the domain of planning research by Straatemeier et al. (2010). It establishes that *in a problematic Context (C), use this Intervention type (I) to invoke these generative Mechanisms (M), to deliver these Outcomes (O)* (Denyer et al., 2008 p. 395-396), offering a useful framework to identify and assess the practical potential of interventions and mechanisms suggested in the literature. In this research, *Context (C)* includes the surrounding factors (the external and internal environment) and the characteristics of the human actors who participate in the scoping phase. Specifically, it concerns the institutional embedding of the EIA scoping phase in the implementation of a

new transport infrastructure (e.g. legal requirements, distribution of responsibilities, cultural attitudes) and the characteristics of the participating public and private organizations, professionals, users, citizens, and others. *Interventions (I)* refers to the specific methods or artefacts that influence the behaviour, perceptions and interactions of the participating actors, for example, creating a dialogue space supported by multi-criteria decision-making techniques. *Mechanisms (M)* are the processes invoked by the interventions. For instance, this might entail the articulation of the participating actors' values through multi-criteria decision-making techniques. Lastly, *Outcomes (O)* are the expected effects, which in our case refers to improving knowledge integration between the involved agents during the EIA scoping phase in the transport planning field.

Table 1. Search key words and main characteristics

3. Review of interventions and mechanisms for improving knowledge integration

Most of the 65 articles analysed in-depth focused on describing problems and proposing general recommendations for stakeholder involvement and public participation during the EIA process (e.g., all interested groups should be included in the assessment; the participatory process should be implemented during earlier assessment phases; etc.). However, only 15 articles contained relevant interventions and mechanisms to overcome the cited barrier, while 10 of these 15 articles tested their proposed interventions in real-life practice or in controlled experiments. This content focus seems to reflect that EIA scholars are more focused on understanding problems than on identifying and testing applicable solutions.

The remainder of this section describes the main uncovered trends in those 15 articles according to CIMO logic and explores to which extent the interventions and mechanisms: (i) address the specific subject of our research, i.e. knowledge integration in the scoping phase of EIA (specificity); (ii) have been tested in real-life practice or in controlled experiments (testing conditions); and (iii) are applicable in our practice of interest, EIA in transport planning (applicability). The CIMO logic of the revised publications is systematically summarized in table 2.

Looking at *specificity*, most articles addressed the subject of our research (knowledge integration during the scoping phase of EIA) with the exception of the studies conducted by Higgs et al. (2008); Ramanathan (2001); Sutheerawatthana and Minato (2010). Nevertheless, these 3 publications covered assessment methods in environmental decision-making processes under conditions similar to the EIA scoping phase. A broad range of

contexts was covered by the 13 publications, such as water resources planning, transport planning, transport infrastructure development, water management, natural hazard planning, industrial location planning, etc.

The *testing conditions* of the proposed interventions and mechanisms was the second issue to be analysed. Specifically, about three-quarters of the publications were tested in real-life situations within their specific contexts. Non-intervention was tested using controlled experiments and in 3 publications (Higgs et al., 2008; Lawrence, 2007; Liu et al., 2013) the proposed interventions were never tested.

The *applicability* of interventions and mechanisms was the third issue. Due to the main process barrier of the scoping phase of EIA in transport planning, integrating knowledge from multiple perspectives and stakeholders together in an effective way for decision-making, the applicability of interventions and mechanisms was assessed according to (i) how interventions and mechanisms provided meaningful information for decision-makers, and (ii) whether they were sufficiently open and flexible to be adapted to the transport planning sector. In processing the 13 publications, all interventions and mechanisms to improve knowledge integration in EIA were first identified and then grouped, based on similarities in their reasoning. Then, three applicability directions were identified: (i) finding a balance between too much and too little information and complexity; (ii) using the EIA to lead a learning process between the involved agents, and (iii) adapting the participatory process to the EIA characteristics in the context of its application, in our case the transport planning field.

A total of 5 publications highlighted that the effectiveness in providing meaningful information to decision-makers from participatory processes in EIA depended on finding a balance between too much and too little information and complexity (see Balasubramaniam and Voulvoulis, 2005; Bojórquez-Tapia et al., 2002; Kolkman et al., 2007; Sainath and Rajan, 2015; Wood et al., 2007 in table 2). First, Balasubramaniam and Voulvoulis (2005); Sainath and Rajan (2015) implemented an intervention focused on creating a space where stakeholders and the public were asked to indicate their preferences and views on project alternatives. While Balasubramaniam and Voulvoulis (2005) particularly supported such interventions as Multi-criteria Decision-Making (MCDM) techniques (e.g. multi-attribute utility and analytic hierarchy process) operationalized through individual questionnaires, Sainath and Rajan (2015) analysed proceedings of 100 public hearings recorded in the Indian state of Gujarat. Both interventions seemed to be flexible and adaptable to the specific context of our research. However, the time required during the participatory process and the huge amount of needed information limits the applicability of such interventions in the specific

context of EIA in transport planning, taking into consideration the broad diversity of agents permanently involved in its decision-making process. Second, the extensive complexity of the proposed interventions, a negative factor for applicability, was also noted in the publications authored by Bojórquez-Tapia et al. (2002), Kolkman et al. (2007) and Wood et al. (2007). In the cases of Bojórquez-Tapia et al. (2002) and Wood et al. (2007), they implemented interventions based on creating spaces where the participants' views were translated into meaningful information for decision-making by using fuzzy algorithms. Kolkman et al. (2007) implemented a specific intervention based on a mental model to construct individual perspectives on the impact of ring-dyke 53 in the Netherlands. While the cited interventions seemed sufficiently open to be adapted to the context of transport planning, their original implementation was a very complex and time-consuming process. In addition, specialized experts would be needed to conduct such interventions, severely limiting their exportability potential.

Using the EIA to lead a learning process between participants was another identified direction for improving knowledge integration during its scoping phase, specifically highlighted by Karjalainen et al. (2013); Kennedy and Ross (1992); Liu et al. (2013) and Saarikoski (2000). In general terms, their interventions are supported by the creation of dialogue spaces of different nature. Dialogue spaces means spaces (physically and figuratively) where EIA actors can give their views and discuss on project alternatives and impacts in different ways (i) interacting bilaterally with decision-makers; or (ii) sharing and discussing their views together. Using interventions that focused on creating a type of dialogue spaces supported by MCDM techniques and in-depth interviews with stakeholders, Karjalainen et al. (2013) and Liu et al. (2013) triggered mechanisms where stakeholders felt safe and encouraged to participate. In both cases, this process facilitated the establishment of the impact framework of EIA. However, the major hindrance was that the triggered mechanisms also limited a mutual learning between participants due to the process was not dealt with as one shared dialogue space where participants can simultaneously interact together, but bilateral dialogues between participants and decision-makers were created. In this sense, Kennedy and Ross (1992) and Saarikoski (2000) showed guiding ideas for overcoming the cited limitation using interventions that focused on creating multilateral dialogue spaces where participants could openly share and discuss their views. The implementation of such interventions evoked free speech mechanisms, whereby stakeholders had the opportunity to get know each other, to share knowledge and to adapt their discourse with the inputs from the other participants. EIA developers and stakeholders were able to better understand each other's standpoints, increasing opportunities for win-win solutions. Nevertheless, certain improvements should be considered to translate such

interventions and mechanisms into EIA in transport planning contexts. In particular, the authors highlighted that the biggest shortcoming was that some community leaders dominated the discussion, thus marginalizing the contribution of others. This outcome suggests that collaborative EIA should include clearer rules for participation as well as an external mediator who can safeguard the input of all involved actors.

Finally, the adaptation of the participatory process to EIA characteristics in the context of application was the last trend identified during the review, affecting the applicability of the proposed interventions in our practice of interest. Adaptation was mainly observed in the publications authored by Higgs et al. (2008); Lawrence (2007); Mwenda et al., (2013) Ramanathan 2001; Richardson et al. 1998; and Sutheerawatthana and Minato (2010). First, guiding the participatory process towards tangible assessment objectives seemed to be a key issue for exporting the revised interventions to the transport planning process, as discussed by Sutheerawatthana and Minato (2010). To improve the identification of the causes of impacts, Sutheerawatthana and Minato (2010) used interventions focused on bilateral meetings between stakeholder groups and EIA developers. Specifically, a deliberative model guided by impact description pathways was used during the participatory process. The mechanisms focused on identifying common views on the causes behind the observed impacts. Second, the use of methods that combine qualitative and quantitative information was another relevant issue for adapting the participatory process to EIA specifics. In particular, Lawrence (2007) proposed interventions based on creating a dialogue space to establish impact thresholds using a combinations of qualitative and quantitative methodologies: (i) a technical approach (legal thresholds, etc.); (ii) a collaborative approach (forums and working sessions with stakeholders); (iii) a judgment-reasoned approach (integrating technical and communicative knowledge and combining them with perspectives, desired scenarios, etc.). Mwenda et al., (2013) used dialogue modes based on spatial information (e.g. satellite images, spatial models, photographs, diagrams, visualizations and figures) to facilitate the understanding of potential impacts during the public participation process in a case study in Kenya. Third and last, guiding the process towards project alternatives assessment seemed to be also crucial for the effectiveness of the proposed interventions. Ramanathan (2001) used interventions based on creating dialogue spaces supported by MCDM techniques to prioritize environmental management actions and to allocate the available budget. With this trigger stakeholders and the public felt encouraged to participate and to indicate their preferences. In addition, the use of MCDM techniques to process participant views facilitated the articulation of the stakeholders' values in a systematic and ordered way.

Table 2. Summary of revised interventions and mechanisms from EIA practice

4. An approach for integrating knowledge in the EIA scoping phase of transport planning

With the aim of identifying what interventions worked or did not work in EIA practice, this section uses the literature review to distil specific interventions and mechanisms for the particular context of transport planning.

Table 3. Suggestions for improving knowledge integration during the EIA scoping phase

With the suggested improvements from table 3, we have structured and translated the identified insights into a specific CIMO approach for the context of the scoping phase of EIA in transport planning. The approach is presented through three sequential interventions and the associated trigger mechanisms (table 4). *Intervention 1*: creating specific rules for participation to find a balance between too much and too little information and complexity. To do this, in a first step mediators would meet face-to-face with EIA-developers and decision-makers; *Interventions 2 and 3*: implemented simultaneously and supported by the rules for participation, mediators would promote the use of EIA to lead a learning process by creating a multilateral dialogue space (intervention 2) and using dialogue modes to adapt the participatory process to the transport planning sector (intervention 3). In the remainder of this section, a more in-depth description of each interventions will be made.

In order to find the balance between too much and too little information and complexity, the first proposed intervention is *the creation of rules for participation and processing of information through face-to-face meetings between mediators, EIA developers and decision-makers*. The intervention triggers the mechanisms through which mediators and decision-makers have the opportunity to get to know each other and build relationships, in turn enabling them to better define their main knowledge needs and how the new information should be processed in a meaningful way for decision-making. In addition, the rules for participation will facilitate that the acquired knowledge from stakeholders will be processed in a systematic and ordered way, thus reducing the complexity of the process. This is due to the fact that such rules for the participation and processing of information, mediators, EIA developers and decision-makers will determine what issues will be addressed; what information gaps should be covered; what types of conflicts should be prioritized to be discussed and how; the duration of the participatory process; as well as how to codify the information provided by stakeholders and the public. The number of participants will be also defined, and while the number of participants should be limited, all involved parties should be represented. In case of physical or psychological disabilities to get to the face-to-face

meetings, those can be virtual meetings by internet. The most relevant issue is that decision-makers and EIA developers have the opportunity to get to know each other before the scoping phase, as well as harmonize viewpoints.

In order to use the EIA to lead a learning process, the second intervention recommends the creation of a multilateral participation space, where EIA developers and stakeholders can meet face-to-face and share their views about the extent and the scope of the EIA. The main aim is to trigger multilateral dialogue and free speech mechanisms between participants. Stakeholders will have the opportunity to get know each other and build relationships, which will enable them to better assess how others may react in future interactions. In addition, this permits to modulate their views and interpretations by learning from other participants during the process. The mediator should be an experienced person in the field but without particular stakes in the assessed project, striking a balance between her/his knowledge of the project and the need to maintain enough distance to stimulate critical discussion and analysis. The mediator should have a central position in ensuring that no participant/group takes a dominant role in the discussion. According to Healey (1996), the mediator, supported by the rules for participation and processing of information, should focus on three relevant issues during the participatory process: (i) *style*, allotting equivalent speaking time to each party; (ii) *language*, finding a balance between scientific/technical, environmental, economic and other terminologies; (iii) *respect*: giving a voice to all participants.

In order to adapt the participatory process to the specific EIA characteristics in transport planning, the third proposed intervention is *using dialogue modes (simulations, story board, role playing, etc.) about specific and tangible objectives, such as impacts and the treatment of transport project alternatives*. This would trigger the mechanisms by which stakeholders can share their views on strengths/weakness and the solutions of transport project alternatives and associated impacts, as well as they can provide solutions for considered alternatives. The intervention would permit the adaptation of the participatory process to EIA characteristics, illustrating arguments, specific problems and other aspects. To achieve this goal, it is important to guide the process towards tangible EIA objectives in transport planning (thresholds, cause–effect logic, etc.)

Table 4. Summary of distilled interventions and mechanisms

5. Conclusions

The paper sought to find the most relevant interventions and mechanisms for improving the integration of knowledge during the scoping phase of EIA in transport planning. To address

this challenge, a literature review of relevant interventions and mechanisms in the field of EIA practice was conducted, and the findings were reinterpreted following the CIMO logic (Denyer et al., 2008). The obtained results showed that most of identified publications focused on describing and understanding knowledge-integration problems in EIA. However, only a limited number (15 publications) paid sufficient attention to the elaboration of solutions that are applicable and testable in practice. Among these 15 analysed articles, most dealt with the specific subject of our research (knowledge integration during the EIA scoping phase) and also had applied and tested solutions in real-life situations.

The analysis of the applicability of interventions and mechanisms found in the reviewed articles provided additional insight into potential pathways for improving knowledge integration in the scoping phase of EIA. Three specific suggestions for improvement were highlighted: (i) finding a balance between too much and too little information and complexity; (ii) using the EIA to lead a learning process; (iii) adapting participatory processes to specific EIA characteristics in its application context. Taking them into consideration, a specific approach for the scoping phase of EIA is distilled. Three sequential interventions and triggered mechanisms are proposed. The first intervention should be implemented in a first step and the interventions 2 and 3 should be simultaneously implemented in a second step. The first intervention is the *creation of rules for participation and processing of information through face-to-face meetings between mediators, EIA developers and decision-makers*. This would articulate the process in an ordered way, avoiding the problem of too much information and over complexity, while acknowledging the diversity of views and issues. The second proposed intervention was the *creation of a multilateral dialogue space facilitated by a mediator*, which makes it possible to employ the EIA as a learning process among participants. The third and last intervention was *the use of dialogue modes about specific and tangible objectives*, such as impacts and the treatment of transport project alternatives. This would facilitate the adaptation of the participatory process to the specific EIA characteristics in transport planning.

This literature review has evidenced that much of the literature focuses on describing the problem of knowledge integration during the scoping phase of EIA, however specific solutions which can be tested in practice or under controlled experiments are not easily found. In order to provide these, by structuring and integrating the evidence in the literature, we have designed three sequential interventions which can be tested in practice paying attention to the social and legal context of the testing country. We can assume the proposed interventions and mechanisms as obvious issues, nevertheless they are not common practice during the scoping phase of EIA in transport planning limiting the capacity to achieve sustainable outcomes (Soria-Lara et al., 2015). Whatever their theoretical promises,

the effectiveness of the proposed interventions should be tested in actual transport planning practice, examining whether they function well (or not) and why. For this reason, additional research could focus on observing and reflecting on the effectiveness of the presented interventions in 'experiential' studies, representing "close-to-real-life" situations (Straatemeier et al., 2010; Soria-Lara., 2016), as well as on evaluating past EIA experiences (ex-post case studies) varying on input (interventions) and/or output (outcomes). Furthermore, testing the proposed interventions in different geographical and institutional contexts would help harness more insight on the contextual sensitivity of the interventions and trigger mechanisms.

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Table 1. Search key words and main characteristics

SEARCHES KEYWORDS	FIRST FILTER (keywords, abstract)			SECOND FILTER (innovative interventions and mechanisms)	
	Total Documents	Documents (without double counting)	Topics	Documents (without double counting)	Topics
EIA; stakeholders	103	103	<ul style="list-style-type: none"> Most of articles focused on exploring problems with stakeholder involvement during EIA (approx. 70%). A reduced group of publications aimed to reflect on the advantages of stakeholder involvement during EIA and potential solutions (approx. 30%). 	31	A total of 15 articles aimed at proposing specific interventions and mechanisms to improve the integration of knowledge during the scoping phase of EIA in transport planning
EIA; public participation	120	101	<ul style="list-style-type: none"> Most of articles covered the effectiveness problems of public participation in EIA practice (approx. 50%). A second group was composed of descriptive articles about how public participation was implemented in EIA in the context of a given country (approx. 25%). A third group of articles focused on describing the potential role of public participation in EIA, including recommendations and proposed solutions (approx. 25%). 	27	
EIA; collaborative	46	27	<ul style="list-style-type: none"> Most of articles focused on general recommendations for collaborative approaches during the EIA process (approx. 85%). A relevant number of articles was orientated towards describing the need for moving away from rational to collaborative approaches, including some specific solutions (approx. 15%). 	4	
EIA; knowledge integration	17	9	<ul style="list-style-type: none"> All articles focused mainly on identifying and highlighting potential integration knowledge problems during EIA implementation. 	0	
EIA; Scoping	56	39	<ul style="list-style-type: none"> Approx. 10% of articles aimed at exploring potential solutions for the integration of knowledge during EIA practice. 	4	

(Source: SCOPUS database)

Table 2. Summary of revised interventions and mechanisms from EIA practice

AUTHORS	CIMO LOGIC						
	CONTEXT (C) <i>"In this problematic Context..."</i>		INTERVENTIONS (I) AND MECHANISMS (M) <i>"...use this Intervention type to invoke these generative Mechanisms..."</i>			OUTCOMES (O) <i>"...to deliver these Outcomes..."</i>	
	Description	Specificity	Interventions	Mechanisms	Applicability	Description	Testing
Balasubramaniam and Voulvoulis (2005)	Earlier stages of EIA on waste management and water resources planning: selection of project alternatives; analysis of objectives and assessment criteria	High: It specifically covers knowledge integration during the scoping phase of EIA.	A space was created where stakeholders and the public were asked to indicate their preferences and views on project alternatives. The intervention was additionally supported by Multi-criteria Decision-Making techniques (MCDM).	Stakeholders and the public felt encouraged to participate and to indicate their preferences. In addition, the use of MCDM techniques to process participant views permitted articulation of stakeholder values on project alternatives in a systematic and ordered way.	The fact that the available information for decision-makers was systematically ordered was seen as positive. However, the process was very time consuming and required too much information to ensure significant input from participants.	Improving the quality of the information and interpretations available to decision-makers, incorporating a diversity of standpoints and social concerns in a reasoned way; prioritizing the social value of project alternatives and their environmental impacts	The intervention was tested in practice using several waste management and water resources plans during the 90s.
Bojórquez-Tapia et al. (2002)	The definition of the scope and extent of EIA to predict impacts on natural habitats of the highway project called "La venta-Colegio Militar"	High: It specifically covers knowledge integration during the scoping phase of EIA.	A space was created to manage the use of macro-knowledge to predict impacts. This included the incorporation and confrontation of standpoints from experts and stakeholders in a systematic and ordered way by using MCDM techniques and fuzzy algorithms	Fuzzy algorithms activated mechanisms by which the judgments of stakeholders and experts were operationalized in maps of impacts on vegetation, geomorphology, soil, etc. Such maps provided decision-makers readable and clearer information about the social concerns of potential project impacts.	While the interventions were specifically applied on the transport planning sector, the process was highly complex needing specialized experts in fuzzy decision-making applications. It was also very time consuming and required too much information.	The integration of subjective and conflicting judgments from experts and stakeholders to improve the decision-makers' understanding of potential impacts.	The intervention was tested in the highway project called "La venta-Colegio Militar" in Mexico during the 1990s.
Higgs et al. (2008)	Involvement of stakeholders and the public in the controversial context of wind farms planning, where the groups of actors usually disagreed about the social and economic benefits of wind farms and their potential impacts	Medium: It focuses on knowledge integration in environmental decision-making, but not specifically in the scoping phase of EIA.	A space was created where stakeholders and the public were encouraged to indicate their preferences on the benefits and impacts of wind farms, including an assessment on the visual impact on landscape. Based on 3D animation, dialogue modes were used to facilitate the stakeholders' understanding of the	Stakeholders and the public felt encouraged to participate. On the one hand, the use of 3D animations allowed participants to increment their knowledge about wind farm projects. On the other hand, the use of MCDM facilitated the articulation of the stakeholders' values in a systematic and ordered way.	While the combination of 3D animations and MCMD techniques seems to be promising in the context of transport planning, more practical evidence is needed on their effectiveness in real-life and controlled situations.	Improving the outcomes of traditional participatory process in environmental decision-making, enhancing participant knowledge about wind farm projects and providing decision-makers meaningful information on the potential impacts and social concerns.	Interventions were never tested in practice.

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	CONTEXT (C) <i>"In this problematic Context..."</i>		INTERVENTIONS (I) AND MECHANISMS (M) <i>"...use this Intervention type to invoke these generative Mechanisms..."</i>			OUTCOMES (O) <i>"...to deliver these Outcomes..."</i>	
	Description	Specificity	Interventions	Mechanisms	Applicability	Description	Testing
			impacts and wind-farm-alternatives. The interventions were also supported by MDMC techniques.				
Karjalainen et al. (2013)	The estimation of the ecosystem service capacity in earlier stages of EIA as a complementary way to determine its scope and objectives	High: It specifically covers knowledge integration during the scoping phase of EIA.	The first intervention was to create a dialogue space between stakeholders and EIA-developers, discussing about ecosystem service capacity issues. The intervention was also supported by MCDM techniques.	Stakeholders felt encouraged to participate and discuss with EIA developers. With bilateral discussions the participants did not feel attacked by project proposals. Questionnaires based on MCDM summarized their views and captured their preferences in an ordered way.	Both bilateral dialogues and questionnaires limited the capacity of the stakeholders to learn from other participants and to modulate their discourse during the process. This approach, however, reduced the capacity to achieve collective agreements during the process.	Defining more realistically the scope and extent of the environmental assessment, by incorporating the interpretations and experiences of the involved actors for the estimation of the ecosystem service capacity	The intervention was tested in the context of Finland in 2012.
Kennedy and Ross (1992)	The application of EIA on natural resources, whereby institutions tried to increment the social acceptability of interventions	High: It specifically covers knowledge integration during the scoping phase of EIA.	A multilateral dialogue space (comprehensive working sessions) was created where stakeholders and EIA developers discussed face-to-face	Free speech mechanisms were activated, whereby stakeholders had the opportunity to get know each other, to share knowledge and to modulate their discourse hearing opinions from other participants. EIA-developers and stakeholders better understood each other's standpoints, increasing opportunities for win-win solutions.	Using free speech mechanism was seen as positive. Stakeholders could freely discuss and learn from other participants. Nevertheless establishing participatory rules, controlling the number of participant and using systematic method to conduct the working sessions were also seen to improve the effectiveness of this type of intervention	Leading to EIA process as a tool to support learning, by incorporating views and interpretations from stakeholders and the public. It provided decision-makers meaningful information about potential impacts and the management of these impacts.	The intervention and mechanisms were tested in several study-cases in the US during the early 1990s.
Kolkman et al. (2007)	EIA procedure for the improvement of ring-dyke 53 in the Netherlands	High: It specifically covers knowledge integration during the scoping phase of EIA.	Defining assessment frames consisting of perspectives and mental models, obtained through semi-structured interviews and focus groups	Experts and interested groups felt encouraged to participate during the process. The use of mental models permitted the articulation of the participants' values in a systematic and ordered way.	Its applicability is not clear because the process is very complex and has low reproducibility in other contexts	Complementing the information and interpretations available to decision-makers, by revealing and juxtaposing the different views of decision-makers, experts and special interest	The intervention was tested in the Netherlands.

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	Description	Specificity	Interventions	Mechanisms	Applicability	Description	Testing
						groups	
Lawrence (2007)	A broader context for EIA application (natural resources, habitats, transport, etc.)	High: It specifically covers knowledge integration during the scoping phase of EIA.	A space would be created where stakeholders and the public are asked to participate. It would be based on a combination of three impacts identification methodologies: (i) a technical approach, (ii) a collaborative approach, and (iii) a judgment reasoned approach.	Stakeholders and the public would feel encouraged to participate. They would combine their views with technical approaches to determine impacts. Free speech and sharing knowledge would be activated during the process.	The capacity of the proposed interventions to combine quantitative and qualitative information was seen as positive. Interventions try to avoid a complex process by guiding stakeholder participation towards tangible environmental issues (thresholds, desired scenarios, desired perspectives, etc.).	Improving the definition of impacts, providing decision-makers a wider spectrum of potential impacts according to technical requirements and social interpretations	Interventions were never tested.
Liu et al. (2013)	Earlier EIA stages in the context of seawater desalination projects	High: It specifically covers knowledge integration during the scoping phase of EIA.	The first intervention was the creation of a space for dialogue between stakeholders and EIA developers. The second intervention was conducting in-depth interviews with stakeholders to investigate their respective standpoints.	In-depth interviews would encourage stakeholders to participate. They would feel safer to discuss with EIA developers the suggested impact framework for the assessment.	Participants can show the motivation of their interpretations and add some remarks they consider relevant in decision-making. However, such interventions do not completely trigger multilateral dialogue mechanisms reducing the capacity of the interaction between each stakeholder and each other.	Determining the impact framework of EIA incorporating the opinion of a wider spectrum of stakeholders	Interventions were never tested.
Mwenda et al., (2013)	The EIA application on a petrol station.	High: It specifically covers knowledge integration during the scoping phase of EIA.	The intervention consisted of applying dialogue modes based on spatial information (satellite images, spatial models, photographs, diagrams, visualizations and figures) to facilitate the process of public participation	Stakeholders and the public felt encouraged to participate. They contextualized their views on potential impacts according to the spatial information used. Free speech and sharing knowledge was activated during the process.	The intervention was very successful. Improvements are related to following a more systematic method to present the spatial information, as well as incorporating a mediator who can explain details related to spatial information given to participants.	Improving and contextualizing the potential impacts of projects	The intervention was tested in the Eastern Province of Kenya , which borders the capital city of Nairobi

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	CONTEXT (C) <i>"In this problematic Context..."</i>		INTERVENTIONS (I) AND MECHANISMS (M) <i>"...use this Intervention type to invoke these generative Mechanisms..."</i>			OUTCOMES (O) <i>"...to deliver these Outcomes..."</i>	
	Description	Specificity	Interventions	Mechanisms	Applicability	Description	Testing
Ramanathan (2001)	The elaboration of an environmental management plan for an industrially backward area in Maharashtra (India)	Medium: It focuses on knowledge integration in environmental decision-making, but not specifically in the EIA scoping phase.	A space was created where stakeholders and the public were asked to indicate their preferences and views on project alternatives and the budget available. The intervention was additionally supported by MCDM.	Stakeholders and the public felt encouraged to participate and indicate their preferences. Also, using MCDM to process participant views allowed articulation of stakeholder values in a systematic and ordered way.	Proposed interventions were clearly guided towards prioritizing alternatives and budget availability. A limiting issue is that the proposed interventions reduce the possibility of interaction between participants during the process.	Providing decision-makers meaningful information from stakeholders and the public to prioritize environmental management actions and to allocate the budget available	The intervention was tested in the area of Maharashtra in India during the 1990s.
Richardson et al. (1998)	The EIA of the development of a recreational park in the Czech Republic	High: It specifically covers knowledge integration during the scoping phase of EIA.	This intervention was the creation of a dialogue space where stakeholders, EIA developers and NGOs met face-to-face.	Participants and EIA-developers had the opportunity to know each other and built relationships. As a consequence, they better understood the standpoints from each other.	The face-to-face meetings activated free speech and multilateral dialogue mechanisms between participants. However, the process was not sufficiently guided towards tangible objectives, thus generating dispersed and unclear information.	Provide decision-makers information about the main public concerns on the impacts of the recreational park, incorporating such interpretations during the assessment process.	The intervention was tested during the development of a recreational park at Rajchertov in the Czech Republic during the 1990s.
Saarikoski (2000)	The definition of the scope and extent of the EIA process in the waste management context	High: It specifically covers knowledge integration during the scoping phase of EIA.	First, a dialogue space was created where stakeholders and EIA developers met face-to-face. Second, they shared their knowledge with each other during a set of working sessions. Third and last, participants discussed their views and preferences.	Free speech mechanisms were activated, whereby stakeholders had the opportunity to get know each other, to share knowledge and to modulate their discourse hearing the opinions of others. EIA developers and stakeholders understood each other's standpoints, enhancing the opportunities for win-win solutions.	Interventions were very successful. Improvements are related to following a more systematic method of conducting workshops towards tangible assessment objectives as well as incorporating an external mediator during face-to-face meetings.	Leading EIA process as a tool to support learning, by incorporating views and interpretations from stakeholders and the public. It provided decision-makers meaningful information about impacts and social concerns.	The described interventions and the triggered mechanisms were tested in real practice in six municipalities in Finland during the 1990s.
Sainath and Rajan, 2015	The assessment of public investments on 5 strategic areas with high environmental impacts.	High: It specifically covers knowledge integration during the scoping phase of EIA.	Public Hearings (PH) are implemented by the EIA authority. During PH, every person	Stakeholders and the public felt encouraged to participate and to indicate their preferences.	The fact that every person can participate was seen as positive. However, the process was very time consuming and required	Incorporating a diversity of standpoints and social concerns	The intervention was tested in the Indian state of Gujarat

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	CONTEXT (C) <i>"In this problematic Context..."</i>		INTERVENTIONS (I) AND MECHANISMS (M) <i>"...use this Intervention type to invoke these generative Mechanisms..."</i>			OUTCOMES (O) <i>"...to deliver these Outcomes..."</i>	
	Description	Specificity	Interventions	Mechanisms	Applicability	Description	Testing
			present at the venue is granted the opportunity to seek information or clarifications on the project from the proponent. All these are recorded and forwarded to the proponent, who in turn will make appropriate changes to the EIA addressing the issues raised.	The views of participants permitted articulation of the public values on public investments on specific projects	much information to ensure significant input from participants.		
Sutheerawatthana and Minato (2010)	The management of the environmental degradation resulting from the use of the road system	Medium: It focuses on knowledge integration in environmental decision-making, but not specifically in the scoping phase of EIA.	A dialogue space where stakeholders could identify the cause and effect of impact was created. Specifically, a deliberative model guided by impact description pathways supported the participatory process.	Participants felt encouraged to determine the cause and effect of potential impacts. Decision-makers could easily identify common views/patterns about the causes behind the impacts.	The deliberative model was based on tangible EIA objectives (cause–effect logic). This increased the applicability of such interventions and mechanisms in other contexts.	Providing decision-makers additional information from stakeholders and the public about the identification of the causes and effects of impacts	The proposed interventions and mechanisms were tested in several study cases in Japan in the 2000s.
Wood et al. (2007)	Earlier stages of EIA in the context of wind farms	High: It specifically covers knowledge integration during the scoping phase of EIA.	A space was created where stakeholders and the public were encouraged to indicate their preferences and concerns on impacts from wind farm projects. Fuzzy impact methods supported this intervention.	Experts and interested groups felt encouraged to participate during the process. The use of fuzzy impact methods facilitated the articulation of the participants' views in a systematic and ordered way.	First, the combination of qualitative and quantitative information is a highlighted issue to be considered in the context of transport planning. Second, the process was complex, very time consuming and required too much information.	Improving the decision-makers' understanding of impact effects by the incorporation the several visions articulated by stakeholders	The proposed interventions were tested in a case study in the UK in the 2000s.

Table 3. Suggestions for improving knowledge integration during the EIA scoping phase

<i>Issues</i>	<i>Suggested improvements</i>
<p>1. Finding a balance between too much and too little information and complexity</p> <p>(Balasubramaniam and Voulvoulis, 2005; Bojórquez-Tapia et al, 2002; Kolkman et al., 2007; Sainath and Rajan, 2015; Wood et al., 2007)</p>	<ul style="list-style-type: none"> • Providing information in an ordered way, easily accessible for interpretation by decision-makers • Less time-intensive participatory processes • Limiting the need for specialized expert inputs • The methods should be easily adaptable to different contexts
<p>2. Using the EIA to lead a learning process</p> <p>(Karjalainen et al., 2013; Kennedy and Ross , 1992; Liu et al., 2013; Saarikoski, 2000)</p>	<ul style="list-style-type: none"> • Stakeholders, the public, decision-makers should learn from each other during participatory processes • Creating spaces where participants can meet face-to-face • Multilateral dialogues should be activated between participants • The number of participants should be limited • Using systematic methods in processing information • An external mediator should be used to facilitated discussion and safeguard participant inputs
<p>3. Adapting participatory processes to the specific EIA characteristics in transport planning</p> <p>(Higgs et al., 2008; Lawrence, 2007; Mwenda et al., (2013); Ramanathan, 2001; Richardson et al., 1998; Sutheerawatthana and Minato, 2010; Wood et al., 2007)</p>	<ul style="list-style-type: none"> • Combining qualitative and quantitative data • Guiding the process with tangible objectives (thresholds, cause–effect logic, etc.) • Orientated towards prioritizing project alternatives

Table 4. Summary of distilled interventions and mechanisms

CIMO framework				
Context (C)	Intervention (I)	Mechanism (M)	Outcomes (O)	
			Specific	General
In the context of the scoping phase of EIA in transport planning...	...create rules for participation and processing of information through face-to-face meetings between mediators, EIA developers and decision-makers...	<p>...to invoke the mechanisms by which:</p> <ul style="list-style-type: none"> • Mediators, EIA developers and decision-makers have the opportunity to get to know each other; • Then, they can better define rules for participation and processing of information; • Such rules will facilitate a process where different views and dimensions are recognized but complexity does not become unmanageable by covering issues such as: which topics will be addressed; which information gaps should be covered; what types of conflicts should be prioritized to be discussed and how; how long should the participatory process take; what is the optimal number of participants? 	...to find a balance between too much and too little information and complexity	...to improve knowledge integration from multiple perspectives and stakeholders
	...create a multilateral dialogue space facilitated by a mediator...	<p>...to invoke the mechanisms by which:</p> <ul style="list-style-type: none"> • Stakeholders and the public feel encouraged to participate; • They feel safer under free speech conditions; • They could build relationships, which can be useful to share detailed information about projects in a process of mutual learning; • Stakeholders can better understand each other's standpoints, increasing opportunities for reaching agreements; • They can change their own views by learning from other participants 	...to use the EIA to lead a learning process	
	...use dialogue modes about specific and tangible objectives, such as impacts and the treatment of transport project alternatives...	<p>...to invoke the mechanisms by which:</p> <ul style="list-style-type: none"> • Stakeholders and the public can focus their participation on the strengths/weakness of project alternatives; • They can provide solutions for the considered alternatives; • They can build their knowledge about project alternatives by illustrating arguments; 3D animations, etc. • They can focus on environmental tangible objectives, such as thresholds, cause-effect logic, etc. 	...to adapt participatory processes to the specific EIA characteristics in transport planning	

