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Inclusion and exclusion of environmental aspects in early-stage planning of transport infrastructure projects: A Swedish case study

Sofia Eckersten, Ulrika Gunnarsson-Östling, and Berit Balfors

Department of Sustainable Development, Environmental Science and Engineering, KTH Royal Institute of Technology, Stockholm, Sweden

ABSTRACT

Sustainable development of the transport system increasingly requires integration of land-use and transport planning practices. To identify and implement measures that maximize synergies between transport, land-use and environmental issues are essential to achieve sustainable outcomes of transport planning. The strategic choice of measures (SCM) approach, applied in early-stage planning of transport infrastructure projects in Sweden, constitutes a platform for collaboration between transport and land-use authorities for better coordination of the different practices in a specific context. This paper aims to analyze SCM processes from a systems perspective to illuminate consequences of system boundaries on how environmental aspects are considered and what aspects are included or excluded. A case study approach is applied, based on observations and document studies of two cases in Stockholm region. The result shows that coordination of transport and land-use planning practice in the SCM process, implies handling of conflicting views of development in the project area. In order to create shared objectives and visions, constructive dialogue and collaboration are two key features. Moreover, it is a challenge to handle all the different problems and measures in the SCM. It is essential to understand synergies as well as how problems and measures in different planning processes relate to each other. A systems perspective as a support when analyzing problems in an SCM can enable the detection of links between transport, land-use and environmental problems. The systems perspective could contribute to the identification of measures with synergetic effects and subsequently the implementation of multi-functional solutions.

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Introduction

Transport and transport infrastructure has substantial environmental, social and economic impact, "such as road accidents, toxic air pollution, local environmental disturbance, land take and congestion" (Gudmundsson et al., 2016, p. 52). Globally, transport authorities are encouraged to maximize synergies in infrastructure planning and development (World Bank, 2017), and previous studies show that there are ways to develop transport infrastructure and simultaneously reduce negative environmental impact (e.g. Soria-Lara et al., 2016). Also, there is an increased awareness that integration of transport and land-use planning is essential for more sustainable outcomes in transport planning (Banister, 2005; Brömmelstroet & Bertolini, 2010). Without integration of transport and land-use planning, inconsistencies among policies are likely to undermine their individual effectiveness and generate policy conflicts (Broaddus, 2020). Integration of transport and land-use planning in early planning stages, for example, goal orientation or visioning, can potentially contribute to the production of shared policy goals, which would promote mutually reinforcing land-use and transport measures (Brömmelstroet & Bertolini, 2010). However, the relationship between these two types of planning is complex (Tornberg & Odhage, 2021), especially in urban areas where there is a strong interdependence between the development of land-use density, diversity and design, and the transport system (Cervero & Kockelman, 1997; Bertolini & Dijst, 2003). In addition, as multiple actors are involved in the practice of planning (Hrelja, 2015) the coordination of transport and land-use planning is challenging. The complexity in planning calls for a systems perspective that describes the dependence of the transport system on other social, economic and environmental systems (Gudmundsson et al., 2016).

Adjustments in transport infrastructure entail land-use changes, since the infrastructure interacts with ecological processes by introducing barriers and disturbance regimes (Fahrig & Rytwinski, 2009), alters hydrological processes with subsequent changes in erosion and sedimentation (Forman et al., 2003), and is one of several biophysical factors driving land-use change (Jaeger et al., 2007). A systems perspective contributes with understanding of relationships between different aspects and the interrelations between aspects within a system.

CONTACT Sofia Eckersten sofiaec@kth.se Department of Sustainable Development, Environmental Science and Engineering, KTH Royal Institute of Technology, Stockholm, Sweden.

As previously mentioned, the transport and land-use planning context is particularly complex. To handle this complexity and enable action in planning, planning projects are arranged (Verweij et al., 2014). From a systems perspective, the planning projects entail certain decisions regarding what is included and excluded from the project. For example, what is denoted as participation boundaries of a project influence which actors are included in the planning process and in what way they are involved (Ashmos et al., 2000), and territorial boundaries concern demarcations regarding the geographical area in focus (Verweij et al., 2014). Thus, planning projects produce boundary issues that have to be coped with and it is common that these issues are underestimated (Fellows & Liu, 2012). This may pose threats to the project's handling of environmental problems (Lexén, 2021). To assist in understanding the interconnection between various systems and across boundaries, different tools are applied in planning (Assmuth & Hildén, 2008; Gudmundsson et al., 2016). These tools can contribute to the identification and assessment of problems and solutions, and also environmental concerns. As in any stage in planning, the early stages have a special character, to which tools and frameworks have to be adjusted. In early planning stages, a wide range of options is still open for discussion; a broad spectrum of potential participants may be involved and the unstructured and diverging needs for knowledge regarding issues at stake complicate the role of tools to support in decision making (Brömmelstroet, 2010).

In this paper, we analyze the integration of environmental aspects in Swedish transport and land-use planning practice. Sweden has a long practice of decentralized land-use planning, whereas transport planning is mostly governed by national authorities. The municipalities are expected to plan and govern where, how and when urban development takes place (Lexén, 2021), whereas the Swedish Transport Administration (STA) is responsible for the development of the transport infrastructure (Swedish Code of Statutes No. 2010:185). This study uses two cases from the Stockholm region in Sweden where transport planning and land-use planning are coordinated in a new way by the use of the strategic choice of measure (SCM) approach, which is a framework in early transport planning. This planning context provides an opportunity to study the interaction between national transport planning and local land-use planning with associated boundary-crossing municipal interests in a complex urban setting. The complexity relates to the number of different problems to address and interests that needs to be taken into consideration.

The overall aim of this paper is to analyze SCM processes from a systems perspective in order to illuminate the consequences of system boundaries on how environmental aspects are considered and what aspects are included or left out. The research process was based on two case studies and guided by the following questions:

- How is the SCM process designed to enable the integration of transport and land-use considerations?
- How are the system boundaries for the SCM process defined in relation to the aim and the scope?
- Which environmental measures were possible to recommend within the system boundaries used in the SCM processes?

The paper contributes to the international scientific debate on transport and land-use planning by providing a deeper understanding of what factors influence the consideration of environmental aspects in contemporary early transport planning practice. Due to the design of the research project, the knowledge generated will also benefit STA directly through workshops and dialogues.

Method and material

The research design consisted of a qualitative case study using observations, several and recurring informal interviews with practitioners, and document studies to gather information on two cases of early transport planning in the Stockholm region, Sweden.

Planning practice is contingent on context-dependent judgment (Flyvbjerg, 2004), and the complexity that characterizes early transport planning in urban areas is influenced by contextual factors. Therefore, a case study approach was used to study transport planning practice (Yin, 2014). Two cases, representing two ongoing examples of SCM approaches, were studied. The first one, European Route E4/E20 Hallunda-Vårby Backe (Case A), comprises 5 km of a road corridor whereas the other one, National Road 73 from Nynäshamn to Stockholm city (Case B), comprised 50 km of a road corridor. Both cases are located within the Stockholm region, which is an urban and peri-urban area that faces challenges from demands for the reduction of environmental impact from the transport system, and at the same time challenges associated with a growing population and increasing freight transport. Both cases consist of roads designated as being of national interest by the Swedish Transport Administration (STA) and the SCM processes involve national, regional and local authorities for transport and land-use planning. The cases are to some extent anomalies by being more complex in comparison with other SCM processes as they contain multiple conflicting interests and demonstrate a local and regional perspective respectively. These kinds of deviant cases selected enable the exploration of positive as well as negative aspects (Seawright & Gerring, 2008). Thus, the cases are selected to be information-oriented as compared to selecting cases randomly (Flyvbjerg, 2006). Even though the knowledge generated by the case studies cannot be formally generalized, the knowledge can enter into the collective process of knowledge accumulation (Flyvbjerg, 2006) in the field of early-stage transport planning.

Gathering of information: observations and document studies

Observations of meetings held in the SCM process were conducted to gain insight into the cases by observing the actual interaction between actors, which made it possible to

Table 1. Documents extracted from the SCM web platform (the SCM project management upload documents concerning the SCM process, which all participants in the SCM can access) and examined in the study.

Documents	Case A	Case B
A. Meeting notes from working, steering and reference group meetings	13	19
B. Presentations held at meetings	4	8
C. Material for workshops	13	10
D. Notes/documentation from workshops	3	12
E. Meeting notes from coordinating meetings with parallel planning projects	15	1
F. Material from coordinating meetings with parallel planning projects	18	8
G. Remaining documents that were addressed/produced in the SCM (excluding those in workshops and coordinating meetings)	16	60
H. SCM report or draft of SCM report	1	1
Total number of documents	82	118

note aspects of the process that are not described in summarized notes from meetings (Kearns, 2016). The observations were conducted over a time-period of approximately two years (from January 2018 through January 2020). During this time, working group meetings and workshops were observed on 17 separate occasions (14 working group meetings and three workshops). However, the observer did not actively take part in the discussions held at the meetings. Furthermore, as a complement, the observer had recurrent informal interviews with process coordinators from the STA including consultants procured by the STA, participants from the Regional Public Transport Authority (RPTA) and participants from municipalities. Informal interviews allow researchers to examine specific phenomena defined by the research project and take notes (DeWalt & DeWalt, 2002). The aim is to gain an in-depth understanding of the phenomena studied and to understand how things work in a particular context (Swain & Spire, 2020). Since several recurring informal interviews were conducted, information about issues that arose during the SCM processes could be obtained.

In addition to observations, a document study (Bryman, 2016) was conducted to gather empirical material about the background, context and process description for the two cases. Government and consultancy reports, as well as official and internal written reports of events (such as meeting notes), were studied (Table 1). Also, administrative documents (e.g. formalized agreements) have provided essential information on the cases. The documents were analyzed through qualitative interpretation, which was motivated by the diversity of document types.

Analysis

The information gathered through observations, informal interviews and document studies was analyzed to examine how environmental aspects were addressed from a systems perspective in SCM processes. The different activities in the SCM processes were identified and sorted into a process scheme. Moreover, the information gathered from the observations, informal interviews and document studies was clustered into three categories. First, the aim and scope of the SCM processes were identified. Second, the environmental aspects addressed in the cases were identified and sorted into six main aspects: Noise, Air, Water, Climate, Health, Landscape. The six aspects were chosen based on how the STA organizes environmental aspects. The tools used in the SCM processes to analyze the environmental aspects were also identified (Table 2). Third, the environmental investigations and measures generated in the processes were identified. After the sorting of different activities, environmental aspects, tools, and, investigations and measures, the gathered information was analyzed from a systems perspective. The systems perspective applied in the analysis were the territorial boundaries that refer to the geographical area in focus, and the participation boundaries that refer to which actors are included in the planning process and how they are involved (Verweij et al., 2014). In addition, a systems perspective is applied that refers to the delimitation of environmental systems in tools that were applied (Gudmundsson et al., 2016).

Introducing the cases

The SCM approach

The SCM processes of Cases A and B followed the SCM guidelines (STA, 2014a) that outline four consecutive phases (Figure 1): (a) initiate, (b) understand the situation, (c) test possible solutions and (d) recommend measures to be implemented. As Ek Österberg and Qvist (2020) describe, SCM processes are initiated by one organization (often STA) and the process organization involves a working group and a steering group with representatives from the initiating organization as well as other stakeholders. Usually, the initiating organization has defined the problem to be addressed in the SCM, however, the definition of the problem will be discussed and potentially modified in the SCM process. According to the guidelines, the SCM process includes different types of consultative forums (workshops, reference group meetings and seminars) in which stakeholders can participate. The working group conducts the SCM, usually led by a representative from the initiating organization as a process coordinator and a consultant as a project manager (appointed by the initiating organization). The SCM results in an SCM report that should describe why and where the process is conducted, the SCM report should also present the different alternatives considered to solve the particular problem, the evaluation of the solutions and the recommended measures (STA, 2014a). In addition to measures, the SCM can recommend investigations concerning potential measures. This might be the case if the SCM cannot, for some reason, recommend the measure.

Table 2. The environmental aspects addressed in the SCMs (Cases A and B) and the tools used to conduct problem analysis associated with the specific aspect.

Environmental aspect	Tools used to describe/assess the problem (Case A)	Tools used to describe/assess the problem (Case B)
Noise: road traffic that affects people and nature	Calculations according to the Nordic calculation approach (SEPA & STA, 1996) based on road traffic estimations for the specific area of investigation	Previous mapping (SEPA & STA, 1996) of noise pollution from state-owned roads was used to assess noise levels along the road
Air: Pollution from road traffic, that is, particles and NO_2	Calculations of PM10 (particles) and NO_2 estimated for 2035 for the specific road section (OSLVF, 2017a, 2017b)	Previous calculations of PM10 and NO_2 concentrations, made by SLB-analysis (Ramboll, 2019a)
Water: Polluted storm water from roads that runs off to surface water and groundwater bodies	Description of a water protection area, ground water body, as recipients for natural runoff and stormwater runoff from the road (Ramboll, 2017a)	Risk analysis of surface and groundwater according to the STA's handbook (STA, 2013)
Climate: Emissions of GHG that induce climate change	Description of how the road traffic contributes to emissions of GHG from the road. Mainly CO_2. Also a description of challenges associated with urbanization (Ramboll, 2017a)	Statistics on proportion of municipalities' total CO_2 emissions caused by road traffic, and absolute value of emissions from road traffic in each municipality (2010–2015) (Ramboll, 2019a)
Landscape: Barrier effects and impacts of the road on the natural and cultural environment	Description of barrier effects, identification of areas with important ecological and cultural values (including natural reserves, nature protection areas), social impact assessment (STA, 2016a; Trivector, 2015)	Landscape analysis according to STA's methodology (Ramboll, 2019b; STA 2016b)
Health: Health risks associated with poor air quality, disturbances of noise, potential accidents with dangerous goods transported on the roads that will pollute air, water bodies and soils	Description of risks to public health as a consequence of barrier effects, poor air quality, noise disturbance, accidents with dangerous goods. A social impact assessment (Ramboll, 2017a; Trivector, 2015)	Description of risks to public health as a consequence of barrier effects, poor air quality, noise disturbance, accidents with dangerous goods (Ramboll, 2019a)

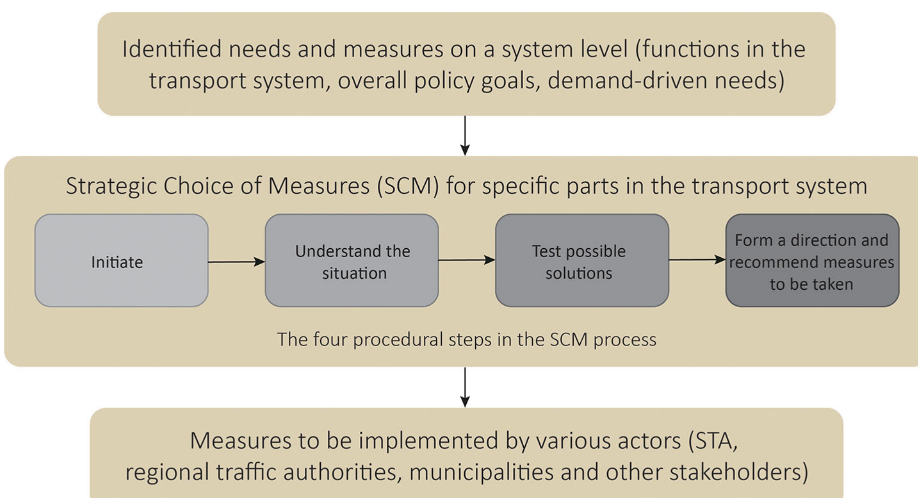

Figure 1. A schematic figure with an overview of the planning system for transport planning in Sweden. The SCM has a central role in identifying measures that will later on be included in transport plans.

European Route E4/E20 and National Road 73

Cases A and B refer to SCMs of two road projects in the southwest and southern parts of Stockholm region, Sweden (Figure 2). Both SCMs faced similar challenges in terms of a strained traffic situation because of increasing population. Also, there was a high exploitation pressure in the case study areas which gave rise to conflicting interests regarding transport infrastructure and land-use development. Both SCMs were limited to covering road infrastructure, though the SCM approach differed between the two cases. The SCM in Case A had a local approach and covered one part of the transport corridor E4/E20 (5 km), between Hallunda and Vårby Backe, located in the central parts of Botkyrka Municipality and western parts of Huddinge Municipality. There are housing and business areas located near the road, as well as important bodies of water and green areas. The SCM in Case B had a sub-regional approach and covered a whole transport corridor (50 km), National Road 73, from Nynäshamn harbor to a traffic junction in Stockholm City called "the Southern Link". The road corridor links suburban city centers with each other and with Stockholm City Center. The road is surrounded by urban and peri-urban areas.

Both cases concerned roads that serve a versatile function for Sweden's economy and welfare and are, according to the STA, of great importance for national and regional interests. The traffic generated on the roads is international, national, regional and local. Case A is a freeway part of the Trans-European Transport Network (TEN-T) (Stockholm Region, 2007), and is located directly adjacent to two major transport infrastructure projects under construction: Bypass Stockholm (STA, 2005) and the Södertörn Crosslink (STA, 2014b). The road 73 in Case B is part of the National Primary Road network and approximately 80% of the road

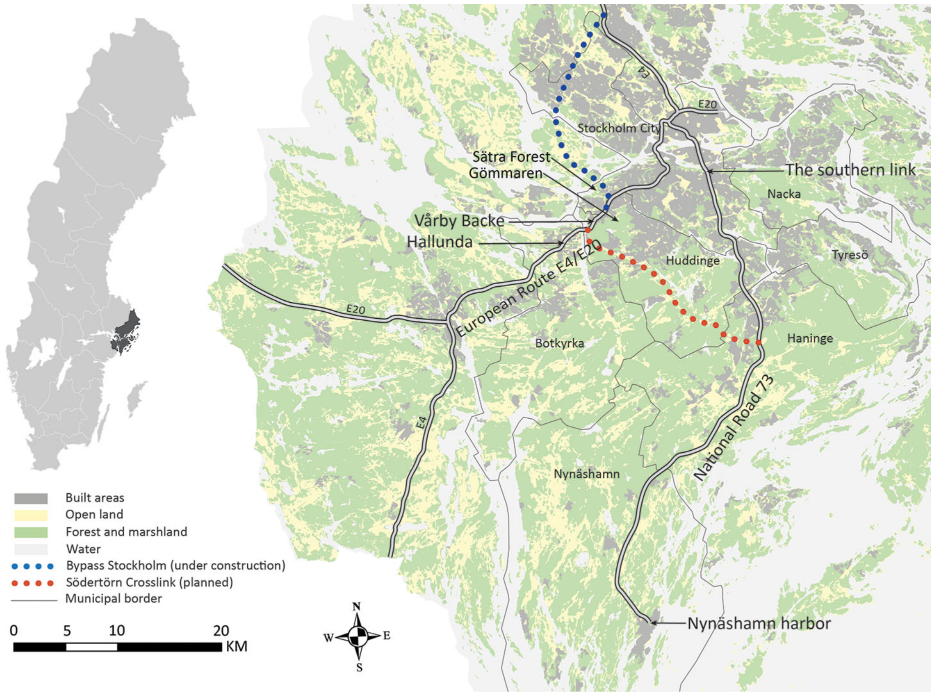

Figure 2. The map shows the study area: European Route E4/E20 between Hallunda and Vårby Backe and National Road 73 between the southern link and Nynäshamn harbor. The map also shows where the infrastructure projects Bypass Stockholm and the Södertörn Crosslink are located, and the nature reserves Gömmaren and Sätra Forest.

is freeway (STA, 2018a). It is an important link for the transport of goods between the harbor in Nynäshamn City and the national transport system. Both roads (Cases A and B) are classified as national interest, which implies that they should be protected against measures that may significantly impede the construction or utilization of the transport infrastructure (STA, 2017). Therefore, land-use development projects, such as new buildings within the infrastructure's area of influence, must not adversely affect current or future use of the transport infrastructure.

Case study results

Three identified activities in SCM: identifying problems; formulating SCM objectives; and generating and prioritizing measures

This section provides an overall description of the SCM processes studied and how they were conducted (Figure 3). Different sources served as input to the two SCM processes (Cases A and B). In Case A, reports authored by STA (2012, 2014c) identified deficiencies along European Route E4/E20 that were consequences of the construction of Bypass Stockholm which served as a main input to the SCM process. In addition, measures from other planning processes (e.g. Bypass Stockholm), as well as national, regional and local goals were significant for the formation of the process. In Case B, more overall strategic documents, mainly from STA (2018b), but also, for example, from the Regional Development Plan for Stockholm (Stockholm Region, 2018), served as input to the SCM process. Also, the formation of the projects was dependent on strategic decisions by officials at the STA. Similar to Case A, national, regional and local goals served as a significant input to the process.

This means that the main problems that the SCM processes should address had been identified by the STA before the SCM processes began; the main focus was limited to accessibility on the roads, which affected the boundaries and scope of the SCM processes. The problems and deficiencies associated with the traffic on the roads were explored in collaboration with the actors involved in the SCM processes and later modified with respect to, among other things, environmental concerns and assessed impacts on adjacent land-use development. Reports produced within the SCM, but also previously published reports on specific topics, were used to facilitate dialogue meetings in which the modifications were developed.

In both cases, the process revolved around three main activities that were applied in parallel and continued throughout the process (Figure 3): (a) identifying problems, (b) formulating SCM objectives and (c) generating and prioritizing measures. There was an interaction between the activities, as updates of the problem description affected the formulation of the SCM objectives as well as the generation of measures. Thus, the process turned out to be iterative due to how the process coordinators chose to structure it. At the end of both SCM processes, there were informal discussions in the working group regarding the extent to which each measure fulfilled the SCM objectives. The process of generating measures also resulted in the identification of knowledge gaps, which had to be further investigated in continuing planning. The SCM reports are documentation of the processes, for example, how the process was implemented and its outcome. The outcome of the SCM processes (Figure 3) was recommendations concerning either "a

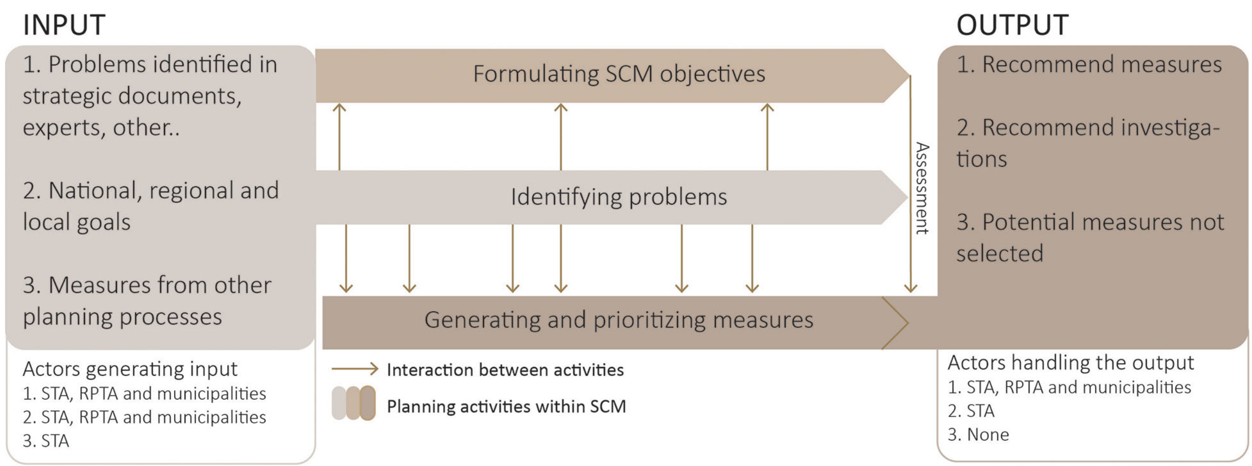

Figure 3. A schematic figure that describes how the SCM processes in Cases A and B turned out. Three main activities were identified: Identifying problems, Formulating SCM objectives, and Generating and prioritizing measures. There was an interaction between the activities throughout the process, thus making the process iterative. However, the main interactions were in the direction from Identifying problems to the two other activities respectively.

measure to be implemented" or "an investigation to be conducted", but also information and motivation about potential measures that were not selected. The report also contained information about the assessment of the recommended measures. Furthermore, to ensure that measures were implemented after the SCM process, responsible actors were pointed out. However, the responsible actors were not legally bound to implement the measure, as the SCM is an informal planning process. This means that even though there is nothing that legally obliges the actors to take on the implementation of measures, it is important that they still feel compelled to do so in order for change to take place.

What was the aim and scope of the SCM processes?

The aim of the SCM in both Case A and Case B (STA, 2018c, 2020) was to develop a common view among the actors of the problems and to devise solutions to the problems, in the areas of interest. In this way, the intention is to work for consensus about future developments in the areas for Cases A and B, which would foster a long-term perspective in the transport planning. However, as previously mentioned, STA had decided the main problems that the process should focus on before the processes started. In Case A, the aim was formulated by the STA as "to develop a long-term perspective in planning along E4/E20" (STA, 2018c). In Case B, a corresponding formulation of the overall aim was "The aim of the SCM is to make the different actors agree on what function(s) the road corridor should have, today and in the future" (STA, 2020).

In Case A, the initial boundaries of the SCM were dependent on another ongoing project, Bypass Stockholm, which would result in capacity deficiencies in the road network surrounding Bypass Stockholm including the European Route E4/E20 from Hallunda to Vårby Backe (STA, 2014c). During the ongoing SCM process (Case A) the boundaries were widened to encompass the connection to a main road in Botkyrka Municipality, as a result of coordination with a municipal land-use development project. In Case B, the reason for the initial boundaries was a preparatory study for the SCM that had been conducted by the STA, which identified deficiencies related to National Road 73. Those deficiencies concerned accessibility for busses, freight transport and commercial traffic, as well as housing exploitation near the road and the design of the road corridor (Notes, working group meeting, 2017-09-08). Based on these deficiencies, the scope of the SCM was limited to accessibility of the roads and in what way it should be developed in order to be of best use from a regional perspective. Although the scope of the SCM was clear from the beginning of the process it was considered important that it was perceived, by the actors in the SCM, to be flexible for potential changes (Notes, working group meeting, 2017-09-08).

Which environmental aspects were handled in the SCM?

Regarding the problems associated with environmental aspects (Table 2), in Case A, calculations were made to estimate the magnitude of air and noise pollution from the road on the initiative by STA. The calculations were based on traffic forecasts made by the STA (Ramboll, 2017b). The calculations of air and noise pollution contributed with information to the decisions on what land areas were allocated for road purposes, the so-called road space (Gössling, 2020). Regarding water, the impact of stormwater from the road on natural surfaces and groundwater were described in an environmental report (Ramboll, 2017a) produced by consultants for the STA. However, no risk analysis was carried out in the SCM, since this was planned to be done in a later planning stage. Regarding landscape, barrier effects from the road were assessed qualitatively (Ramboll, 2017a). In addition, the representatives from the municipalities and environmental experts at the STA expressed concerns regarding the connectivity between two nature reserves (Gömmaren and Sätra Forest), since this issue had not been taken care of by the previous planning of "Bypass Stockholm" and "the Södertörn Crosslink". Therefore, the representatives from the municipalities and the environmental experts from the STA thought it should be addressed in this SCM (Case A). Furthermore, in association with landscape and health

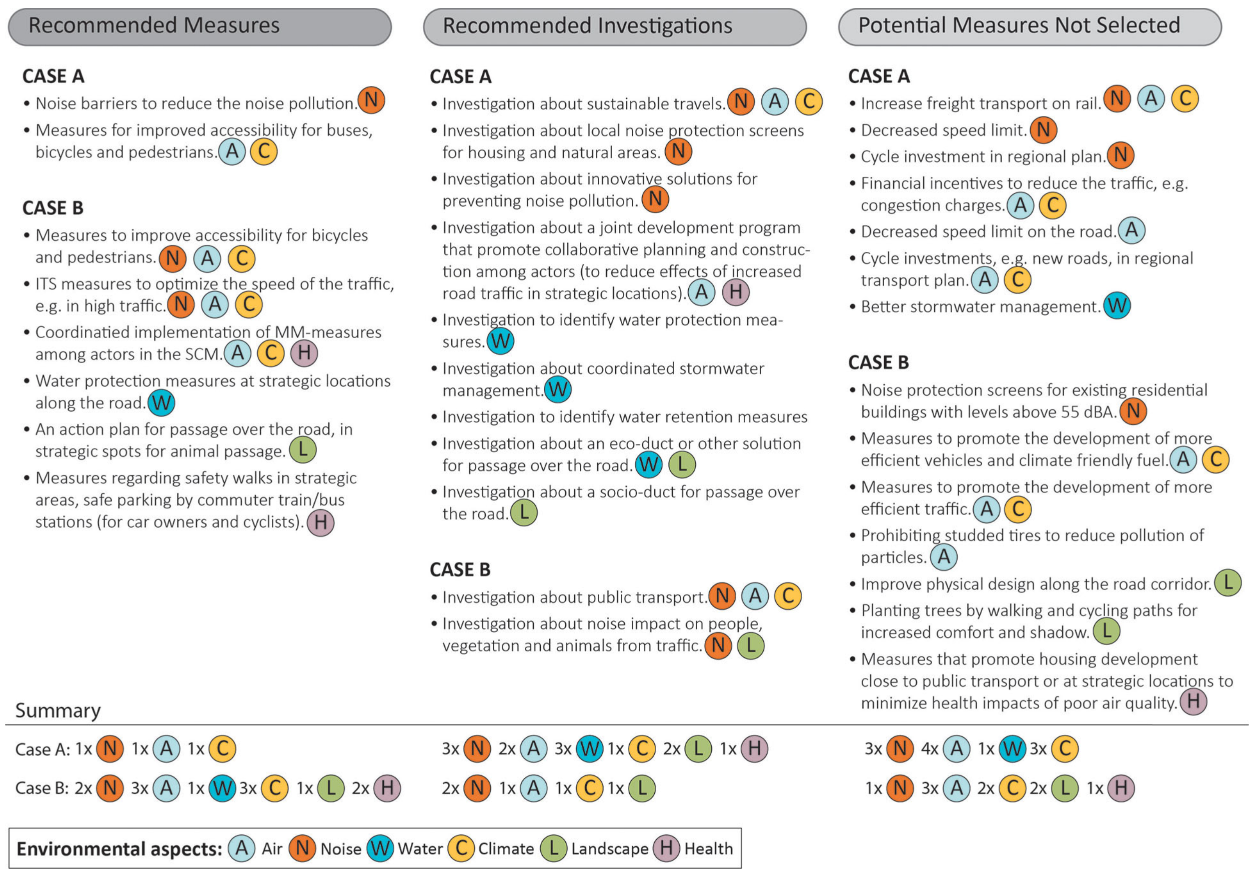

Figure 4. The figure shows recommended measure, recommended investigations, and potential measures not recommended for the SCM in Cases A and B. Which environmental aspect that can be associated with each measure or investigation is marked with a letter in a colored circle.

aspects, a social impact assessment was conducted by STA in collaboration with the municipalities (STA, 2019a). The social impact assessment was initiated after discussions in the working group in which the representatives from the municipalities expressed the need to investigate the social impacts of the road further. The social impact assessment concerned, among other things, the connectivity for people across the E4/E20 and the connecting roads Bypass Stockholm and the Södertörn Crosslink that are under construction. The working group in Case A maintained that it was difficult to delineate the problems and coordinate their analysis and assessment, since the SCM had to address detailed and comprehensive issues as well as problems caused or not solved by other planning projects. In an attempt to address detailed and comprehensive issues simultaneously, the geographical area was divided into three sub-areas. This way, the working group could zoom in on sub-areas and thereby structure the discussions around problems that are more detailed than what was possible when addressing the full geographical area at once. To address problems that concerned areas and actors outside the SCM boundaries, coordinating meetings were arranged with parallel planning projects (e.g. Bypass Stockholm, the Södertörn Crosslink). This way, problems that concerned actors that were not or only partly involved in the SCM were discussed, which indicated that the SCM boundaries were temporarily extended as the SCM was coordinated with other STA projects as well as municipal development projects. The previously mentioned connectivity between the two nature reserves serves as an example of an issue that required coordination between the SCM and other infrastructure projects.

In contrast to Case A, Case B was not as influenced by other ongoing municipal development projects or STA projects. Also, several environmental problems were brought up early in the SCM process by the process coordinator, including climate, environment and health, and also concerns related to urban development, the regional importance of the road, transport modes, road safety and accessibility. Similar to Case A, the working group in Case B divided the geographical area into three parts, to facilitate more detailed discussions of problems concerning a certain area. All actors in Case B considered emissions of GHG from traffic as a severe problem. It is a prioritized problem in strategic documents on a regional level, and the actors thought that the newly introduced National Climate Act (Swedish Code of Statues No. 2017:720) was considered an opportunity to promote the implementation of measures reducing GHG emissions, such as bus lanes. The working group in Case B also addressed problems related to water, such as polluted stormwater that flows into lakes and how stormwater from connecting roads flows down to National Road 73. A risk analysis for surface water and groundwater was carried out (STA, 2019b), because the working group thought that it was too late to conduct a risk analysis in later planning stages, that is, in a road plan or a municipal detail plan. In addition, a landscape analysis was conducted by procured consultants, which identified seven areas with different landscape characteristics. The different landscape characteristics were associated with specific challenges from the perspectives of the road users. The working group found it problematic that the consultant had perceived that their task was to apply the road user's perspective, as it generated measures that improved the road user's experience of the environment along the road, rather than the interaction between the road and its surroundings.

Which environmental measures was it possible to recommend?

As previously mentioned, the recommended measures and investigations from the SCMs were appointed to actors that were involved in the SCM process. The implementation of the recommended measures was then handled by the subsequent planning, to be included in a national or regional investment plan facilitated by the STA or the RPTA, or in a local plan facilitated by municipalities. In the SCMs (Cases A and B), it was found that the processes had limited scope for action, meaning that the working group could not recommend all measures that they found necessary to counteract the environmental impacts from the road (Figure 4). The limited scope for action was a consequence of the working groups' limited mandate to recommend such measures.

Recommended environmental measures to be implemented and investigations to be conducted

In Case A, the recommended environmental measures (Figure 4) comprised noise protection along one specific road. The SCM also recommended measures to improve infrastructure for buses, bicycles and pedestrians. The recommended environmental measures only addressed noise pollution, air pollution and GHG emission. In addition to these measures, the SCM in Case A proposed investigations (Figure 4) of environmental measures in order to reduce environmental impact from the road regarding coordination of stormwater management between the STA and the concerned municipalities, an ecoduct and alternatives to increase the connectivity between green areas, a socioduct to decrease barrier effects for people, protection of nature reserves and sustainable travel.

In Case B, the recommended environmental measures (Figure 4) comprised a plan of action for a passage across National Road 73 to decrease the barrier effects, measures for water protection along the road, as well as improved infrastructure for pedestrians and cyclists along and across the road. In addition to these measures, investigations on how noise pollution affects natural and recreational values along the road were recommended, as well as investigations linked to public transport. The environmental measures and investigations were generated at a workshop specifically focused on environmental aspects, in which the working group, environmental experts from the different actors in the SCM, and one consultancy firm participated. At that workshop, several measures were generated. Later on environmental experts at the STA together with the SCM project management made a selection of the measures based on their feasibility and contribution to the SCM objectives. Furthermore, investigations were recommended by the working group when they considered they did not have enough knowledge to recommend a measure as the solution to a problem. In comparison with the measures and investigations in Case A, the measures and investigations recommended in Case B were less detailed, as a consequence of being a road corridor. In Case A, measures could be discussed more in detail because the SCM covered a smaller geographical area.

Neither in Case A nor in Case B did the actors think that the measures discussed in the SCM could fully solve the identified problems. Notes from the working group meetings showed that there was a perception that there are no established technical solutions to complex problems with environmental impacts such as air and noise pollution in urban areas. What was meant was that the SCM boundaries were too narrow to deal with the social and environmental impact of the road. In Case A, several of the measures proposed required continued investigation, for example, concerning an ecoduct. Also, continued coordination and cooperation after the SCM process was required in order to complete the investigations and implement some of the recommended measures. Moreover, some of the municipal representatives expressed opinions about how the municipal development had to be held back in favor of the development of the road, as a consequence of the construction of Bypass Stockholm and the Södertörn Crosslink. The two major environmental problems that affect people's health, air and noise pollution, do not have an obvious technical solution according to the working group (Notes, working group meeting, 2018-06-19). Therefore, the actors thought that in order to meet requirements of air quality, authorities at national, regional and local level need to develop new ways to collaborate on urban development. In the SCM report it is stated that individual measures can contribute to improvements regarding poor air quality, but it is the joint efforts of all actors that provide the best results. Therefore, continued collaboration was proposed as a measure, mainly with regard to "Mobility Management" measures. The SCM in Case A and Case B resulted in a need for continued and improved dialogue among actors in order to solve problems with air and noise pollution, barrier effects and other environmental problems.

Potential environmental measures not selected

In both Case A and Case B, some measures that were discussed in the SCM process were not recommended in the SCM reports (Figure 4). Examples of such measures, in Case A, concerned congestion charges, fuel tax and an increased proportion of freight transport by rail. According to the actors in the process, these types of measures require political decisions and are beyond the control of the SCM. Furthermore, it was not possible to recommend measures such as prohibition of studded tires, due to legal restrictions on national roads. Measures concerning housing intended to decrease people's exposure to poor quality air were not recommended because it was considered a task for the municipal planning, and measures concerning stormwater treatment were expected to be considered in later planning stages. In Case B, noise protection measures for housing exposed to a noise level that exceeds the environmental quality standards were not recommended because STA cannot finance noise protection for existing houses. According to an environmental expert at the STA, the STA is only able to finance noise protection screens if there is substantial redevelopment or new housing exploitation. Similar to Case A, adapted housing strategies were considered a matter of municipal planning, and should not be a recommended measure from the SCM. Measures concerning efficient vehicles and sustainable fuels were regarded as something that the SCM could not affect, as they were considered to be beyond the control of the SCM. To sum up, there were many different measures raised in the SCM process but for various reasons not considered in the subsequent planning process.

Analysis and discussion

This study has looked into early-stage planning of transport infrastructure projects by focusing on two cases where the SCM approach was applied, in order to analyze SCM processes from a systems perspective so as to illuminate consequences of system boundaries on how environmental aspects are considered and what aspects are included or excluded. The rationale for the choice of cases was that they were rich in information and provided examples of two different perspectives of the SCM process in an urban complex planning context: the cases had a local and a regional perspective, respectively. The study is limited to the type of early transport planning in Sweden as represented by the SCM approach. Even though the study is context dependent, the knowledge generated is of relevance for the field of early-stage transport planning.

SCM boundaries

Planning can be described as an arena for contested knowledge, where "creating a joint understanding of the world, developing knowledge following particular conceptual guidelines is power" (Hajer & Versteeg, 2005, p. 181). In the cases, we studied how the SCM process through its guidelines and established practices leads to what aspects to include and what aspects to sort out, how some solutions become possible and others impossible, which implies that some solutions become legitimate, others outmaneuvered. The practice does to some extent follow the argumentative turn of planning practice, which means that the public servant becomes a facilitator for collaborative problem solving and a challenge is to combine knowledge from separate spheres of knowing, for example, the "technical, local/experiential and political" (Fischer & Gottweis, 2013, p. 430).

One factor that determined what aspects and different types of planning projects were included and excluded in the process was the choice of SCM boundaries. As discussed in Verweij et al. (2014), drawing boundaries is one way of reducing complexity in planning projects. However, depending on the system boundaries, some aspects may be neglected and unexpected problems related to the boundaries may occur in the planning process.

Territorial boundaries

The territorial boundaries of a project set out the geographical area that is included in the project (Verweij et al., 2014). Common in the studied cases was that the spread of noise and air pollution from the road influenced the SCM geographical boundaries by defining the road space, whereas the spatial distribution of other environmental aspects, such as water, climate, landscape and health, stretched beyond the geographical boundaries of the SCM and did not influence the definition of the SCM geographical boundaries. Regarding water, climate, landscape, and health, the SCM working groups struggled with handling those aspects due to the geographical SCM boundaries. The difference in scale between the two SCMs gave different character to the boundary issues: the SCM in Case A was demarcated to a local geographical area whereas the SCM in Case B was defined as a sub-regional geographical area. In Case A, calculations were made of air and noise pollution from the road which made it possible to have discussions on details of mitigation measures in the particular area. The discussions revealed whether the actors shared a consensus on how the measures would be designed. In Case B, no specific calculations regarding noise and air pollution were made. Instead, estimations from previous calculations regarding the whole region were used, which resulted in less detailed discussions regarding mitigation measures. The SCM in Case B on the other hand comprised a risk analysis for surface and groundwater, and a landscape analysis, which was not considered relevant in Case A due to the limited geographical area. The landscape analysis partly contributed with insights into how the different aspects along the road corridor were connected. However, the results of the landscape analysis did not provide the useful systems perspective that the working group thought it would, due to its focus on the road users rather than the role of the road in the landscape. Using the landscape perspective as a way of understanding the interconnections between the different aspects of landscape has been claimed to be a useful way of addressing complex environmental problems in spatial planning and transport planning (Clemetsen & Schibbye, 2015; Kristensen & Primdahl, 2020), especially in early planning stages that comprise larger geographical areas. In Case A, to address the problem of connectivity between two nature reserves (Gömmaren and Sätra Forest, Figure 2), the working group collaborated with other adjacent infrastructure projects that also addressed the issue of connectivity between the nature reserves. This implied that in Case A, in order to deal with problems that stretched over larger geographical areas, the

SCM boundaries were temporarily extended beyond the primary boundaries of the SCM.

Participation boundaries

The desired outcomes of SCMs cannot be achieved by one organization in isolation and therefore collaboration between stakeholders is necessary. One aim of the SCM is to facilitate dialogue between the actors about problems, objectives and measures within the SCM geographical boundaries. The actors involved in the SCM define the participatory boundaries of the project. However, in SCM processes STA's national planning merges with transport and land-use planning on a regional and local level, and conflicts in interests between these different administrative levels occur. For example, in Case B, Stockholm municipality describes the northern parts of National Road 73 as a future urban space in their strategic documents, whereas according to the STA the road is part of the national road network and therefore accessibility for road traffic should be prioritized. The different views on the future of the road demonstrate an example of contradicting national and local interests that exist and arise in the SCM process. As emphasized in Pettersson and Hrelja (2020), shared objectives and visions are important for co-action, nevertheless it is difficult to achieve. Granqvist et al. (2019) provide a similar example in the Helsinki region in Finland, that illustrates conflicting interests between national and local interests regarding a land-use development initiative of city-boulevards to expand central Helsinki. The example shows how local interests can be overruled by regional/national interests, as in how accessibility for road traffic is prioritized before expansion of the city, which might have a negative effect on collaboration between actors if not dealt with in a constructive way (Pettersson & Hrelja, 2020).

The actor's mandate determined what measures could be recommended from the SCM process. In Case A, measures with an expected effect on air pollution, noise pollution and GHG emissions, such as improved public transport, cycling and walking were recommended, but the working group did not consider them to be sufficient to solve the severe environmental problems identified within the SCM geographical boundaries. No measures were identified that could locally reduce the air pollution to desirable levels. This was because the traffic on the road, generating air and noise pollution, were mainly national and international. The national and international induced traffic could not be impacted by any measures within the mandate of the actors. If the best solutions fall outside the mandate of the participating actors, it is likely that they will not be recommended and later on implemented. Such measures included congestion charges and usage of sustainable fuel (Figure 4). Another example of how the mandate of the actors affected the recommended measures concerns the reduction of barrier effects. In Case B, a passage plan for wild animals to reduce barrier effects was recommended and the STA was designated to take responsibility for its implementation. However, in Case A, a similar measure to reduce barrier effects between the two Nature Reserves Gömmaren and Sätra Forest could not be recommended. This was because STA's representative did not have the mandate to take such a decision within the SCM, the decisions had to be taken at a higher level within STA. Yet, in order to deal with the problem, the SCM recommended an investigation that would further explore the feasibility of an ecoduct or other alternatives to increase the connectivity between the green areas. This means that while decisions on investments in measures that expand the transport infrastructure in this area are made, countermeasures for barrier effects from the road are not implemented. Meanwhile, capacity-increasing measures with negative impact on barrier effects, air quality and noise are implemented. To sum up, it is difficult to involve the right actors in order to make sure that all the best solutions are recommended from the SCM process. This is in line with Verweij et al. (2014) who claim that many actors are part of and influence the complex urban system, and therefore a planning project might only to a certain extent attribute to that complexity.

Application of systems perspective in the planning process

As previously mentioned, transport and land-use planning practices are brought together in the SCM process. In Cases A and B, the aim of the process and the initial problem definition were specified by the STA. However, as the processes proceeded, the descriptions of problems were elaborated upon by the actors involved in the SCM, and problem analyses were conducted to extend and deepen the problem descriptions. Many of the environmental problems concern and are addressed in both transport and land-use planning (Deakin, 2020), and as discussed in Eckersten et al. (2021) the consideration of environmental aspects in the SCM process is affected by the transport authority and municipalities' different interests in them. Problems related to air and noise pollution engage the actors in the SCM process, whereas problems related to landscape and water invoke less engagement. The impact of the transport infrastructure on landscape aspects such as biodiversity is complex (Helldin et al., 2015), with barrier effects, altered hydrology and fragmentation of landscape. Knowledge of landscapes is an important foundation for planning decisions that change the use of land, such as transport and land-use planning (Löfgren, 2020).

The environmental aspects related to transport infrastructure and land-use changes are interconnected and to understand the interconnections a systems perspective is required. However, handling environmental aspects in planning processes that are context specific, such as the SCM, involves delimitation and categorization of the overall systems (Gudmundsson et al., 2016). Consequently, different tools are used when analyzing environmental aspects, which implies the exclusion and prioritization of some specific environmental aspects. The tools used to analyze environmental problems in Cases A and B were partly different (Table 2), depending on the scope and geographical boundaries of the specific SCM and also on what type of information was available when the SCM processes started.

However, in both cases, a mixture of qualitative and quantitative tools was applied to gather and sort information about problems related to environmental aspects. Noise and air pollution were analyzed through calculations of current and future expected levels of pollution in the project area. The analyzes of almost all other aspects: water, climate, landscape and health, had a qualitative approach or were summaries of quantitatively and qualitatively derived information acquired from the STA, RPTA, and the municipalities. The different types of information from the analyzes were used in the discussions in the working group and workshops for prioritizing problems and for identifying possible solutions to the problems. This implies that the aggregation of information on environmental problems was made by the participants in the working group and workshops. The acknowledgment of the interconnection and potential synergies between aspects that could be used when identifying solutions, potentially multi-functional solutions, depended on the participants' knowledge of them. However, in the two cases, the participants in the working group thought that the SCMs did not manage to get fully to grips with the environmental problems raised, and one reason for this could be that the SCMs did not have a clearly structured way of forming knowledge on the connections between transport infrastructure, land-use and environmental concerns in the process, and a lack of competence on how to use such knowledge. A landscape analysis has the potential to provide a systems perspective and account for ecological and functional interconnections between landscape types, but also cultural heritage like ancient monuments, settlements and fields (e.g. Antrop, 2004). However, a landscape perspective is not enough but must be combined with a striving for an open process where knowledge can be shared and an arena must be developed for combining knowledge from separate spheres of knowing.

Conclusions and recommendations

This study has shown that multiple boundary issues arise in the SCM process as transport and land-use planning are brought together. Depending on the character of environmental aspects, the consequences of systems boundaries on how these aspects are considered in SCM processes varies. For some environmental aspects the system boundaries do not coincide with the actors' mandate. This applies, for example, to the climate issue, which becomes difficult to handle for areas beyond the territorial boundaries of the road project. The actors' mandate to implement measures associated with an environmental aspect as well as the geographical scope of an environmental aspect in relation to the territorial boundaries of an SCM project, affects the consideration of an aspect. The following conclusions can be drawn from this study: Firstly, as transport and land-use planning practices merge in the SCM, the process has to deal with different and often conflicting views of development in the project area. The SCM process provides an opportunity for transport authorities and municipalities to create shared objectives and visions. The process does also contribute to address and potentially solve municipal cross-border issues that cannot be handled by a municipality alone. This requires collaboration and an open and constructive dialogue. Secondly, which environmental aspects are considered depends on whether there is a local or sub-regional perspective to the SCM. The sub-regional perspective is better suited to address environmental aspects such as water, landscape and climate, and to identify measures in relation to those aspects. Thirdly, the result shows that it is challenging for the working group to manage all the different problems and measures handled in the SCMs. For effective sorting and prioritizing between problems and measures, it is essential to understand synergies as well as how problems and measures in different planning processes relate to each other. Consequently, it is important that the working group receives necessary support regarding which problems to include in the scope of the specific SCM. Fourthly, one task for the working group in the SCM process is to implement overarching goals and strategies from earlier planning stages. However, for successful implementation the link between national, regional and local goals and strategies and the aim and scope of the SCM process must be clear, otherwise, the process coordinator and the working group might struggle to fulfill goals and strategies that are not possible to handle within the specific SCM process. Lastly, a systems perspective as support when analyzing problems in an SCM can enable the detection of links between transport, land-use and environmental problems. However, the application of a tool that would introduce a systems perspective to the planning process, such as landscape analysis, has to be adapted to the scope of the specific SCM. The systems perspective could contribute to the identification of measures with synergetic effects and subsequently the implementation of multi-functional solutions.

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