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Sustainability in Railway Investments, a Study of Early-Phase Analyses and Perceptions

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Abstract: This article presents a study of sustainability in railway investment projects. The purpose of the study was to analyse how sustainability is interpreted and evaluated in the early phases of major public investment projects. These phases are characterized by potentially very influential decisions being made prior to when precise, detailed knowledge is available. The research uses a mix of qualitative and quantitative information sources and three datasets; 12 interviews, document analyses for 10 railway projects, and a case study. The qualitative data are from semi-structured interviews, while the quantitative data are based on structured document review of planning documents from ten Norwegian railway projects. In addition, a detailed case study of a major rail infrastructure project has been performed. The findings show that several aspects of sustainability are evaluated in the early phase of investment projects, but there are no explicit requirements to do an overall analysis of sustainability. Environmental aspects of sustainability are predominant in the respondents' interpretation of the concept. Still, the structure and requirements of the early phases in the national project model ensures that the economic dimension of sustainability has the most influence in decisions regarding which project concepts that receive financing for further development.

Keywords: project management; railway infrastructure; project evaluation; sustainability

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1. Introduction

Infrastructure projects represent some of the most interesting dilemmas faced by policy makers in industrialised nations. Investments in new infrastructure incorporate direct and indirect costs in many forms during and after the construction periods, as well as benefits during the infrastructures' operational lifetimes. Some prime examples are found in the ongoing development of the railway infrastructure in Norway, both currently under construction and in the planning phases. The InterCity programme will expand the grater Oslo area and allow for commuting in major parts of south-eastern Norway, where the majority of the population is located. It is a general perception in society that railways are a sustainable means of transport. As sustainable development has received greater attention, both in business and within the society in general, that notion has grown more complex.

While railways in general are considered as a sustainable mode of transport, compared to most other alternative modes, the environmental impacts related to the development, operation, and maintenance of the railways have previously received less attention.

The Norwegian project model for large public investment projects has received significant attention and been the object of multiple studies since its inception in 2001 [1]. The model emphasises the early phases of project development in order to maximize the likelihood for decision makers to prioritize among alternative investment projects. Originally established as a tool for improved cost control, environmental aspects and sustainability have become more important in the model over the last decade [2]. For sustainability to be a decisive factor in evaluating and prioritizing alternative infrastructure projects, sustainability needs to be addressed in the early phases of all investment projects.

In addition, long-term impacts with regards to sustainability as well as other effects should be evaluated for all such projects [3]. We, therefore, considered it important to study how sustainability is addressed in practice in the early phases of major railway projects in this model.

The study has benefitted from access to a large number of decisions support documents that are produced in a consistent way and, therefore, appear suitable for an analysis of how sustainability is addressed and presented to decision makers. In addition, practitioners in the industry have been interviewed to complement the document-based part of the study.

The purpose of the paper is not to evaluate the actual sustainability of the studied projects. None of the projects are finished at the time of writing, meaning that data on sustainability performance are not available yet. The purpose is to study how sustainability has been addressed in front-end documentation of Norwegian railway projects, and how practitioners working on the projects interpret sustainability.

This has been performed by focussing on the following research questions:

1. How is sustainability addressed and documented in the early phases of railway projects?
2. What challenges are seen by practitioners in relation to evaluating the sustainability of railway projects?

The study is descriptive by nature and, to a lesser extent, normative. We believe that a good understanding of present practice can serve as a foundation for future improvements in working practice and sustainability performance of future and ongoing projects. This study adds knowledge about how sustainability is addressed related to railway investments. This is important to make sure that these investments really make important contributions to sustainability. From a research methodological point of view, we present a relatively novel method for doing this type of research, by applying text analysis. The study also uses mixed research methods when the text analysis was supported by interviews with railway practitioners about what sustainability means to them, and a case study looks deeper into one selected project.

1.1. Sustainability and Projects

Much of the literature on sustainability can be traced back to the definition in the report "Our Common Future" [4] from 1987. It defines sustainable development as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This report contributed to widening the perspectives sustainability to include economic and social dimensions along with the environmental aspects. However, sustainability remains an ambiguous concept open for interpretations [5]. Elkington [6] introduced the "triple bottom line" or people, planet, and profit (triple P) to highlight the three aspects of social, environmental, and economic sustainability.

The "triple bottom line", or triple P, can be applied to evaluate the sustainability of projects in a life cycle perspective. To projects, the economic perspective relates to financial performance of the project itself, its impact on the financial situation of the host organization, and project impact on economic development on a societal level. The social aspect relates to corporate social responsibility such as paying decent wages to workers, respecting stakeholders´ interests, and the distribution of benefits and drawbacks of the project. The environmental consequences of a project include local, regional, and global aspect. According to Goel [7], the triple bottom line or three pillars provide a framework for measuring the performance of a business and the success of the organization not only from the economic point of view but also from the social and environmental point of view. A key idea in the use of triple bottom line is that if you measure something you are likely to pay attention to it. If companies and organisations measure their environmental and social impacts; as a result, there may be the potential for more socially and environmentally conscientious organizations [8].

There are many interpretations of sustainability. Lædre, Volden, and Haavaldsen [5] argue that sustainability tends to be used as a buzzword in the public debate. This is also addressed by Hopwood et al. [9], who claimed that the concept of sustainability at

best becomes so wide that is becomes meaningless, and at worst ends up as a slogan for extremism. Most definitions of sustainable development share some core principles. First and foremost, it is a way of looking at environmental challenges in relation to the economy and society. Neither social development nor economic growth can take the ecological foundation for granted, or that ecological conservation cannot take economic consequences or support from society for granted [10].

According to Johnston et al. [11], the concept of sustainability is not properly understood due to inconsistency and ambiguity in definitions and that the true meaning of the term is distorted. Hay et al. [12] state that the reason why sustainability is difficult to define is that there are several understandings of the term and that several different interests make a unified definition difficult.

Another issue is the vagueness of the guidelines for sustainability. The analyses of Waseem and Kota [13] show how the majority of definitions are to a very little extent measurable and generally very ambitious. However, there are several recent studies on management and evaluation of carbon emissions. Cai et al. [14] studied how emissions can be allocated between neighbour provinces, cities, or counties to facilitate emission reduction plans. Fu et al. [15] developed a model for examining the effects of different policy options for carbon mitigation policies. As an illustration of the emerging field of environmental informatics, Khaiter and Erechtchoukova [16] present an environmental software modelling framework, which can be used to illustrate environmental impacts and related stakeholders.

There appears to be two main interpretations of sustainability; either the three dimensions of social, environmental, and economic sustainability (that may be further divided in sub-dimensions, such as in Silvius and Schipper [17]), or the focus is fundamentally on the environment. Naturally, combinations can be observed, which acknowledge the three aspects, but with main emphasis on the environment.

Sustainability in projects can be related both to the implementation of projects and to aspects of the completed delivery. A railway project contributes to sustainable development when the railroad is finished by transferring transport from road to rail and increasing accessibility for those who do not have a car. Nevertheless, the project implementation causes disadvantages.

All projects consume resources and, thus, constitute a form of environmental impact. In most cases, a delivery project has an impact on the environment when it is erected and many years after when the solutions that the project has delivered are to be operated and maintained. A delivery project has major impacts on the environment locally when it is executed. Construction projects create a large temporary transport need (material must be brought to the construction site), it creates noise (from the transport but also from the production/assembly on the construction site), it creates CO_2 emissions (from transport, heating, and the use of explosives) during the construction period, and impacts the environment globally by consuming energy, steel, concrete, timber, etc., creating emissions (to air and to water) and waste materials.

In project evaluations, one often makes a distinction between internal efficiency (doing things right) and external efficiency (doing the right things) [18]. A similar distinction can be made between "project internal" sustainability and "project external" sustainability. Emissions, disadvantages, and costs of implementation must be weighed against reduced emissions, benefits, and revenues from the use of the output of the project. This is typically done in a life cycle analysis (LCA). Table 1 illustrates how the triple bottom line can be applied in a project management perspective, with a distinction between sustainability effects from both project execution and following use of the project delivery. For railways, this mainly means effects from construction and long-term effects from use of the railway.

Table 1. Sustainability in projects and life cycle analysis (LCA) (based on Rolstadås, Johansen, Olsson, and Langlo [18]).

Sustainability Aspect	Environmental	Economical	Social
Project execution (internal)	Less emissions, energy use, sustainable materials	Cost consciousness, distribution effects (of investment funding)	Decent working conditions and salaries
Use of the project output (external)	Reduce environmental impact (low energy use, use or produce renewable energy, reduced emissions)	Payback of investments	Support equal opportunities, support development in desired direction

1.2. Sustainability and Railways

Gudmundsson and Höjer [19] cite four basic pillars for sustainable development in the transport sector:

1. Secure a natural resource base within critical loads, levels, and usage patterns.
2. Maintain the option value of the capital base (natural, human, and man-made) for future generations.
3. Improve the quality of life for individuals.
4. Equality in the distribution of quality of life.

The pillars encompass all three aspects of sustainable development—social, economic, and environmental.

It is a general perception that travelling by train is a sustainable form of transportation. According to Statistics Norway [20], airplanes use seven to eight times as much energy as the train, per passenger-kilometre. A modern car is considered to use three times as much. In addition, most of the energy used for rail transport is electricity. Fifty percent of the EU rail network is electrified [21]. The proportion of electrified track in Norway is almost 59% [22]. One of the reasons for this is access to hydropower [19]. Bane NOR [23], the company responsible for the Norwegian railway infrastructure, points out a number of environmental benefits from using trains over other means of transport. Besides high energy efficiency, there are low greenhouse gas emissions due to the use of electric trains, efficient land use, and no local pollution.

The construction of railways has large impacts on the environment, even though railways themselves are emissions-efficient [24,25]. According to Bane NOR [23], construction represent 76% of greenhouse gas emissions in rail projects. In total, this amounted to 117,800 CO_2 equivalents in 2016. Environmental impacts include production emissions from electricity and material use, energy consumption for infrastructure and train production, collision with animals, preservation of cultural heritage, noise and vibration, land use, contaminated land, and litter along the railway [25]. There are several environmental impacts that can be related to the construction of railway infrastructure. Energy consumption, climate gas emissions, impacts on biodiversity, noise, and pollution are examples of such environmental impacts.

Emissions mainly come from construction equipment and transport, while indirect emissions are a result of production emissions of materials, such as concrete or steel. O'Toole [26] points out that even though train transport saves a lot of energy and has low emissions, the construction of railway lines uses large amounts of energy and emits significant amounts of greenhouse gases. In many cases, it will take decades before the saved energy makes up for the energy costs and emissions construction.

To be able to assess the individual railway infrastructure in a lifecycle perspective, emissions are considered as an "expense" in the climate accounts. In this way, one can, thus, consider projects based on a payback period, that is, the time it takes for the project to yield a net climate gain [25]. Primary positive environmental effect of constructing new railway lines comes from transfer of traffic from road or air to rail [27,28]. The economic footprint can be defined as the economic impact of the railway considering gross value added, job creation, and other financial variables, both directly and indirectly. Rail transport

creates significantly more value in the EU's economy than both air and water transport according to Molemaker and Pauer [21]. The authors go on to state that the importance of rail transport is not only reflected through the number of passengers and freight volumes but depends on different economic effects. The direct effects are created by rail transport itself and include other job creation, both as a result of transporting goods and persons from A to B and the values created as a result of such activities.

The indirect effects are created through upstream supplier relationships, which include value and jobs created through services such as train production, maintenance, or repairs. Finally, Molemaker and Pauer [21] point to other induced effects, which are related to value created as a result of workers making money directly from work railway. In addition, it has been pointed out that there are a number of effects on the economy related to rail, such as changes in population density.

1.3. On Balancing Control and Flexibility in Projects

According to Olsson [29], Szentes and Eriksson [30], and Eriksson, et al. [31], among others, changes are inescapable in complex construction projects as a result of factors such as unpredictable weather and ground conditions, prices, duration of activities such as fabrication and installation, poor design solutions and incomplete drawings, clients' learning curves, and following scope changes. This necessitates a shift from the control-focused approaches of project management in the construction industry to more organic approaches, as discussed by Johansen et al. [32]. Previous studies have identified three key management practices that contribute to flexibility in complex projects: increased collaboration among stakeholders, exploratory learning, and adaptation [31]. Exploratory learning can be achieved by performance feedback in construction projects. Pesämaa et al. [33] found that that performance feedback has significant positive effects on construction process performance. As described by Osipova and Eriksson [34], flexible project management approaches have an adaptation perspective in order to accommodate changes. Adaptation means continuous optimization and modification of plans, technological solutions, and aspects of the conceptual solution as the project unfolds and new knowledge is obtained [35].

2. About Large Governmental Investments in Norway

In the following, we briefly present the framework for large governmental investments in Norway. This framework serves as context for the study, and documentation related to the framework is a main source of the data we use.

2.1. The Project Model for National Investment Projects

The Government is responsible for the development and selection of projects and proposes prioritized projects during national assembly's budgetary processes in Norway. National project with an estimated cost above the threshold value must follow requirements for assessment, planning, and quality assurance in line with the state's project model (Figure 1).

The planning process for large governmental investment projects consist of processes on the local, regional, and national level. The responsibilities at the local and regional level are primarily consisting of development of zoning and plan for land use, in which the Environmental Impact Assessments (EIA) is also integrated.

This study is focused on the project selection process, when several alternative project scenarios are still eligible, i.e., the concept definition/decision phase from the decision to investigate a potential project idea in the form of a structured project to the first decision gate, in which Government decide on the project concept and provide funding for the pre-project phase.

The Norwegian QA scheme for large, national public projects is thoroughly described by Volden [36]. According to Klakegg and Volden [37], Norway is a pioneer in the area of structure-based governance of public projects. The QA scheme begun as a measure for cost control in investment projects but has developed to include front-end choice of project

concepts, which include economical sustainability considerations and long-term effects of projects.

The QA scheme was introduced and applied to all the largest state-funded investment projects across sectors in 2001, with external quality assurance of the planning documents as the essential element. All public investment projects with an estimated cost exceeding 1000 million NOK are included in the quality assurance scheme of large governmental investment projects.

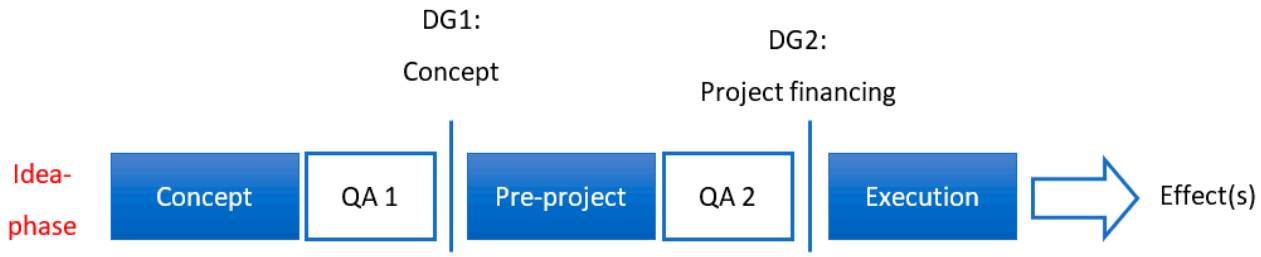

Figure 1. The Norwegian project model for large public investment projects (adapted from the Ministry of Finance [38]).

The quality assurance of large governmental investments in Norway includes two key decision points, respectively, QA1 and QA2, where the former is quality assurance of conceptual evaluation (CoC) before the Cabinet decision to initiate a pre-project. The latter is quality assurance of cost estimates of the project along with at least two alternative scenarios.

2.2. The Concept Definition Phase (CoC)

Norwegian Ministries and underlying departments and agencies, such as the national rail administration Jernbanedirektoratet, prepare the choice of concept (CoC) documentation during the project concept phase. The choice of concept documentation must include the following chapters:

(1) Problem Description: The problem description should explain an unresolved issue and present arguments to support that it is in the population's interest to address the issue(s). The description should include details on the scope of the problem and how serious it is and present an overview of affected actors and stakeholders. The problem description should not present proposed solutions. Additionally, the problem description must include both today's perspectives along with those that are expected to arise due to future development. The problem description should also include an assessment of the root causes of the problems.

(2) Needs assessment: The needs assessment provides insight into the width of specific needs associated with the project initiating issue described in the problem description. The assessment takes on the point of view of society in general. It maps out the interests of relevant stakeholders and actors in a stakeholder analysis. The analysis identifies actors affected by the issue and reveal potential conflicts of interest. The analysis must include an assessment of the importance of the various identified needs and provide guidance as to how these will be treated in the process.

(3) Strategic goals: Founded in the preceding chapters, goals for the project consequences are presented. Two goals or sets of goals are presented; goal(s) from the societal viewpoint and goal(s) from the users' point of view (effect goal). The societal goal is long term and founded in general policies put in place to drive society in a wanted direction.

(4) Framework for concept selection: The framework consists of conditions rooted in the preceding chapters and a set of non-project-specific goals, targets, and general principles of wanted development. The framework will define the opportunity space of potential project concepts.

(5) Feasibility assessment: Alternative project concepts within the opportunity space are evaluated to identify the best-suited solutions for further development. Less fitting

alternatives are left behind without investing significant resources in developing them beyond the point necessary to identify them as inferior to other concepts.

(6) Alternative analysis: The two most realistic and interesting project concepts along with the basic alternative (minimal, realistic investment) are further developed with a complete socio-economic analysis. The analyses must include monetized cost and benefits, as well as non-monetized effects.

The results of the analysis, which also includes an assessment of goal fulfilment for each alternative, provide a ranking of the three alternatives. A recommendation of which alternatives (if any) should be put forward for further development concludes this part of the report.

(7) Guidelines for the pre-project phase: Significant insight into a range of aspects of relevance for a potential project is generally gathered throughout the choice of concept phase. The insight forms the basis for the guidelines for the subsequent pre-project phase. The guidelines should include recommendations on contract strategy, benefit realization, important interfaces with other projects and activities, and project management (including key competence needed in the project team).

2.3. Sustainability in the Concept Definition Phase (CoC)

Sustainability is not the primary subject of any sections of the Norwegian choice of concept documentation. However, due to the central position of sustainability, climate change, and environmental concerns in the political debate (and stated political goals and policies), fragments of sustainability are treated throughout the documentation. The project model is itself the result of the need for economically sustainable public finances, whereas environmental sustainability is included in most concept definition processes via the strategic goals (step 3) and as part of the cost–benefit analysis (CBA) in step (6).

The cost–benefit methodology is the most widely used tool to assess public investments in infrastructure as of today [39]. The methodology of CBA is not the subject of this article as thorough textbooks and introductions to the methodology are readily available in scientific literature, such as in [40–43]. A few points on sustainability and CBA are worth noting, however.

Most of the posts on the cost side of the CBA are easy to calculate. The benefits may be harder to measure. Normally, the most important benefit of infrastructure projects is travel-time savings [42]. Factors related to environmental sustainability, such as savings in carbon emissions, are handled differently in different countries. Olsson, Økland, and Halvorsen [42] go on to present how the Norwegian and Danish guidelines on CBA for infrastructure projects use the price of CO_2 quotas on the international market for global climate emissions, fixed at the time of the publication of the guidelines. The British methodology uses the shadow price of carbon as presented by DEFRA [44], including a year-on-year adjustment in the cost of future emission due to an assumed rise of 2% per year as the concentration of carbon in the atmosphere rises. Swedish methodology also uses a cost factor set by a panel of experts. The cost factor in Swedish methodology is, however, not adjusted during the appraisal period.

The transfer of traffic from road to rail is a declared goal of both the EU and many individual governments, including Norway's [45], and is, thus, frequently stated as one of the relevant strategic goals in step 3 of the concept definition phase. Another set of potential strategic goals derives from international agreements and commitments such as the Paris agreement. As the goal of the transfer from road to rail primarily is driven by expectations that such transfers will contribute to reductions in global climate emissions, including both as strategic goals constitutes double counting.

2.4. Quality Assurance 1 and Decision Gate 1

The quality assurance scheme is an integral part of the Norwegian national project model introduced to ensure economically sustainable investment projects and public finances. Whereas the concept choice documentation in most cases are prepared by govern-

mental agencies on behalf of the respective ministries (such as the Ministry of Transport in the case of railway projects), the QA assurance is executed by pre-qualified external consultants [1]. The consultants are commissioned by the Ministry of Finance and the ministry responsible for the investment. The groups typically include a combination of consultancies specialised in project management and consultancies or research institutes with special competence in socio-economic analysis. The consultants review documentation and investigate consistency and realism [46]. In particular, they assess the concept evaluation documentation and to what extent the project documentation includes an analysis of different relevant alternatives.

The external QA consultants evaluate the documentation with special emphasis on internal consistency, relevance of the evaluated project concept, and the validity of the stated problem definition, needs, goals and framework, and the exploitation of the available opportunity space. The QA consultants produce an independent uncertainty analysis and their own alternative socio-economic analysis of the alternative project concepts.

3. Materials and Methods

The analysis is based on triangulation between different methods and data sources. Key data sources have been interviews and project documentation. The project documentation is analysed both on a detailed level, using word counts, and on a more general level to identify the topics and approaches of the documents. In particular, two types of documentation are used: CoC and QA1. These documents address the same project but from different perspectives, as the latter is a critical review of the former.

3.1. Selection of Case Projects

The study combines perspectives from project management, governance, and sustainability of railway infrastructure projects. A total of 10 railway projects have been the subject of the study. None of the projects in the study have been finalized, as no railway projects that have been the subject of quality assurance of concept choice (QA1) have been completed to this date. An overview of the projects included the study is presented in Table 2.

Table 2. Overview of selected case projects.

#	Project	Type of Project	Year of CoC	Year QA1	Scheduled Completion
i	InterCity Oslo–Halden	Rail	2012	2013	2034
ii	InterCity Oslo–Lillehammer	Rail	2012	2013	2034
iii	InterCity Oslo–Skien	Rail	2012	2013	2032
iv	Arna–Bergen	Road/rail	2007	2008	2024
v	Dobbeltspor Sandnes–Nærbø [1]	Road/rail	2012	2012	Undecided
vi	Ringeriksbanen	Rail	2008	2015	2029
vii	NordlandsbanenStjørdal–Åsen [2]	Road/rail	2011	2012	Stopped
viii	Grenlandsbanen	Rail	2016	2017	Stopped
ix	Østre linjes forbindelse til Oslo	Rail	2015	2016	Undecided
x	Voss–Arna	Road/rail	2014	2014	Undecided
xi	Follo line [3]	Rail	-	-	2022

[1] Included in choice of concept (CoC) and QA1 for project "Transportation system at Jaeren"; [2] included in CoC and QA1 for project "Transportation solution for road/rail Trondheim—Steinkjer"; [3] exempt from requirements of documentation of choice of concept and QA1.

Both qualitative and quantitative data have been collected from the documentation produced in the concept phase (documentation of choice of concept) and the quality assurance reports (including appendixes). The qualitative aspects of the documents serve mainly as background input, with the exception of the documents from Follo line. The case of Follo line constitutes an 11th case and serves as an in-depth case where additional documentation such as QA2, the environmental impact assessment (EIA), environmental management plan has been reviewed. It has, however, not been the subject of the choice

of concept and quality assurance of concept (QA1), as the project was further along in development at the introduction of QA1 in 2005.

Railway infrastructure projects consisting primarily of logistic hubs and freight terminals were excluded from the study to ensure a sufficiently homogenous sample of projects. Seven of the projects are railway-only projects, while four projects are combinations of road and rail infrastructure, in which the railway infrastructure and road infrastructure are built in tandem.

3.2. Document Analysis

The document analysis utilizes a method described by Stendebakken and Olsson [47] consisting of a three-step process of (1) identifying relevant keywords, (2) performing automated searches, and (3) evaluating each hit. The documentation produced in the concept development phase and QA1 process is very extensive and well suited for automated and semi-automated analyses.

The keywords used are presented in Table 3.

Table 3. Selected keywords. * signifies several versions of the keyword were included in the search.

General Sustainability	Economic Sustainability	Environmental Sustainability				Social Sustainability
Sustainability	Efficiency *	CO_2	Compenc *	Natural areas	Area *	Urban environment
Sustainable development	Productivity *	Emission	Nature management	Noise	Impact	Urban development
Viable *	Benefit	Fossil *	Pollut *	Cultivation	Cultivated land	Development
Future *	Profitability	Electric	Protect *	Agriculture	Consequence	Cultural heritage
		Environment *	Biodiversity	Renewable		Mobility
		Wetland	Climate	Energy		Availability

The word-count-based document analysis used in this study is an application of content analysis. According to Stemler [48], content analysis is "a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding". There are several different approaches to content analysis [49]. Riffe et al. [50] describe how content analysis is commonly applied in the analysis of media messages, a practice that has been fuelled by the growth in internet related data. Content analysis can help researchers to analyse large volumes of text [48]. According to Weber [51], content can be a useful technique for allowing us to discover and describe the focus of individuals, groups, or social attention. It offers researches an opportunity to complement qualitative research with more quantitative approaches, which we had the ambition to do in this study.

There are recent examples of text analyses used in research with similarities to ours. Lewis and Young [52] describe the use of language processing applied in corporate reporting. In a public management context, Mackieson et al. [53] used thematic analysis to study official records of parliamentary debates in the Australian State of Victoria. One innovation point in this study is the use of such text analysis in project investment decision documents, which as far as we know, have only been done to a limited extent. The text analysis is possible, because we have access to a relatively large and consistent set of documents. An advantage of our applied method is that the project analyses can be studied in detail for relatively large document volumes. Stemler [48] discusses limitations of word counts and points to two key challenges: errors in definitions of categories and the use of non-mutually exclusive categories. We addressed the first challenge by doing a separate analysis of to what extent selected words were used in a substantial context. Related to categories, we have grouped the words into the three categories of sustainability but also shown the counts for the individual the key words. This was possible given the relatively limited

number of key words and categories. To not be overly focused on written text, the study also includes interviews, described in the following.

3.3. Interviews and Selection of Candidates

The qualitative data have been collected in semi-structured, in-depth interviews with key informants in the rail industry. In-depth interviews are one of the most widely used data collection techniques [54]. A total of 12 interviews were conducted as part of the study, of which 9 were conducted in person and the remaining three interviews were conducted via telephone. The interviewees had in general extensive experience from developing and managing railway infrastructure projects. Their experience ranged from seven to more than thirty years.

Prior to the interviews were conducted, an interview guide was made and tested in line with the recommendations of Halvorsen [55]. The interview guide was quite detailed, consisting of a series of open-ended questions. Although the questions were formulated in advance, respondents were free to elaborate freely about relevant topics and venture beyond the intention of the questions. The guide also served as a reminder of the themes that every interview was intended to cover.

Open-ended questions can also make the analysis complicated, due to the fact that the respondents will interpret questions in slightly different ways. The answers will, thus, not be directly comparable and make comparative analysis more difficult [54]. On the other hand, as most respondents worked in a similar environment and with closely related tasks, they are also likely to interpret the questions largely in a consistent manner.

A total of 12 people were interviewed. The interviewees all play key role in the development and management of railway projects and other governmental investments, and the areas of responsibility range from early phase to the execution phase in projects. Some of the respondents are in positions of higher administrative responsibility. The variation of different hierarchical positions and roles among the respondents has contributed to a mix of "bird-eye view" and "finger on the pulse of the problem" perspectives. A summary of the respondents' role is presented in Table 4.

Table 4. Overview of interview respondents.

Position	Employer	Duration	Medium
Engineering Manager	Bane NOR	25 min	Telephone
Project Manager	Consultancy	45 min	In person
Employee	Bane NOR	26 min	Telephone
Project Manager	Bane NOR	40 min	In person
Project Manager	Bane NOR	23 min	In person
Project Manager	Consultancy	45 min	In person
Environmental coordinator	Bane NOR	18 min	Telephone
Master of Science	Consultancy	43 min	In person
Discipline lead environment	Bane NOR	45 min	In person
Employee	Railway Directorate	55 min	In person
Employee	Railway Directorate	50 min	In person
Project Manager	Consultancy	40 min	In person

Thorough summaries were made from all the interviews. The summaries were subsequently sent to the interviewees for review and approval. All interviews have been made anonymous in the analyses.

3.4. Case Study

To add further insight and understanding of sustainability in railway projects, a deeper investigation into the case of the Follo line has been executed. The case of the Follo line has not been the subject of the current project model, as it was at a later stage of development when the QA1 was introduced in 2005.

The rationale for choosing this particular project is a combination of several factors. Firstly, it is the largest transport project currently being executed in Norway [56]. Secondly, Follo line is a pilot project for the use of environmental accounts in the project execution. Environmental accounts may be introduced in all national transport infrastructure projects across transportation modes in the future, making it an especially relevant case relation to the issues addressed in this article.

The Follo line is a key part of the InterCity Oslo–Halden developments. The case project has no dedicated CoC or QA1. However, we used CoC and the QA1 reports for the InterCity section Oslo–Halden to investigate the significance of the number of hits on the selected words, because the Follo line constitutes the main part of the Oslo–Halden InterCity project.

All the documents studied in the Follo line case are publicly available. The Project Manager and person responsible for developing the environmental budget were both also among the interview subjects, allowing for additional questioning of details regarding the case.

4. Results

The quantitative analyses are based on the number of hits per keyword as presented in Table 5. Each column in Table 5 relates to the projects listed in Table 2, numbered from i to x. Project i, ii, iii (and xi) were reviewed jointly in one QA1. The most frequently encountered keywords are "environment", by a fair distance with a frequency of 769 hits in the choice of concept documentation and 377 in the quality assurance documentation, respectively; "area" with frequencies of 629 and 214; "consequence" with frequencies of 392 and 437; "nature" with a frequency of 364 and 142, and "efficiency" with a frequency of 335 and 83.

Table 5. Number of hits per keyword in choice of concept documentation and quality assurance documentation for selected railway projects. * signifies several versions of the word have been included in the count.

Keyword	Frequencies per Case (Choice of Concept/QA1)								
	i.–iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	Sum
Sustainab *	0-2-2/0	1/0	0/6	8/0	5/3	7/2	3/0	0/3	28/15
Future *	20-1-4/17	0/3	1/23	3/17	24/13	35/23	27/8	0/13	115/117
Efficiency *	34-27-12/7	52/15	41/10	37/10	42/22	20/1	33/5	27/13	335/83
Productivity *	1-20-6/7	0/0	1/9	0/13	4/7	13/5	0/1	5/7	50/49
Benefit	4-2-1/20	3/2	0/9	1/12	8/4	10/26	7/6	0/4	36/83
CO_2	6-6-9/25	6/0	0/1	2/0	6/7	4/0	0/13	12/6	51/52
Emission	37-33-33/23	12/7	1/11	14/1	25/13	33/23	4/5	0/13	192/96
Environment *	74-69-88/76	78/14	5/47	80/17	110/45	100/101	93/32	72/45	769/377
Wetland	0-4-0/0	0/0	0/0	0/4	2/0	0/0	0/0	1/0	7/4
Compens *	0-5-2/5	1/4	1/1	1/3	0/3	0/0	1/3	5/3	16/22
Nature *	74-39-44/8	12/2	1/15	36/12	35/0	47/0	63/15	53/69	364/142
Pollut *	0-17-5/0	10/10	0/2	3/0	4/3	4/1	0/0	0/3	46/19
Protect *	0-7-3/8	1/17	2/13	1/11	2/5	7/16	1/3	6/5	32/78
Biodiversity	0-1-1/0	0/0	0/0	3/1	5/5	0/0	2/1	0/5	12/12
Climate	26-28-24/21	18/15	0/15	20/0	9/2	22/18	8/1	25/2	180/74
Noise	10-21-8/28	17/4	0/8	12/2	20/14	4/9	47/14	8/14	147/93
Agriculture	1-6-4/0	1/0	0/4	1/1	11/5	9/0	4/2	14/5	52/17
Energy	1-0-0/5	3/5	0/17	6/0	1/3	0/2	0/0	1/3	12/35
Area *	52-48-70/73	38/3	121/37	21/30	72/13	68/31	91/14	48/13	629/214
Impact	0-0-0/0	1/7	4/9	0/3	0/2	2/4	1/11	0/2	8/38
Consequence	34-9-24-/18	27/38	161/180	20/48	33/31	22/75	39/16	28/31	392/437
Business Development	3-1-1/0	5/2	2/0	6/0	6/4	6/4	2/0	2/4	34/14
Cultural heritage	7-8-17/0	5/1	0/0	3/1	17/10	6/11	30/7	0/10	93/40
Mobility	1-0-2/0	6/0	3/1	4/2	5/0	1/0	0/0	1/0	23/3
Availability	19-10-8/0	29/2	37/4	17/0	4/1	18/11	4/0	0/1	146/19

In general, the average frequencies of hits for the keywords are higher in the choice of concept documentation compared to the frequencies in the quality assurance documentation. It is worth noting, however, that the average number of pages of the choice of concept documentation is higher than the average number of pages for the quality assurance documentation. The difference in average frequencies may, therefore, be due to this factor. Some keywords digress from the pattern, namely "consequence", "future", and "energy".

Keywords removed due to low number of hits (<5 occurrences in both sets of documentation) are "viable/viability", "fossil*", "electric/electricity", "cultivation/cultivate", "renewable", "agriculture/cultivated land", and "urban development".

Looking at the frequencies per sustainability dimension, it may come as a surprise that the term "sustainability" itself is mentioned so few times in the documents. In total, it is mentioned a total of 28 times in the choice of concept documentation, and even less frequently with 15 times in the quality assurance documentation. Several of the reports do not mention the general term "sustainability" at all. Words related to environmental sustainability appear much more frequently than the keywords that constitute the other dimensions of sustainability. Even when accounted for the higher number of keywords used in the searches, the emphasis on aspects of environmental sustainability is far greater than for the other dimensions of sustainability (see the columns for average number of hits per keyword in Table 6.

Table 6. Number (#) of hits per dimension of sustainability.

	Total # Hits		**# Hits per Project**		**Average # Hits per Keyword**		**Average # Hits per Keyword per Project**	
	CoC	**QA**	**CoC**	**QA**	**CoC**	**QA**	**CoC**	**QA**
General Sustainability (2)	143	132	14	17	72	66	7	8
Economic Sustainability (3)	421	215	42	27	140	72	14	9
Environmental Sustainability (16)	2909	1710	291	214	182	107	18	13
Social Sustainability (4)	296	76	30	10	74	19	7	2

Even though the keywords associated with environmental sustainability were by far the most frequent, some among them were surprisingly rare. These include keywords such as "CO_2", "renewable", and "emissions". Admittedly, the total number of occurrences of "emissions" does not stand out, yet this is mostly due to it occurring so frequently in the choice of concept documentation for cases i–iii.

There is a significant degree of correlation between the number of hits on a keyword in the choice of concept documentation and the corresponding keyword in the quality assurance documentation. The correlation factor was found to be 0.85, based on the frequencies presented in Table 5. Figure 2 presents a scatterplot diagram of the relationship between the hits in CoC and QA1, based on the sum of hits in the word search.

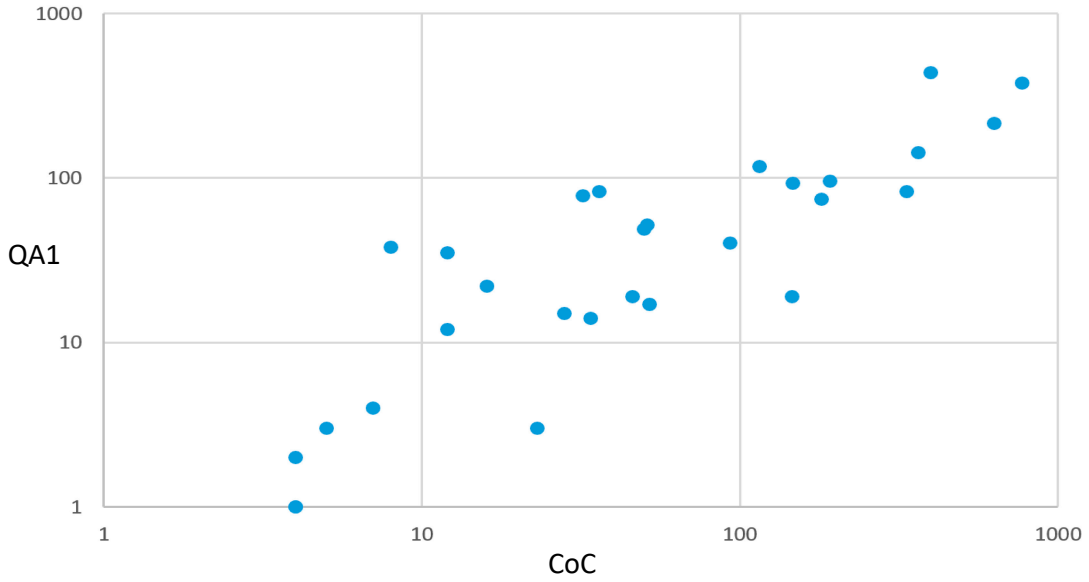

Figure 2. Scatterplot illustrating the number of hits for keywords in the choice of concept documentation and the corresponding keyword in the quality assurance documentation. Take note that the scales are logarithmic.

4.1. Case Study: The Follo Line

In order to evaluate the emphasis on the three dimensions of sustainability in the documentation, an additional investigation was carried out for the case of the Follo line. The project is part of the Inter City section Oslo–Halden and has been under construction since 2010. It is due to open in 2022. The core of the project is a 22 km long railway tunnel connecting central Oslo with suburbs in the southeast. As the frequencies of key words provide little to no insight into the details of how the keywords are used, an additional manual analysis was performed.

The Follo line project is of special relevance with regards to sustainability, and it was the first project to use an environmental budget as an active tool for controlling and evaluating greenhouse gas emissions during construction. It is expected that the environmental budget will become a requirement in all national infrastructure projects in the longer term.

The construction of the tunnel accounts for the largest emissions in all impact categories. Construction and maintenance make up a total of 90% of greenhouse gas emissions during the construction phase. Steel, cement, and concrete each makes up about a quarter of the potential greenhouse gas emissions and accounts for almost 75% of the total emissions in the tunnel construction.

The project has also produced an environmental follow-up plan (MOP) to handle and manage environmental issues during the construction. The MOP is a systematic follow-up of the following environmental considerations: landscape and visual environment, natural diversity, cultural heritage and cultural environment, health, well-being and outdoor life, natural resources, noise and vibration, emissions to air, water and soil, waste management, material selection and energy use, sentences, and mass stability.

Tunnel boring machines (TMB) are actively used in the Follobanen project to construct the tunnel partly due to the environmental benefits vis-à-vis using large amounts of explosives. During the construction of the tunnel for the Follo line, approximately 11 million tons of rock will have to be displaced.

The benefits from the project once completed are a transfer of passengers and freight traffic from road to rail that leads to reduced greenhouse gas emissions, as well as potential for a reduction in the number of traffic accidents. There will be improved railway connections, both in term of frequency and travel time and, thus, an extended housing and labour market in the region.

The manual analysis of the CoC documentation and QA1 documentation for the Follo line used the keyword hits as a starting point but added the classification of hits into hits with substance and without substance (in addition to the group of false hits), shown in Table 7. Hits were evaluated as having substance in the cases where the mentions of sustainability keywords were part of a larger argument connecting sustainability with the choice of project concept. On the other hand, hits were deemed without substance when the keywords were left unconnected from any discussion relating to the choice of project concept. Admittedly, such an evaluation easily becomes subjective. In cases of doubt, keywords that provided a clear conclusion or message of sustainability were included in the "substance" category, even though they were not part of the choice of project concept discussion of the section in which they were found. False hits were mentions of sustainability keywords that were either not part of the main document (such as headers and footers) or hits in which the meaning of the word was not sustainability related (such as cases were the keyword was part of another word with a different meaning).

Table 7. Overview of use of keywords with and without substance in CoC and QA1, which included the Follo line. * signifies several versions of the word have been included in the count.

	Keywords Used without Substance		**Keywords Used with Substance**		**False Hits**		**Percentage of Use With Substance**	
	CoC	QA1	CoC	QA1	CoC	QA1	CoC	QA1
Future *	5	12	14	3	1	2	70%	18%
Efficient *	3	1	28	3	3	3	82%	43%
Productive *	0	2	1	5	0	0	100%	72%
Profitable	2	6	1	10	1	4	25%	50%
CO_2	0	3	22	22	1	0	83%	88%
Emission(s)	6	2	25	17	6	2	68%	74%
Environment	4	1	54	65	16	10	73%	86%
Nature *	3	0	26	1	5	7	76%	13%
Protect	2	0	0	0	0	8	0%	0%
Climate	2	1	20	8	4	12	77%	38%
Noise	1	0	9	28	0	0	90%	100%
Energy	0	2	1	2	0	1	100%	40%
Area	10	16	36	32	6	25	69%	44%
Consequence	13	10	17	4	4	4	50%	22%

In the CoC documentation for InterCity section Oslo–Halden, a clear majority of sustainability related keywords (16 of 21) are mentions with high percentage of hits with substance (>66% of hits with substance). The keywords with especially high degree of substantive hits (>83%) as well as the keywords with low degree of substantive hits are both characterized by low number of occurrences.

"Environment" was the most common term and was evaluated as having substance in 73% of the occurrences in CoC documentation and 86% of the occurrences in QA1. Climate-related keywords, such as "CO_2" and "emissions", were used in a substantial context between 68% and 88% of the time in both types of documentation. Of the most frequently used keywords, "consequence" had a lower ratio of use with substance in both the CoC documentation and the QA1 documentation.

4.2. Interviews

The interviews revealed that the understanding of the concept of sustainability was quite uniform among the respondents. Several interviewees pointed out that "sustainability" or "sustainable development" is tightly coupled with a long-term perspective. However, the majority of respondents also revealed that their interpretation of the concept was primarily linked with the environment and climate change. Several of the respondents proved of their own accord that they had knowledge of the division of the term in the form of social, economic, and environmental sustainability, yet the environmental issues always

remained the main focus in practice. The evaluation of project concepts includes mandatory elements such as greenhouse gas emissions, land use and protection of land areas, management of natural resources, and natural diversity. Several pointed out that there is little room for adding other sustainability related argumentation that is not part of the mandatory elements. Adding new elements to the argumentation is understood to provide low potential for influence compared to the pre-defined mandatory subjects for evaluation.

In addition, several respondents emphasized the difficulties of evaluating overall sustainability. In their opinion, there is no consensus in the industry over what sustainability is. It is, therefore, difficult, if not impossible, to measure and differentiate the overall sustainability of alternative project concepts.

All the candidates agreed that there has already been great development in the importance of sustainability in recent years, and that it seems likely that the trend will continue. The experienced development takes on the form of new requirements, laws, and regulations, but also a growing focus in the general population and, thus, a stronger motivation to act more sustainably.

Although the respondents had a shared understanding of sustainability, there was, nevertheless, significantly different opinions of whether it is profitable to act sustainably (in the case of railway infrastructure investment projects) and whether it will be profitable in the future. When asked how candidates think the focus on sustainability will evolve over time; most expected that sustainability is becoming an increasingly important element in the construction industry.

With regards to the planning and implementation phase of projects (the subsequent phases after deciding on the preferred choice of project concept), the opinions were somewhat spread on how social, economic, and environmental sustainability impacts the projects. While some meant that environment has a minor role in these phases, others believed that greenhouse gas emissions and other environmental challenges were among the most important elements in the planning and implementation phase. Relevant issues include reducing CO_2 emissions from material use such as concrete or steel, as well as fossil-free construction machinery, and an ambition of fossil-free construction sites.

Efficient use of space was also highlighted by several candidates, i.e., minimizing the space occupied both in the construction phase and after the new infrastructure is in operation. This was also highlighted as a challenge throughout the CoC phase, because the evaluation of efficient use of space is qualitative, which makes it difficult to document the benefit, or differences in benefit, resulting from various project concepts.

There were different opinions among the respondents considering whether or not railways can be considered sustainable. Some respondents believed that choice of line location, protection of natural areas, transfer of traffic from cars and air traffic to rail, and electrified railways are sufficient enough to claim that the railroad is sustainable. Others pointed to the long payback period in terms of CO_2 emissions from the construction phase as a challenge for staking such a claim. The way railway projects are interconnected with the functioning of society in general complicates the evaluation. A prime example is the location of new stations, of which many respondents pointed out is less a question of sustainability and more a question of economics and politics.

Asked what could make the rail sector more sustainable in the long run, a large proportion of the interview candidates agreed that the initiative must come from the authorities, and then be made explicit in the form of laws, rules, regulations, and requirements.

Several of the interview candidates also believed that it is the contractors and suppliers who are the biggest contributors to the ongoing increase in attention to sustainability, especially with regard to greenhouse gas emissions in the construction phase. The findings from the interviews are summarized in Table 8.

Table 8. Summary of findings from the interviews.

	1	2	3	4	5	6	7	8	9	10	11	12
Sustainability in general												
Long term	X		X	X								
Primarily environmentally focused		X		X	X					X		X
Difficult to define		X	X		X	X	X	X				X
Lack of consensus						X	X		X			X
Sustainable development												
Increase in attention	X						X			X	X	
Importance will increase further	X	X	X	X	X	X	X		X	X	X	X
Sustainability will be profitable in the future			X	X							X	
Sustainable development is a cost driver		X								X		
Importance of sustainability in project concept evaluation												
CoC and QA1 contribute to increasing attention to sustainability	X							X				X
The most important decisions concerning sustainability are made in CoC and QA1 phases of the projects								X		X		X
Efficient use of space/areas				X								X
Sustainability and railways												
CO_2 in construction phase					X				X	X		X
Prioritization of infrastructure projects are made on wrong or insufficient foundation						X					X	
Need for more focus on cutting emissions							X	X				
Railways are by definition sustainable								X	X		X	
Which actor has the primary responsible for increasing attention and weight assigned to sustainability in project evaluation?												
The Government/authorities	X			X	X	X	X	X			X	
All the actors in the industry										X		X
The project owners									X			

5. Discussion

The interpretation of the word "sustainability" was quite uniform among the interviewed subjects, and heavily skewed. Even though several subjects were aware of both the Brundtland definition of sustainable development and the multi-dimensional nature of the concept, it became clear that the environmental dimension was predominant. This is by no means uncommon, as has been pointed out by several authors ([9–13]).

This is due to several factors, one being the complexity and the scope of the term itself, illustrated by the UN's 17 sustainability goals, and the associated 169 targets [57]. As the concept is so large and complex, it becomes difficult for practitioners to relate to the different aspects and their relationship with the specific project they are working on. Rather than evaluating overall sustainability of the project concept under consideration, a selection of mandatory elements related to sustainability become subjects of the analyses. The term "sustainability" itself, therefore, becomes little used at the micro level. This becomes evident in the document analysis, which shows the word "sustainability" was at most mentioned eight times in the evaluated CoC and QA1 documentation.

Several of the interviewed subjects pointed out that the term sustainability largely functioned as a political overarching term of which some elements can be measured, but not the overall sustainability of a project concept. However, there was a desire for developing or implementing a method to measure the sustainability of a project.

The predominance of the environmental dimension of sustainability of the interviewed subjects is reflected in the evaluated CoC and QA1 documentation. Keywords associated with environmental aspects of sustainability had a higher number of occurrences than the keywords associated with the economic or social aspects of sustainability. Overall though, it can be argued that the economic dimension of sustainability is the most prominent in the documentation, as the introduction of the QA1 in the national project model and the

requirements for the CoC documentation are rooted in the Ministry of Finance's guidelines. The documentation provides clearly stated evaluations of the economic and financial effects of the project concept alternatives, in line with the rationale for introducing the model. The role of CoC and QA1 with regards to the economic dimension of sustainability does not appear to be included in the interviewed subjects' interpretation of sustainability.

Some of the keywords associated with environmental sustainability, such as "environment", "climate", and "consequence" had in both CoC and QA1 a somewhat lower percentage of hits with substance than other keywords, which may also indicate that these words are used more loosely in the documentation, without being part of the argumentation. This can also support the claim that there is a wish for adding more emphasis on environmental sustainability when developing the recommendation of a project concept.

It is a general perception that railway projects represent sustainability. Several authors (e.g., [19,21,23,25]) highlight examples of environmental benefits of the railway, such as limited or no CO_2 emissions from transport with electric trains, efficient land use, and the absence of local pollution. In addition, analyses such as for the Follo line illustrate the long-term effects from transfer of transport from road to rail and economic sustainability in the form of increases in the housing and labour market. These analyses have come under some criticism, as the calculations of future savings in emissions are based on static projections. Olsson, Økland, and Halvorsen [42] pointed out the limitations of using the carbon price of today for evaluating the cost of emissions 40 years from now. A special commission for smart mobility appointed by the Norwegian Government added the argument that emission savings of railway transport 20, 30, and 40 years from now should not be based on comparisons with emissions from road transportation of today, due to the rapid electrification of road transport [58].

There is an important connection between the preparations and planning of a project and the sustained effects. We have manly studied the early preparations for the projects, but we also mapped how practitioners planned for sustained effects, mainly in construction and to a lesser extent in the railway traffic planning.

The construction phase of railway projects entails substantial emissions of greenhouse gasses [23,25,59]. Still, the document analysis of CoC and QA1 documentation showed a low proportion of hits for the keyword "CO_2" and "emissions".

The direct greenhouse gas emissions are mainly due to use of explosives, construction equipment, and transport, while the indirect emissions are the result of production emissions of materials such as concrete and steel [25]. The analysis of Follo line shows that Bane NOR has developed and implemented a method for accounting for both direct and indirect greenhouse gas emissions during the construction phase, through an environmental budget and environmental accounting. The preparation of the environmental budget is based on a life cycle assessment of the project. The environmental budget as of today is not included as part of the basis for decision making for project funding in QA2. There are also no requirements for public hearings in relation to the individual infrastructure projects prior to political decision making.

The limited role of environmental sustainability in evaluating project concepts contrasts the Paris Agreement's goal of keeping global warming well below 2 degrees compared to 1990 levels and Norway's commitment to cut greenhouse gas emissions by 40% by 2030 [60]. The National Transportation Plan for 2018–2029, a rolling document summing up the approved transport policy, state that the Government will ensure that the transport sector contributes to the fulfilment of Norway's climate policies. The transport sector accounts for about 60% of non-quota obligations emissions in Norway. The interviews revealed that action has already been taken at the operative level for current projects in the execution phase. For example, active measures are being taken to reduce greenhouse gas emissions in the rail project Tønsberg–Skien. The development is driven mainly by requirements from the authorities. Still, limiting emissions and strong environmental focus in the construction phase may be of lesser potential than adding more emphasis to these factors in the earlier project phases.

Fossil-free construction sites are a much-discussed topic in both theory [60] and in the interviews. Construction machinery mainly uses fossils energy and accounts for a large proportion of the pollution that occurs during the construction phase [25]. The analysis of the Follo line project showed that measures have been taken to optimize the power supply at the construction site, so that the possibility of using electric machinery is present. Nevertheless, it was pointed out in the interviews that the responsibility for that development in this area lies with the authorities. The suppliers and contractors in the construction industry are ready for the transition from fossil to renewable energy. However, the prerequisite is that the transition has to be profitable. It is, therefore, likely that significant changes in this area will not happen until there are clear governmental requirements for fossil-free construction sites.

Infrastructure projects such as railways will be in use for a long time and will, therefore, affect future generations for a very long duration; first, through the use of the new infrastructure. Subsequently, the investments may reduce the likelihood of future investments in other forms of infrastructure that utilize technologies that are not mature today. This is one of the key reasons that the Ministry of Finance introduced the QA regime, including QA1 and CoC, which have been studied here. Both direct and indirect effects of the railway are addressed in a long-term perspective even though the level of uncertainty is highly significant in the early phases of such projects. For railways, direct consequences include economic growth as a result of greater housing and labour markets and better mobility and accessibility for the population. Indirect effects include lower incidence of traffic accidents and a lowering of greenhouse gas emissions resulting from the transfer of both person and freight traffic from road to rail. We have studied how this is done in the front-end of projects. In addition, it is important to evaluate actual sustainability performance of these projects, and such evaluations are being prepared (Volden, 2018).

6. Conclusions

The main purpose of this article has been to map how sustainability is addressed in the early project phases of Norwegian railway infrastructure projects. The early phase project phases of infrastructure projects in the Norwegian national project model consists of an informal idea phase followed by a structured concept phase (choice of concept, CoC) and an external evaluation of the documentation from the CoC, the Quality Assurance 1 (QA1). Interviews with 12 practitioners with experience of these phases of infrastructure projects along with document analysis of the documentation from 12 projects' early phases show that the environmental, social, and economic sustainability dimensions are accounted for in these processes. There is, however, no explicit requirement for an overall assessment of sustainability in either the CoC or QA1. The environmental aspect of sustainability is given a greater emphasis by volume, or number of occurrences of keywords, than the other dimensions of sustainability. Still, the CoC and QA1 requirements are designed to provide information about the economic sustainability of alternative project concepts and cover this dimension much more thoroughly than the environmental and social dimension. The interviewed subjects interpret the weight assigned to the economic dimension of sustainability to be much greater than the environmental and social dimensions of sustainability in the subsequent decision gate for financing of pre-project.

There are no explicit requirements for general sustainability evaluation in the CoC and QA1 documentation. A potential reason is the challenge of assessing non-monetized effects. These effects are evaluated based largely on subjective judgement or relative rankings of isolated aspects of sustainability for alternative project concepts. These judgments are difficult to transfer to discussions between alternative projects, such as a railway link in one geographic area versus another geographic area. A lack of consensus on the concept of sustainability has led the interviewed subjects to consider sustainability to be an overarching political term, and it is used to little extent at the micro level.

The study, and in particular the interviews, highlights the need for the authorities to set sustainability standards. Major further development areas will not materialise unless

there are clear governmental sustainability requirements, for example for fossil-free construction sites, but also for other societal needs. To achieve a sustainable development, it is not enough to hope for a general development in the society, it is the involved organisations that need to take an active role. For railways, governmental agencies and ministries are key, both as clients for construction and other procurement, but also as regulating authorities.

Combined, these factors contribute to the selection of project concepts for further development that are not necessarily the ones that provide the greatest benefit to society or are the most sustainable. Environmental and social sustainability are addressed in detail in the subsequent project phases illustrated by the case study of environmental budgeting. The emphasis on sustainability in the construction phase may ensure the most sustainable execution of the particular project concept. However, an even more sustainable alternative project concept may have remained undeveloped as the result of limited weight assigned to sustainability when evaluating alternative conceptual solutions of a project in the CoC phase.

We hope that a deep understanding of present practice in railway planning can serve as a foundation for desired sustainability performance of future and ongoing projects. The study is based on mixed methods, including text analysis, which to our best knowledge, has not been widely applied on this topic.

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