

The framing of a sustainable development goals assessment in decarbonizing the construction industry – Avoiding “Greenwashing”

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ABSTRACT

The aim of this paper is to contribute to the establishment of a robust framework for the assessment of Sustainable Development Goals (SDGs) in businesses, using the construction industry as an example and with the primary focus on combating climate change (SDG 13). We provide a critical analysis of a selection of relatively widely used SDG impact assessment tools, combined with a case study from the construction industry to explore how a meaningful SDG assessment can be framed with linkages between SDG 13 and other related SDGs.

Our analysis points towards the importance of framing SDG assessments in a way that discourages “Greenwashing”. Any SDG assessment that relates to climate targets in line with the Paris Agreement should identify the processes and activities that can be expected to be particularly challenging in terms of their abatement. In our road construction work case, we identify four such hard-to-abate activities: 1) introducing biomass for renewable transportation fuels for use in construction equipment and heavy transport; 2) electrification of transport and industrial processes; 3) substitution as part of transitioning from fossil fuel use; and 4) applying carbon capture and storage technologies in the production of basic materials, such as cement and steel. The approach applied will avoid that businesses only focus on SDGs in situations where they are already performing well or can apply low-cost measures or that they only relate to the part of the supply chain that pertains to their own business (Scope 1 emissions). For an SDG assessment to provide basis for informed decisions regarding real change towards more sustainable and equitable corporate practices it should: (i) identify and include concrete measures to align with the terms of the Paris Agreement; (ii) include relevant value chains; and (iii) consider both the short-term and long-term effects of strategic choices.

1. Introduction

In 2015, the leaders and Governments of the United Nations Member States agreed on Agenda 2030, which is a political resolution that proposes a “comprehensive, far reaching and people centred set of universal and transformative Goals and targets” with the aim of being fully implemented by Year 2030. The Agenda includes 17 Sustainable Development Goals (SDGs), together with 169 associated targets [1]. The SDGs and the targets are intended to ‘stimulate action over the next 15 years in areas of critical importance for humanity and the planet’ – while balancing the economic, social and environmental dimensions of sustainable development. The scope and ambition are, undoubtedly, high in that the Agenda brings together international processes and declarations for human rights and protection of the environment within a single

framework, with the vision of moving the world towards a sustainable pathway. The SDGs, which span global challenges such as poverty, health, climate change, injustice and equality, should be viewed as a holistic and indivisible entity.

Agenda 2030 is first-and-foremost a governmental and intergovernmental commitment, although the resolution also acknowledges the importance of involving a multitude of stakeholders from the public, private and civil society towards realization of the SDGs. With the goals in place, attention has shifted to their implementation, towards the development of a sustainability policy, plans and programs at the national level [2]. An important difference between the SDGs and their predecessors, i.e., the Millennium Development Goals (MDGs), is the shift in emphasis, from primarily addressing challenges in developing economies, to identifying challenges and actions for all countries (both

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developed and developing) and societal actors (cf. [3]). Thus, Agenda 2030 acknowledges the mutual interdependence of countries and of different stakeholders in and across countries in the realization and advancement of a global sustainability transition.

Agenda 2030 with its goals and targets also represents a long-term political framework for business to contribute to sustainable development, in describing guidelines for what will be needed, accepted, and supported by societies in the coming decades and, consequently, what will be demanded by the markets in the long term. As an example, Pedersen [4] declares that *“the SDGs most likely represent the best long-term strategic market outlook ever put in front of business”*. Pedersen continues by stating that to achieve the SDGs, most companies will be required to do things differently, and in many cases, to do different things.

Several countries, including EU Member States, require large companies to publish regular reports on the social and environmental impacts of their activities [5, 6]. Indeed, Ioannou and Serafeim [5] have demonstrated that not only do companies make more disclosures in response to these regulations, but they also voluntarily enhance disclosure credibility, for instance by adopting reporting guidelines and obtaining third-party assurance of the reporting. Thus, there has been a trend towards increasing pressure on businesses to act and report on sustainability strategies [7]. Assessing impact is fundamental to evaluating the positive and negative contributions that a business makes towards fulfilling the SDGs [8]. As a consequence, various tools, principles, results indicators, and reporting formats have emerged that enable the measurement and communication of a corporation's approach and contribution to sustainability, as reported by Beloff et al [9], and, more recently, the realization of the SDGs, as evidenced by the range of initiatives brought forward in the Global Goals Business Guide [10].

Nevertheless, a recent company survey on attitudes towards SDGs demonstrated that although half of the companies surveyed acknowledged or had identified priority SDGs, only about one-quarter disclosed meaningful targets and key performance indicators (KPIs), or mentioned SDGs as part of their business strategy [11]. Similarly, Blasco and co-authors [12] found that although 40% of top-level companies acknowledge SDGs in their corporate reporting, only 8% report a business case for action and 10% have set specific and measurable business performance targets related to the SDGs. In addition, Beberman and Unerman [13] found that reporting could be used to camouflage business-as-usual by applying SDG-related sustainability rhetoric. Furthermore, a recent study of the sustainability reports of the 2,000 largest stock market-listed businesses worldwide conducted by van der Waal and Thijssens [14] shows not only that corporate involvement in the SDGs is still limited, but that it is also largely symbolic and intentional in nature, rather than substantive.

In the best cases, SDG assessments provide a tool for informed decisions regarding real change towards more sustainable and equitable corporate practices (i.e., the 10% of companies in [12]). In the worst cases, however, SDG assessments contribute to yet another layer of Greenwashing [8]. There are, for example, indications that companies are tempted to focus their reporting on the SDGs that are related to areas in which they are already performing well or know that they can improve easily, in what is sometimes referred to as “cherry-picking” (see, for example [15]). In a survey of 81 European and North American multinational companies, van Zanten and Tulder [16] found that the companies engage more with SDG targets related to situations in which they can act (“actionable within their value chain operations”) than with those SDGs that they consider not actionable. They also found that the companies related more with SDG targets that “avoid harm” than those that “do good”. Overall, the extent to which there is a true “sustainability aim” in performing an SDG assessment depends of course on the underlying motive for performing the SDG assessment. It is of great importance that the motive for SDG reporting in private companies is genuine, so as to avoid Greenwashing, which is also referred to as

“SDG-washing” [15].

It should also be of importance to define the scope of the SDG assessment in relation to the operations of a company. In a recent report from WWF [17], it has been proposed that companies should include not only the direct operations of the company, but also the goods and services that it provides and the investments it makes along the value chain. This should also be a way to avoid the taking of suboptimal measures that are not sustainable in the long run. The concept of the value chain is linked to the supply chain, which refers to the typically cross-sectoral networks of facilities and distribution channels that facilitate the sourcing and primary production of materials, as well as the further processing and assembly and delivery of products or services to the customer, as described, for example, by Stevens [18]. The value chain concept expresses the value creation and the margin that can be obtained from a certain supply-chain business (see the original work of Porter [19]; and, for example, Mentzer et al. [20] and references therein). The activities along a value chain (and its corresponding supply chain) generate emissions, and if there is a cost associated with these emissions (e.g., as from the EU-ETS), this must obviously be lower than the profit margin of the value chain if the business is to be economically sustainable (cf [21]). The concepts of supply and value chain are applied in the GHG Protocol Corporate Accounting and Reporting Standard [22], which divides the Greenhouse Gas (GHG) emissions from a business into three categories: (i) direct emissions from owned or operated assets (Scope 1); (ii) indirect emissions from purchased energy (Scope 2); and (iii) indirect emissions from events occurring along the value chain in which the company operates (Scope 3). While Scope 3 emissions are typically more challenging to measure than Scope 1 and Scope 2 emissions, they are of importance as they may account for a major share of the carbon footprint of a business [23, 24]. Thus, it is argued, for example by Kesidou and Sovacool [25], that a thorough SDG assessment should preferably include the entire value chain, i.e., cover all the operations along the supply chain in which the business is operating, to avoid sub-optimization.

Here, our starting point is the implication that climate change can undermine the remaining 16 SDGs, while combatting climate change can reinforce all 17 SDGs, as proposed by Fuso Nerini et al [26], among others. Therefore, our study takes its departure from a common setting in which a business is seeking strategies to limit the carbon footprint of their business activities in line with the Paris Agreement, i.e., SDG 13 *Take urgent action to combat climate change and its impacts*. An SDG assessment should, consequently, consider the implications that different climate actions will have for other sustainability goals of relevance, and should identify and explore both synergies and trade-offs [27].

When it comes to climate change, there is obviously a feeling of urgency, as indicated by the goal formulation, since we, as a global community, are running out of time to fulfil the Paris Agreement to limit global warming to well below 2°C. After having leveled off a few years ago, global carbon emissions were again on the rise before the unravelling of the COVID-19 pandemic (cf. [28]). However, without a change in course, carbon emissions will most likely return to the historically high levels when the pandemic recedes – in similarity to what happened following the financial crisis of 2008. Thus, there is a clear and pressing need for a change of course. Based on the analysis presented by Rogelj et al. [29], Rockström et al. [30] have proposed a halving of gross anthropogenic carbon dioxide (CO₂) emissions every decade (from Year 2020 and onwards), together with immediate ramping up of carbon removal to reach net-zero emissions after Year 2050. Although immediate action is required to combat climate change, this may impose a risk of sub-optimal “panic”-type actions, which may not be sustainable in the longer run if other relevant sustainability goals are not considered [31]. A thorough SDG assessment could help to avoid sub-optimal and non-sustainable responses to climate goals and demands from the market. At the same time, it is important that companies should formulate a clear target for their operations that complies with the target of net-zero

carbon emissions in mid-century [24], i.e., not avoiding to set this target by “hiding” behind a number of other SDGs in relation to which the business is doing well or only limiting actions to low-cost actions whereas neglecting all types of actions required to fulfil the target.

The aim of this paper is to explore how an SDG assessment can be framed to increase the likelihood that the assessment will contribute to a transformation of business towards increased sustainability, in particular when setting out with the aim to reduce climate impact (SDG 13). Initially, we review the research literature related to the use of SDGs as a guide for business sustainability transitions. Thereafter, we adopt a multi-pronged approach that identifies and assesses a sample of SDG assessment tools that are relatively widely used. Following on this, we propose a number of key elements related to the framing of an SDG assessment, so as to provide a sound basis (for a subsequent SDG assessment) with focus on the climate agenda. To exemplify this framing exercise, a case study from the construction industry is used to explore how an SDG assessment should be framed to avoid SDG-washing (cherry-picking). The construction industry is chosen because it involves supply chains that include both carbon-intensive basic industry and numerous operations on the way to a completed project.

2. SDGs as a guide in the sustainability transitions of businesses

In the literature, various studies have considered SDG assessments for businesses through case studies. Axon and James [32] have detailed examples of the approaches of chemical companies to the SDG Agenda, stating that the companies do not yet apply the SDGs to drive innovation and concluding that there is a need for a harmonized, systematic tool to assess and measure development, manufacturing, uses and benefits, mapped onto specific UN SDG indicators. Further along the supply chain, Vildåsen [33] has described a case study of the strategic management approach of a plastic component producer that is following a circular business model in line with four prioritized SDGs. The company argues that while it is affecting and being affected by all the goals in principle, in terms of practical decision-making, there is a need to prioritize. This leads Vildåsen to view the SDG application as an emerging process that requires time to narrow the gap between individual actors and the broader SDG agenda. Moriorka et al. [34] have examined companies of different sizes that have adopted sustainable business models, arguing that the strongest connection between SDGs and a company's competitive advantage is the value proposition of the company. Moriorka and colleagues [34] deduce that defining a company's purpose and offerings with respect to SDGs can create synergies between the individual and collective goals.

Jha and Ranagarajan [35] proposed a framework in which the 169 SDG targets are screened to identify sustainability attributes that are actionable in the corporate world, deciding on a model with 98 indicators. Their study looked at whether substantive actions across these indicators were mentioned in the public disclosures of Indian companies. However, the framework did not analyze the alignment to business strategy (embracing both internal activities and external philanthropy), did not differentiate between sectors, and did not state the scope of the included operations. In contrast, Muñoz-Torres et al. [36] specifically devised a supply chain sustainability assessment tool, although they provided scant details on the framework and its links to the SDGs. Moldavska and Welo [37, 38] have developed and refined an SDG assessment method, in which an organizational model is first constructed. An external sustainability expert (with limited company influence) links the relevant criterion for sustainable manufacturing and the SDGs. The selected criteria are connected to elements of the organizational model, to enable tracking according to a traffic light system. While this represents a comprehensive assessment method, the scope of the organizational model and the requirements surrounding the alignment to business strategy are not clear.

Few of the identified published articles provide readily accessible SDG impact assessment tools that are applicable to the multitude of

SDGs (not least embracing SDG 13 on climate action) and to a broad range of private sectors. These are the types of SDG tools for businesses that are in focus in the present study.

Of the publications that do reference readily accessible SDG impact assessment tools for businesses, Muff et al. [39] detail an add-on to the SDG Compass tool developed by GRI, UN Global Compact and WBCSD [40], while Grainger-Brown and Malekpour [41] include an extensive literature review that explores tools and frameworks linked to strategic management, and categorizing tools into mapping, reporting and aligning types. Grainger-Brown and Malekpour [41] investigate the fit within the strategic management process, i.e., if the tools can enable transformative actions. Using a scoping methodology to review the tools that are available to organisations for SDG actions, the authors identify some tools that align with the early stages of strategic management, i.e., ‘problem definition’ and ‘goal setting’. These are tools that are also applicable to the objective of the present paper.

3. Method

To achieve the aim of this paper, a multi-method approach was used that comprised: (i) a systematic review of the literature to identify readily accessible SDG impact assessment tools for companies and corporate projects in different sectors; (ii) a critical analysis of the selected SDG impact assessment tools from the perspectives of value chain inclusion, directing change processes, use of performance data, and target setting; (iii) contextualising the available tools with respect to their interpretations and representations of climate action; and (iv) a case study from the construction industry – a road construction work – to explore how a SDG analysis assessment can be framed with linkages between SDG 13 and other related SDGs.

The literature review was designed as a scoping investigation, to identify existing strategic SDG impact assessment tools that are available to businesses across various sectors. When it came to the identification of SDG tools for businesses, the literature review approach was tempered with a number of conditional criteria, to identify the relevant documents. These criteria were: date of publication, search database, and search keywords. The date of publication was limited to Year 2015 and onwards, i.e., from the year in which Agenda 2030 was introduced. In terms of search databases, a combination of academic bibliometric databases and web browser searches was used to enable the sourcing of the relevant grey literature, which is not as evident in academic bibliometric databases. The web browser search was primarily prompted by the diverse origins of SDG-related tools, e.g., reference to and use of SDG consultancy tools by large corporations, together with tools referenced in the Global Goals Business Guide, which lists a range of resources to support businesses [10].

The bibliometric databases used for the scientific literature were Web of Science and Scopus, as these are major bibliometric databases for academic publications, providing significant coverage of the literature. The same keywords were used in all the searches, with algorithms targeting a combination of business, SDG, impact assessment, and tool¹. The keyword search in the academic bibliometric databases returned 55 unique academic publications, which were screened for their relevance using selection criteria that included explicit reference to a multitude of SDGs, targeting the private sector, and including a reference to impact assessment or tools/frameworks, while excluding studies that have developed tools for the conceptual analysis of the SDGs for academic purposes. The screening resulted in 12 publications with links to the SDGs, to business, and to tools/frameworks.

The generic tools identified in the Global Goals Business Guide [40] include: the SDG Compass; the *SDG Selector* produced by PWC; and the

¹ Using combinations of the search algorithm: business OR corporation* OR corporate OR company OR companies AND SDG* OR “Sustainable Development Goal*” OR “Global Goal*” AND impact AND assessment OR tool.

'*DG Industry Matrices and How to report on the SDGs framework* produced by KPMG. Furthermore, the generic tools identified by Grainger-Brown and Malekpour [41] were included in our review. The web browser search returned various online and published gray literature resources that fulfilled the selection criteria. These papers in the gray literature were authored in the main by consultancies and NGOs. The web browser search results included the *SDG Impact Assessment* produced by the consultancy firm Ramböll [42] and the *SDG Impact Assessment Tool* generated by the Gothenburg Centre for Sustainable Development (GMV) [43], which were also chosen for assessment within this study.

Based on the review, we thus identify five established corporate SDG assessments tools, which are then assessed discovering terms of how they can contribute to support businesses in meeting the goals and targets of Agenda 2030. We analyze these tools with respect to the extents to which they encourage a supply (and value) chain perspective, the use of performance data rather than a qualitative assessment, and the setting of clear targets when it comes to combating climate change (SDG 13), which, in the Swedish case, implies net-zero emissions by Year 2045. There is probably also a need to assign clear values to the targets for some of the other SDGs of relevance. However, establishing the actual values for these targets is considered to lie outside the scope of this work.

The case study used for the framing example in the present study is in the form of the construction of a new stretch of road in Sweden, where a particular objective is to investigate how such a construction project can be designed and developed in the future so as to limit the carbon emissions to close to zero. The road construction case has been described in detail by Karlsson et al. [44]. The study was developed as a participatory-integrated assessment, involving stakeholders from across the road construction supply chain and exploring different measures to reduce the climate impact of road construction. The work involves energy, material flows, and emission analyses of a newly built road segment in Sweden, and investigates how the GHG emissions from the materials and operations can be reduced to zero by Year 2045 (the Swedish target-year for net-zero GHG emissions). The case study uses inputs from supply chain stakeholders, together with a literature review to identify and categorize possible GHG abatement options that are relevant to road construction works according to the current, best-available technology, as well as technologies that are foreseen to be available up to Year 2045.

Based on this inventory, the potentials for GHG emissions reductions of the identified abatement options were evaluated and compiled in a scenario analysis. The assessment considered emissions that materialize up to the point in time at which the road is finalized and becomes available for use (i.e., not including emissions from the vehicles using the road). As such, the main types of abatement options considered in the assessment are shifts in: material production processes; transport vehicles and construction equipment technologies; and fuel substitutions in both equipment and production plants. The results indicate that key priorities for carbon emissions abatement include: upscaling of sustainable transport biofuel and industrial biomass fuel, in the short term, together with robust expansion of the climate-neutral electricity sector; transformative shifts in basic industry (electrification and/or CCS in the steel and cement industry); and continued progress towards hybridization and electrification of heavy transport and construction equipment. Details of the case study, including quantification of the emissions reductions accrued from the different measures, can be found in the publication of Karlsson et al. [44].

The analysis is carried out along the supply chains involved in the road construction - from the input of raw materials, through the primary and secondary activities, to the final product and service demanded by the end-user. Thus, various companies and public authorities are involved in the project. All these companies must relate to the SDG goals and targets if the ambition is to meet a long-term target for reducing the climate impact of road construction work that is in line with the Swedish climate target (which, in turn, is in line with the Paris Agreement). Using the supply chain as the framework for the assessment makes it easier to

understand if and in what ways the different companies depend on each other for the realization of the goals. The framing exercise relates the climate aspect of the case study to the full range of SDGs and targets.

As indicated in the *Introduction*, an SDG assessment should be framed so it can support the development of strategies that limit the carbon footprint of the construction, which in the longer term is in line with the Paris Agreement, while understanding the implications that different climate actions will have for other sustainability goals. The aim is to frame the assessment so it can support the transformation of the businesses along the entire supply chain of the road construction.

We perform the framing in a network setup that is partly in line with the method proposed by Nilsson et al. [45]. While primarily intended for use in national assessments, this is a generic method for investigating how the SDGs and their targets interact with each other. This method is chosen for framing as its aim is to identify and test developmental pathways that minimize negative interactions and enhance positive ones, thereby building an evidence base and identifying knowledge gaps. Our point of departure is SDG 13 – *Climate action* – and we relate this to the long-term goal for Sweden to achieve net-zero GHG emissions by Year 2045 (which is in line with the Paris Agreement). This is the chosen setup because for several industrial processes that are involved in the supply chain for road construction, only a few investment cycles remain up to Year 2045. Setting out from SDG 13, we subsequently map out and identify the interactions in relation to the other 16 goals and their targets. Nilsson et al. have proposed a seven-point scale of SDG interactions based on positive and negative interactions [45]. To match the subject of the framing exercise in this application (as distinct from the analysis of a nation), this scale has been adapted so as to divide the interactions into direct, indirect, and potential impacts. Direct impacts are defined as the immediate impacts of implementing the solution, whereas indirect impacts are those impacts that may arise as consequences of the implementation [43].

4. Review and comparison of assessment tools for sustainable development goals and businesses

Table 1 gives an overview of the five SDG assessment tools analyzed in this work. These tools all have different aims, scope, complexity, and levels of support. There is a wide gap between the simple and comprehensive tools in terms of the time and resources required to apply the tool, as well as the extent of the supportive resources. For example, the Ramböll SDG Impact Assessment is reported to take around 10 minutes to complete, while the task of selection of indicators towards defining priorities as a subtask in the second step of the SDG Compass would require an assessment of the relevance and feasibility of more than 1,500 indicators² across all the 169 targets of the 17 SDGs [40, 46]. It should be stressed that the items listed in Table 1 under aim, scope, boundary, focus, and the use of the results are the interpretations made by the authors of this work and do not necessarily reflect the intentions of the authors of the SDG assessment tools. The effects of the SDG tools will also depend on how the organization applying the tool will use the results, and how the use of the tool is incorporated into their organization. The concept of *Materiality* in Table 1 is defined according to the Global Reporting Initiative [47] as: “*Topics that reflect the organization's significant economic, environmental, and social impacts OR substantively influence the assessments and decisions of stakeholders*”.

Just as the target of application of the assessment may vary substantively, so will the requirements or suitability of the applied method or tool. On the one hand, it is unlikely that a single-person assessment taking less than 1 hour to complete will provide more than a glimpse of Agenda 2030 and its complexity. On the other hand, for an assessment of a smaller project, it is probably not feasible to embark on a wide-ranging

² See the SDG Compass list of indicators: <https://sdgcompass.org/business-indicators/>

Table 1

Summary and review of the tools, resources and guidelines analyzed in this work. It should be stressed that the aim, scope, boundary, focus and the use of the results represent the interpretations made by the authors of this work.

Tool/Guide	Ramböll SDG Impact Assessment [42]	Navigating the SDGs: a business guide [48, 49]	SDG Industry Matrix [50]	SDG Compass and Business reporting of SDGs [40, 51]	SDG Impact Assessment Tool [43]
Developer	Ramböll	PricewaterhouseCoopers (PwC)	UN Global Compact & KPMG	GRI, UN Global Compact and WBCSD	Gothenburg Centre for Sustainable Development (GMV)
Aim	Gain a first overview of SDG impacts	Prioritize SDGs relevant to a business	Inspire and inform greater private sector action	Align strategies to the SDGs, and measure and manage their contributions	Better understanding of how solutions relate to the SDGs and equip users to prioritize actions
Scope	Production company operations (pharmaceutical and building material sectors)	Industry impact and opportunities in selected industries; priorities and performance on a country-by-country basis	Companies in selected industries	Multinational corporations – entity, product, site or regional level	Solutions, research activities, organizations, projects and other initiatives
Boundary	Company operations and logistics	Company operations and value chain	Example actions cover stakeholders	Value chain – including value chain mapping	Flexible - set in the assessment
Focus	Assessing existence of policies, systems and targets – mainly risk-focused	Mitigate risks in business and identify business opportunities	Finding business opportunities through a “shared value” ^a lens	Align business strategies - reduce negative impacts while enhancing positive contributions to the agenda	Identify opportunities (positive impacts), risks (negative impacts), and knowledge gaps
Materiality ^b	No materiality approach	Limited to sector and country levels	Limited to sector level	Priorities defined through materiality	Not defined
Practical method	Online questionnaire-based tool, mainly with yes/no questions	Online identification of relevant SDGs based on industry and country	Sector-specific guidance with ideas for action and practical examples for each SDG	Comprehensive step-by-step approach covering value chain mapping, principles prioritization, goal setting, business integration and reporting	Online five-step self-assessment, including sorting based on relevance and assessing the SDGs for direct and indirect impacts
Supporting resources (i. e., included as part of the tool)	Short guidance on potential risks and opportunities	Business guide for each SDG detailing importance to business with prompts and links to other SDGs	Good practice principles and initiatives, multi-stakeholder partnerships	Guidelines for integrating the SDGs into corporate reporting: a practical guide and an extensive database of indicators at the target level	Short introductions to each SDG and its targets
Results	Simple report, graphically presenting directly impacted SDGs	Graphical representation of SDGs of overall sector and country relevance	A detailed “menu” of potential action items for each SDG	Complete business agenda	Graphical visualization collating the assessments for all the SDGs
Use of results	Very initial idea of policy links to SDGs	Different utility depending on level of assessment, from selected SDGs to analysis based on prompts	Inspiration for possible actions	Overarching framework to continuously shape, steer and communicate strategies, goals and activities	Facilitates discussions and prompts actions and/or addressing knowledge gaps
Required time/resources	Low	Low for SDG Selector; Medium for complete assessment via business guide	Low	Very high	Low - medium
Directing change processes	Not directly	Partly in the business guide (which collects the guidance for each SDG)	Not directly	Yes, directly driving core business strategy	To some extent possible through the resulting strategy formulation
Value chain perspective	No	Yes	No	Yes	Yes (for business)
Use of performance data	No	No	No	Yes	No
Target setting	Yes (post-assessment guidance)	No	No	Yes	Yes (for business)
Critical review	Very simplistic model focusing on policies rather than practices.	SDG Selector only entails risk of oversimplifying and missing key impacts. Comprehensive business guide but without clear step-by-step approach and arbitrary prompts.	Large inventory of action items, albeit without a structured or systematic assessment approach.	Wide-ranging assessment tool with clear strategic change management approach. Not as applicable for smaller companies or for assessments of solutions or initiatives. Does not cover the links between SDGs and targets within the SDGs.	Flexible, albeit simple model capable of assessing a range of targets. May require external resources to provide sufficient guidance, and would be supported by an initial materiality analysis.

^a Defined in the matrix as the point at which the market potential, societal demands, and policy action come together.

^b Materiality is here defined according to the GRI as “*topics that reflect the organization’s significant economic, environmental, and social impacts OR substantively influence the assessments and decisions of stakeholders*” (Global Reporting Initiative, 2016).

strategic change management approach. Such an approach will have to be an integrated part of the overall operation of the business, with the aim of repositioning the core business so as to embark on a path towards fulfilling explicit targets of the SDGs. As pointed out in the *Introduction* of this paper, it should be obvious that a reduced climate impact (SDG 13) will require actions that are in line with the Paris Agreement, limiting

global warming to well below 2°C. This will require more or less zero GHG emission by mid-century, i.e., in some 30 years. For many, if not the majority of businesses this will require transformative changes in production processes, for which there are in many cases only a few investment cycles remaining to Year 2050, although the investment cycles may be shortened if there is a sufficiently high cost or other driving force

associated with complying with the Paris Agreement.

4.1. Ramböll SDG Impact assessment

Ramböll's digital impact assessment tool was designed to assist private sector companies in arriving at an initial overview of how they impact the SDGs [42]. The tool is aimed at decision-makers who are seeking more sustainable business models or employees who are working with sustainability (such as in Corporate Social Responsibility, CSR, departments), the circular economy or similar functions. The tool is based on a questionnaire with the output being produced as a custom-made report. The tool was developed to fit manufacturing companies, with the initial focus on the building materials and pharmaceutical sectors. A few questions target the products and services of the company, while the bulk of the questionnaire is focused on the operational practices of the company. The questions mainly relate to the existence of policies, agreements, and targets within different sustainability areas. Most of the questions have a yes/no/do not know format, while others are multiple choice (mostly of the single-choice type). Some sample questions to illustrate the simplicity of the questionnaire are listed below:

What is the main source of energy in the production process? (single choice)	How do you manage waste? (multiple choice)
<ul style="list-style-type: none"> • Fossil • Nuclear • Waste • Renewable • Other • Do not know 	<ul style="list-style-type: none"> • Reduce • Reuse • Recycle • Waste to energy • Disposal • Do not know

The result is an SDG overview, which shows graphically those SDGs that are estimated to be directly impacted by the business, and divided into products and services, and its operational practices. Goals that are not assessed to have direct impacts are all judged to have indirect links to the business operations or products/services. The tool results in an assessment that the company either already supports the specific SDG or has *potential* to support the specific SDG.

In the report provided upon completion of the assessment, it is stated that the tool is a first step to engage with the SDGs, i.e., a first high-level guidance. A short guidance section is provided regarding prioritizing efforts, development of a strategy, including target setting, an action plan, and a roadmap, as well as a plan for implementing and executing the strategy together with measuring and communicating performance and progress. Thus, the operational and strategic opportunities identified following completion of the questionnaire should include a detailed assessment that facilitates a more thorough and actionable understanding of how the business can be changed so as to be in line with the SDGs.

4.2. SDG Selector and Global Goals Business Guide

The online SDG Selector, developed by PwC, was derived from research on business readiness for Agenda 2030 [52]. Business leaders were asked which SDGs they considered that their business had an impact on, and which SDGs might be represent opportunities for them going forward. Their responses guided a compilation of selected SDGs that is applicable to the industries included in the business readiness research. To view an assessment of the SDGs that are relevant to a business, either an industry or a country needs to be selected, such that the industry SDG Selector exhibits two assessments, with one focusing on business impacts and the other targeting business opportunities.

The industry guidance is accompanied by a country guide whereby data sources to score countries performances against each SDG target within the PwC Global Business Navigator tool drives a country-based SDG selection. The reason for the focus on country priorities is that each government will have its own set of challenges and priorities,

which will drive the national policies and actions it needs to take. Thus, companies might want to understand and review the priorities of the national governments in the countries in which its operations are located, as well as those of suppliers and customers around the world.

The result is an online interactive graphic depiction of the SDGs that are assessed as being relevant for the specific industry or country, with pop-ups for each goal providing background information, quick advice on what the business can do, and a selection of countries in which the performances related to certain SDG targets are challenging. Links are provided with detailed guidance for each SDG (see, for example [53, 54]), which are also available in a collated business guide [49]. By providing detailed guidance on each of the SDGs, including the linkages between the SDGs, and why they matter to business, the aim is to help companies understand: the challenges that each goal is seeking to address; the ways in which each goal is relevant to business; and how business leaders can take action to mitigate the risks and grasp the opportunities that each goal presents.

For a comprehensive assessment, the initial view of identified goals needs to be supported by a careful consideration of all the goals, as described in the business guide.

4.3. SDG Industry Matrix

The SDG Industry Matrix was developed jointly by the United Nations Global Compact and KPMG, with the aim of converting the interest stimulated by the Sustainable Development Goals into strategic industry activities with potential to grow in scale and impact [50]. The SDG Industry Matrices were compiled through a participatory process, in which a pre-populated preliminary draft was sent out for review within the UN Global Compact Network, with a multi-stakeholder working roundtable finally being convened to agree on the specific opportunities to highlight.

The matrices represent a set of publications (see, for example [55, 56]), which provides industry-specific practical examples and ideas for action for each Sustainable Development Goal within the following sectors:

- Financial Services
- Food, Beverage and Consumer Goods
- Healthcare & Life Sciences
- Industrial Manufacturing
- Transportation
- Energy, Natural Resources & Chemicals

The SDG Industry Matrices comprise a guidance document that profiles the identification of business opportunities in addressing social and environmental challenges, through a focus on "shared value", which is a concept coined by Porter and Kramer [57], whereby businesses seek strategies that create value for both shareholders and for Society. The shared value opportunities identified in the SDG Industry Matrices are to be found through:

- Developing products, services, technologies and distribution channels to reach low-income consumers;
- Investing in supply chains that are ethical, inclusive, resource-efficient and resilient;
- Improving the skills, opportunities, well-being and, thereby, the productivity levels of employees, contractors and suppliers; and
- Increasing investment in renewable energy and other infrastructure projects.

The SDG Industry Matrices are a guidance document that companies within the various industries can use to obtain information and derive inspiration. However, since there is no specific or structured method to be followed, it should be seen as a supportive document rather than as an assessment methodology.

4.4. SDG Compass and a practical guide to Business Reporting on the SDGs

SDG Compass has been developed with the focus on large multinational enterprises, with the aim of supporting sustainability as an outcome of core business strategy. The objective of SDG Compass is to guide companies as to how they can align their strategies, as well as measure and manage their contributions to the SDGs. The guide highlights a range of perceived benefits and targets for companies to work with the SDGs:

- Identifying future business opportunities
- Enhancing the value of corporate sustainability
- Strengthening stakeholder relations and maintaining the pace with policy developments
- Stabilizing societies and markets
- Using a common language and shared purpose.

Developed by the Global Reporting Initiative (GRI), the UN Global Compact, and the World Business Council for Sustainable Development (WBCSD), SDG Compass is a comprehensive framework that incorporates the feedback received through consultation with companies, government agencies, academic institutions, and civil society organizations worldwide.

The SDG Compass guide presents a five-step process with sub-tasks to assist companies in maximizing their contributions to the SDG, as listed in Table 2.

Each step and sub-task is supported by detailed guidance and tools, which can be used to support the transformation process. In the impact assessment, company representatives are encouraged to define their priorities based on an assessment of their positive and negative, current and potential impacts on the SDGs across their value chains, so as to identify the areas in which positive impacts can be scaled up and negative impacts can be minimized or avoided.

The practical guide to Business Reporting on the SDGs is a complementary resource that provides a more detailed approach to defining priorities [51]. This guide is based on principled prioritization, a process that includes consideration of the risks to people and the environment, as well as beneficial SDG-related products, services and investments. The aim of principled prioritization is not only to align company strategy, efforts, and allocation of resources with SDG targets that reflect their significant impacts, but also to identify new actions that are needed to contribute to the SDGs.

For measuring, monitoring and reporting purposes, SDG Compass is

Table 2
Steps and tasks in the SDG Compass assessment methodology.

#	Step	Tasks
1	Understanding the SDGs	<ul style="list-style-type: none"> • What are the SDGs? • Understand the business case • The baseline responsibilities for business
2	Defining priorities	<ul style="list-style-type: none"> • Map the value chain to identify impact areas • Select indicators and collect data • Define priorities
3	Setting goals	<ul style="list-style-type: none"> • Define scope of goals and select Key Performance Indicators (KPIs) • Define baseline and select goal type • Set the level of ambition • Announce commitment to SDGs
4	Integrating sustainability into the core business and governance	<ul style="list-style-type: none"> • Anchor sustainability goals within the business • Embed sustainability across all functions • Engage in partnerships
5	Reporting and communicating	<ul style="list-style-type: none"> • Effective reporting and communication - mapping SDG reporting priorities through materiality • Communicating on SDG performance

supported by a comprehensive analysis of indicators linked to each goal and target, forming an extensive database for measuring and reporting the organization's contributions to the SDGs [46].

The wide-range strategic change management approach adopted when applying the SDG Compass is illustrated in Figure 1, which describes the goal-setting approach.

Although SDG Compass is the most comprehensive tool in the current review with the ambition of causing a real transition in businesses towards sustainability, it may be challenging to use it in a more quantitative way, given that the approach lacks a structured assessment and guidance around the interactions and linkages that exist between the SDGs and the included targets.

4.5. SDG Impact Assessment tool

The SDG Impact Assessment tool is an online tool that visualizes the results obtained from a self-assessment of how an activity, organization or innovation affects the SDGs. The tool, which was developed by the Gothenburg Centre for Sustainable Development (GMV) in collaboration with SDSN Northern Europe and the Mistra Carbon Exit project, aims to stimulate the user to acquire a better understanding of the complexity of sustainable development and the different aspects of the SDGs [43].

The assessment is performed for each SDG in order of relevance, where the tool provides a short introduction to each SDG and its targets.

The method provides an opportunity for a systematic approach to how a solution relates to the SDGs, ensuring that all aspects of sustainability are covered and discussed. It follows a five-step process that is designed to be simple but structured:

1. **Gather your forces** – Ideal setup devised as a small group with a moderator.
2. **Define, refine and draw the line** – Set the boundary.
3. **Sort the SDGs** – Sorting the SDGs based on perceived relevance.
4. **Assess your impact** – Where each SDG is assessed according to the direct and indirect positive and negative impacts³ on the specific SDG that the assessment target (activity, organization or innovation) is deemed to have, or whether more knowledge is deemed to be required.
5. **Choose your strategy going forward** – Formulate actions to mitigate trade-offs (negative impacts), support further synergies and potential benefits (positive impacts) and/or take on the filling of knowledge gaps.

The procedure requires substantial discussion and understanding of the object of the study in order to pinpoint the relevant aspects. One of the challenges is to define the impacts as either direct or indirect. In several instances, the impact may not be part of the actual object but instead is part of the prerequisites in which the study object is found. In this context, ensuring that the object is well-defined will reduce the level of complexity.

The objective is to formulate a single summarized assessment for each SDG. This could pose dilemmas in which, hypothetically, a solution might be assessed as having positive impacts on one target and negative impacts on another target. However, the sub-task of aggregating the target assessments to a single assessment for the specific SDG, in which a discussion of how to consider trade-offs and benefits is put together, is an important part of the self-assessment. The result would typically not be a case of simple arithmetic but would be based on qualitative reasoning and discussions.

The SDG Impact Assessment Tool was developed as a flexible tool to support assessment of the impacts on the SDGs of solutions, research

³ "Direct positive" and "direct negative" are defined as immediate impacts of implementing the solution, whereas "indirect positive" and "indirect negative" refer to impacts that might arise as consequences of the implementation.

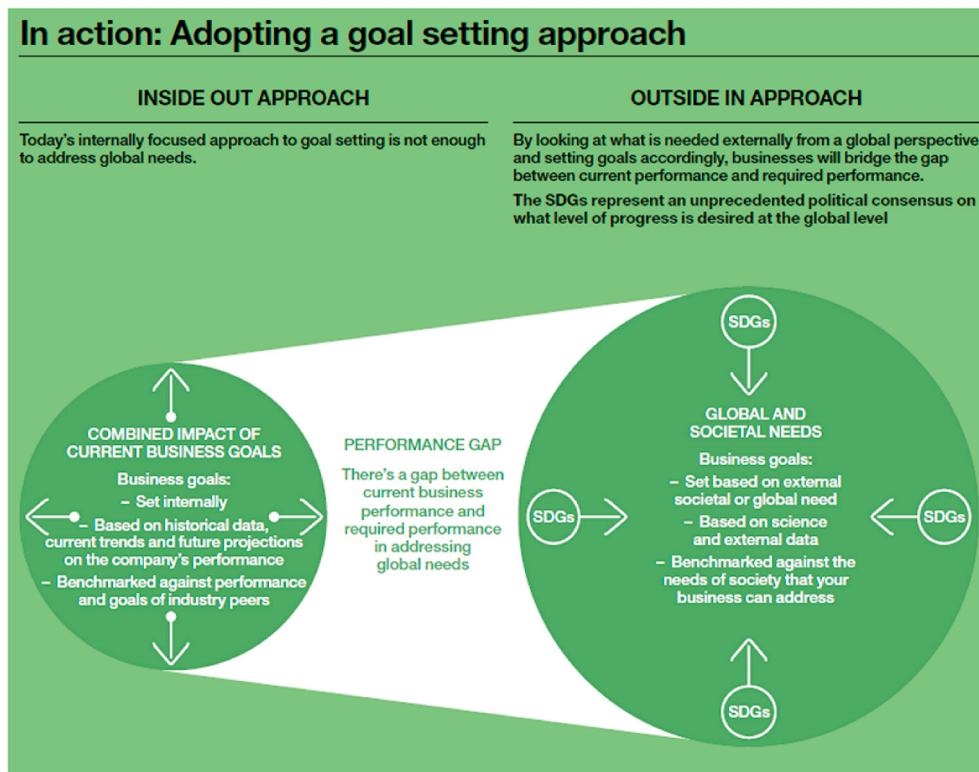


Figure 1. Illustration on the adoption of a goal-setting approach as per the SDG Compass guidance. Source: GRI, UN Global Compact and WBCSD [40].

activities, organizations, projects, and other initiatives. Application of the method can be executed in different ways. One approach is to have a group of experts or stakeholders, as well as one moderator who will facilitate the process. We note that it is intended first-and-foremost as a learning experience and as a first strategic step towards improving sustainability, giving users the ability to gain a better understanding of how a solution relates to the SDGs, thereby making them better equipped to prioritize forward actions.

5. Summary of the tool review

From the above review and comparison of the SDG assessment tools for businesses, we conclude that the tools to some extent encourage a value chain perspective and the setting of targets, while SDG Compass is the only reviewed tool to incorporate quantified performance data. In addition, only the SDG Compass methodology includes a structured approach for how to include the value chain perspective in the assessment. However, considering the trade-offs and benefits between different SDG targets is dealt with clearly only in the GMV SDG Assessment Tool methodology, while the PwC SDG Business Guide is the only tool that provides guidance on the linkages between the SDGs. In summary, the tools each have their advantages and drawbacks, and for any specific application, it should be essential to start by setting a clear scope, boundary, and objectives for the exercise. This allows one to draw from each resource to create an effective and useful approach.

We consider the framing of an assessment as a crucial step, and we focus below on how to frame an SDG assessment around efforts to combat climate change. In this context, the assessment should require a value chain perspective, setting clear targets for emission reductions and involving conflicting goals. Thus, if applying a sound framing to the SDG assessment, it should be of great value to apply any of the above SDG assessment tools.

6. Framing a value chain SDG assessment

The case studied here – the above-described road construction work in Sweden (and detailed in [44]) – aims to illustrate the framing of a supply chain SDG assessment for businesses that are seeking strategies to limit the carbon footprint of their business in line with the Paris Agreement. As mentioned in the *Introduction*, an SDG assessment should help to elucidate the implications that the different climate actions will have on other sustainability goals of relevance. A road construction work includes a number of businesses, all of which obviously must comply with a similar SDG framing if the entire project is to meet the SDG goals and the critical targets identified. In Sweden, there seems to be promising conditions for agreement on common goals, at least when it comes to meeting the national climate targets. This is the case because organizations such as the National Road Administration and many construction companies have expressed their willingness to comply with strict carbon emission targets. An SDG assessment should help to ensure that the measures taken are as sustainable as possible in the long run and that sub-optimization is avoided.

Karlsson et al. [44] have shown that it is already possible to halve the level of emissions from road construction through applying available technologies and practices. However, to reach zero or near-zero emissions, a number of key transformative technologies with associated shifts in practices will be required. Here, we focus mainly on the latter group of measures when discussing the framing of an SDG assessment, since these measures are crucial for identifying opportunities and barriers related to mitigating carbon emissions along the entire supply chain of the road construction sector (including Scope 3) when targeting deep emission cuts in line with the Swedish target of net-zero emissions by Year 2045.

The key measures identified in [44] as being required to reduce to zero the carbon emissions associated with road construction work are: the use of biomass sources as renewable transportation fuels in construction equipment and production plants; electrification of transport and industrial processes; and substituting for fossil fuels or using CCS

technologies in the basic materials industries. In addition, there is a need to speed up the implementation of alternative abatement measures, including the optimization of material needs and mass handling requirements, increased recycling of steel, asphalt and aggregates, and the use of alternative binders in concrete.

From framing the SDG assessment in a network setup, we get the network exhibited in Figure 2, in which the identified direct, indirect, and potential impacts are indicated, as well as the trade-offs and synergies. Below, we discuss the key challenges and linkages between climate actions (SDG 13) and the other SDGs identified in the network framing with the focus on the key measures required to reach near-zero emissions.

6.1. Biomass – a short-term measure

There will be a need for sufficient availability of sustainably produced, second-generation biofuels. Previous research has demonstrated that a significant shortfall in the supply of biomass will be experienced unless production is ramped up or wood and agricultural products from other uses are directed to the manufacture of transport and combustion fuels (see, for example [58]). Taking the Swedish perspective on hydrogenated vegetable oil (HVO) as an example (which offers a direct replacement of diesel fuel as it does not require any engine modifications), it is likely that there will be limitations linked to upscaling, as the current use of waste-based raw materials is near its maximum limit, particularly if palm oil and its derivative PFAD are ruled out due to their links to deforestation [46]. Moreover, in a world that advances in line with the Paris Agreement, the competition for, and thereby the value of, biomass will increase with time. This and the issues related to the climate benefits of forestry derived biomass are discussed by Berndes et al. [59].

This signifies linkages to SDG 7 (Affordable and Clean Energy), and in particular to Target 7.2 which is concerned with increasing renewable energy. On the one hand, this is a clear prerequisite for successful decarbonization, while on the other hand, it highlights further linkages to both SDG 15 *Life on Land* and Target 15.2 on sustainable forest management and the halting of deforestation, as well as SDG 2 *Zero Hunger* and more specifically, Target 2.4 on sustainable food production and resilient agricultural practices. These are all relevant aspects for ensuring a feasible and sustainable transition regarding biofuels. Thus, while transport biofuels have a role to play in reaching the full climate

mitigation potential in the short term, greater emphasis is needed on speeding up the implementation of the alternative abatement measures, including the electrification of transportation.

6.2. Electrification and CCS –required for deep cuts in emissions

The study conducted by Karlsson et al. [44] together with previous research demonstrate that construction with close to net-zero emissions is possible. This will require a climate-neutral electricity sector and transformative shifts in basic industry, mainly in the production of steel and cement. The latter will require a combination of electrification and the application of carbon capture and storage (CCS) technologies. The lead-times in these industries are long, with few investment cycles remaining to mid-century. In addition, such fundamental changes in industry processes are associated with high upfront costs. Transformation of basic industry would entail positive links to SDG 9 on *Industry innovation and infrastructure*, and more specifically, Target 9.4 on *Upgrading infrastructure and retrofitting industries to make them sustainable*.

There will also be a need for continued progress on the hybridization and electrification of heavy transport and construction equipment [44]. Electrification of heavy transport and construction equipment has an indirect positive impact on air pollution, particularly for road construction in cities, thereby creating linkages to SDG 11 on *Sustainable Cities and Communities* and particularly Target 11.6.

When it comes to CCS it is important to remember that it relates to the future of fossil fuels on a global level [58]. It is also important to note that there are only three options for complying with the Paris Agreement: to leave the fossil fuels in the ground, to apply CCS technologies or a combination of these. It is sometimes proposed that the costs for renewables (in particular, wind and solar power) are now close to, or in some regions even cheaper, than the costs for fossil fuels, implying that the fossil fuels will be outcompeted and eventually not be used. Renewables would obviously be even more competitive if the external costs were included and subsidies for fossil fuels were removed [60]. However, as shown by Johnsson et al. [61], fossil fuels seem not to be outcompeted by renewables on a global scale, mainly because regions with fossil fuel endowments continue to use them, such that in many parts of the world much of investments in renewables and fossil fuel technologies made to date have satisfied an increasing demand rather than replacing old fossil capacity. Moreover, so far, there have been no policy measures that make it costlier to emit CO₂ emissions from fossil fuels

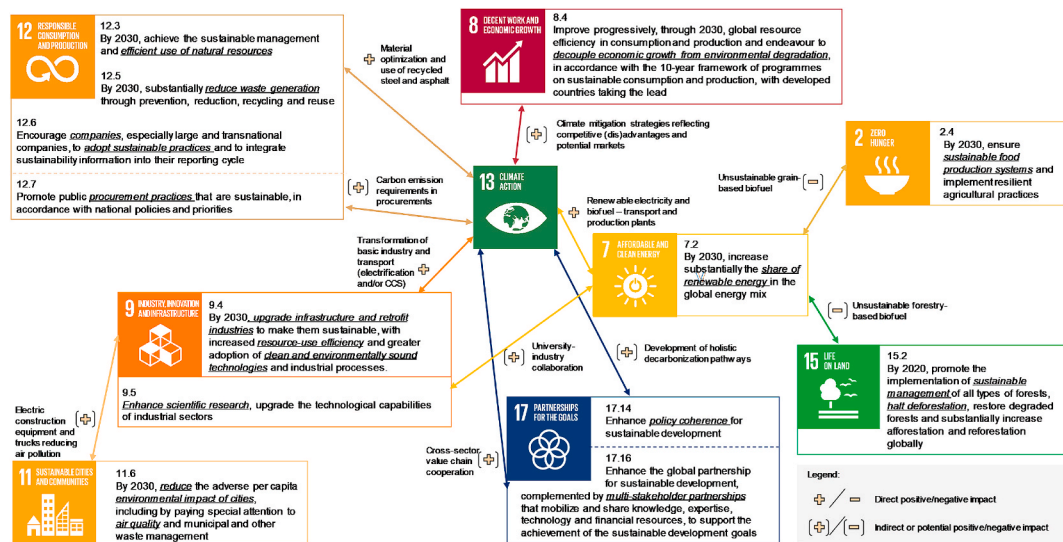


Figure 2. Schematic of the links between the Sustainable Development Goals and Targets, and road construction carbon mitigation. Following the previous publication [47], “Direct positive” or “direct negative” are defined as immediate impacts of implementing the solution, whereas “indirect positive” or “indirect negative” are impacts that could arise as consequences of the implementation.

than applying CCS. In addition, fossil fuels are used in industrial processes and in transport where comparing the cost of electricity generation from fossil fuels with renewable electricity generation only reflects part of the transformation (in the electricity sector). There are costs – direct and intangible – associated with electrifying the industrial processes and transportation. In summary, application of CCS, a shift away from fossil fuels through electrification and combinations of these, are measures that require transformative changes in technologies and practices and, thus, are associated with long lead-times.

6.3. Resource efficiency and policy coherence

By attracting attention to resource efficiency and circularity principles, stronger linkages are created to SDG 12 on *Responsible Consumption and Production*, both related to Target 12.3 on *Efficient use of natural resources* and Target 12.5 on *Reduced waste generation*. Policy measures and procurement strategies that are aligned to support these measures, with a clear supply chain focus, emphasize resource efficiency and circularity principles and create linkages also to Target 12.7 on *Sustainable public procurement*.

What emerges is a need to prepare for deeper abatement already now, to carefully consider the pathway for getting there while avoiding pitfalls along the way, such as over-reliance on biofuels or cost optimizations that cannot be scaled up to the required levels. Achieving the required transformative shifts will require holistic decarbonization pathways that ensure that policy coherence for sustainable development, as per SDG Target 17.14, is achieved. Procurement should constitute an important possibility for setting targets. Yet, in construction businesses, as in many other businesses, there are many companies involved in a project - developers, contractors and subcontractors. Here it should be a challenge to develop procurement requirements that can handle short-term possibilities (e.g., the possibility to halve emissions with current technologies and practices, as identified by Karlsson et al. [44], for the road construction used in this work), as well as stimulate the innovations and long-term development required to reach deep cuts in emissions. Public procurement has been shown to be of great importance for the development of new products and services [62, 63].

By designing the pathways to reflect competitive (dis)advantages and potential markets (e.g., access to biomass, zero-carbon electricity and heat, and the development of hydrogen supply chains [64] and CCS infrastructure), it may be possible to apply an SDG assessment as a support for ensuring long-term competitiveness. This links to SDG 8 on *Decent work and Economic Growth*, and specifically with Target 8.4 on *Decoupling economic growth from environmental degradation*.

The present work exemplifies a participatory integrated assessment that involves selected stakeholders from across the road construction supply chain. Links to Target 9.5 on *Enhancing scientific research for technological capabilities of industrial sectors* would be maintained by continuing these types of cross-sectorial collaborations [65], e.g., in the interdisciplinary and multi-stakeholder research program *Mistra Carbon Exit*⁴ (involving the researchers behind this paper).

7. Discussion and concluding remarks

From the above assessment, we conclude that there is a large span in scope between the different SDG tools for business, from the approximately 10-minute qualitative SDG assessment (Ramböll SDG Impact Assessment) to the comprehensive SDG Compass, which includes its practical guide to Business Reporting on the SDGs.

The use of SDG assessments in business has the potential to reflect on those aspects of sustainable development that are critical for the business in focus. Even the initial qualitative assessment has been found to spur healthy reflections on business practices (for an example, see [66]).

Such exercises can serve as the basis for a more thorough SDG assessment, with the aim of ensuring that the business development will comply with targets for climate change mitigation, while considering the influences of different SDGs. Thus, when applied in a thorough way, an SDG assessment can be used as the basis for minimizing future business risks when it comes to new market demands for carbon-lean or carbon-free products.

However, due to the complexity of all the aspects included in the 17 SDGs, including their associated targets and interconnections, there is a risk that important aspects and targets will be “drowned out” in an overall SDG analysis. In the worst case scenario, the complexity may lead to SDG assessments being deliberately used for SDG-washing (cherry-picking), to hide areas in which the necessary improvements are more difficult in favor of highlighting areas in which the business is already performing well. Thus, as pointed out in the *Introduction*, an SDG analysis should include routines aimed at avoiding SDG-washing. In a climate change context, it is clear that drastic cuts in emissions are required over the next decades, and this should not be hidden behind some complex SDG assessment that focuses on other SDGs while not identifying explicit targets for reducing carbon emissions. Therefore, we propose that an application of the SDG assessment in a carbon emission setting in a business should relate to the Paris Agreement and should be clear as to how the entire value chain is tackled from a carbon emission point of view. Obviously, the capacity to act will be different for different businesses, depending on where in the value chain the business operations are placed, how much of the value chain is included, and how the carbon emissions are distributed along the value chain. At the same time, when reduction of climate impact is in focus, an SDG assessment that is soundly framed can help to avoid violations of other SDGs that would result in sub-optimal solutions and measures. It is also important that the SDG tool is not applied as an add-on to existing businesses, but is instead integrated into the strategic management process [41], since for most businesses there is a need for transformative changes in the core businesses if one is to comply with many of the SDGs, including SDG 13 *Take urgent action to combat climate change and its impacts*.

When it comes to SDG 13, our case study of SDG framing shows several of the profound consequences this will have for the operation of many of today's construction businesses. The challenges discussed as part of the SDG framing case highlight the need for transformative changes at different points along the value chains, as well as the need for compromises and trade-offs when trying to fulfil all the SDGs relevant for the businesses. This, in turn, points to the following more general challenges and trade-offs that are of relevance in the wider SDG setting:

- By mid-century, almost no carbon will be allowed to be emitted to the atmosphere if there is compliance with the Paris Agreement. In addition (not discussed above), the world will most likely have emitted far more GHGs than are desirable or permissible in a few years, which will mean that sometime during the second half of the century the world will have to achieve negative emissions.
- There are only two options for the use of fossil fuels, to leave them in the ground or to use them and apply CCS technologies (and a combination of these). However, there are opinions circulating among the public and some NGOs that the CCS technology is inherently non-sustainable and may lock-in societies and businesses to the continued use of fossil fuels, thereby hindering a change towards a more sustainable path. Nevertheless, given that countries and regions with substantial fossil-fuel reserves continue to use them at the same pace as previously, CCS could offer the possibility for continued use of their domestic resource while still complying with strict emissions reduction targets. In that scenario, fossil-fuel use will occur at a higher cost (internalizing their environmental costs with respect to climate change), which would be beneficial in terms of expanding the role of renewables (cf. [63]).
- The value of biomass will increase over time, i.e., there will be increased competition for carbon-based fuels and feedstocks that

⁴ The Mistra Carbon Exit programme, www.mistracarbonexit.com/

entail no net emissions to the atmosphere. In relation to biomass, it is not clear how crop-derived biomass can be grown sustainably without: (i) conflicts with food production systems; (ii) negative externalities associated with the use of pesticides to ensure increased yields; and (iii) negative effects on biodiversity. For forestry-derived biomass, there is ongoing debate surrounding the climate benefits to be derived from using biomass to substitute for fossil fuels and feedstocks, as compared to maximizing forest growth for carbon uptake. This debate is partly based on different experiences with forest management (cf. Berndes et al. [59] and references therein). The biomass challenge is also linked to bioenergy CCS (BECCS), and it is uncertain as to whether it is possible to produce the large quantities of biomass used for BECCS in several of the 1.5°C warming scenarios presented by the Integrated Assessment Models (IAM).

- There must be substantial ramping up of CO₂-free electricity generation, as underlined by the fact that systems for direct or indirect electrification of the transportation and industry sectors are key options for decarbonization. Electrification is one of the options (and currently perhaps the main option) for decarbonizing the transport and industry sectors. This is especially the case if including both direct and indirect electrification systems. Direct electrification refers to Electric Vehicles (EVs) and Electric Road Systems (ERS) and to electrifying industrial processes, for example, by applying plasma burners in cement production. Indirect electrification comprises the production of hydrogen (or other electrofuels) for both transportation (fuel cell-powered cars) and industry, such as hydrogen-based steel production. Increased electrification of the transport and industry sectors is a promising alternative, although it is important to remember that the impact of electrification of the transport and industry sectors will depend on how it is managed in terms of the interlinkages and interactions across sectors.
- There must be increased material efficiency and strong efforts to achieve circularity in material handling. Although increases in the efficiencies of production processes for materials have occurred and the above-listed key measures exist to reduce the climate impacts of these processes, it is clear that Society needs to increase its recycling of materials, striving for circularity of material use. In a recent report prepared by Material Economics [69], it was concluded that improvements in product material efficiencies and in the recycling of steel, plastics, aluminum, and cement could cut EU industrial emissions by more than half by Year 2050. In terms of sustainable development, it is likely that increased recycling and product efficiency will have more positive outcomes in an SDG assessment than will end-of-pipe solutions in the production processes [70]. It seems likely that there will be a need for both upstream and downstream interventions along the value chain.

Although these are only examples, they are rather fundamental and the authors of this paper are certain that almost all businesses will be directly or indirectly affected by one or more of the abovementioned consequences if they want to fulfil SDG 13 and its targets, with the imperative that the actions are in line with the Paris Agreement. Thus, the effect could be manifested directly (Scope 1 emissions) within the core business (e.g., when burning fossil fuels in processes within the business or using plastics as material in the products), as well as indirectly through the purchase of materials or energy based on fossil fuels and indirectly in the use-phase of the product or service (Scope 2 and 3 emissions).

The implication is that any SDG assessment should include a strategy up to mid-century, i.e., some 30 years from now. Many businesses have rather long lead-times to make major investments and changes in their production processes. Considering that the world has so far not been able to even start decreasing the overall GHG emissions, there will be a significant risk of widespread public opinions putting pressure on businesses to change immediately and perhaps also holding them responsible for emissions. This may cause “panic”-driven actions, which

may result in wrong or sub-optimal solutions. A thorough SDG assessment may help to avoid such an outcome, through helping businesses to formulate a long-term plan that fits with the above facts. Then, there should be time to adopt and find business models that are sustainable in the long run. However, this requires that the SDG assessment is not applied in a cherry-picking or SDG-washing manner.

It should be mentioned that the interactions between SDGs may vary between high- and low-income countries (for a discussion, see [67, 68]). This is not considered in the present work, although it is assumed that from a business point of view that what is in line with Agenda 2030 is generally applicable independent of the region in question. Nonetheless, the economic conditions for business obviously vary greatly across the world.

We conclude that when using an SDG assessment as support for decarbonizing business it should have a supply (and value) chain perspective (covering Scope 1, 2 and 3 emissions), be governed by clear targets on climate change mitigation in line with the Paris Agreement, and include the main SDG goals affected by the climate change mitigation measures identified. For the case study included in the present paper, fossil fuel use, including the option to apply CCS in basic material production, biomass availability, material recycling, and the future of electricity are the factors that will be decisive with regards to the transition towards zero or near-zero carbon emissions.

Author contribution

Filip Johnsson: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing Ida Karlsson: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing Johan Rootzén: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing. Anders Ahlback: Discussions, Reviewing Mathias Gustavsson: Discussions, Reviewing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

- [1] United Nations General Assembly. Resolution adopted by the General Assembly on 25 September 2015, 70/1, Transforming our world: the 2030 Agenda for Sustainable Development. General Assembly 70 session, 16301; 2015. p. 1–35.
- [2] Schmidt-Traub G, Kroll C, Teksoz K, Durand-Delacré D, Sachs JD. National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nature Geoscience* 2017;10(8):547–55. <https://doi.org/10.1038/NGEO2985>.
- [3] Allen C, Metternicht G, Wiedmann T. Initial progress in implementing the Sustainable Development Goals (SDGs): a review of evidence from countries. *Sustainability Science* 2018;13(5):1453–67. <https://doi.org/10.1007/s11625-018-0572-3>.
- [4] Pedersen SC. The UN Sustainable Development Goals (SDGs) are a great gift to business! *Procedia CIRP* 2018;69:21–4. <https://doi.org/10.1016/j.procir.2018.01.003>.
- [5] Ioannou I, Serafeim G. The Consequences of Mandatory Corporate Sustainability Reporting: Evidence from Four Countries. *Harvard Business School Research* 2014. <https://doi.org/10.2139/ssrn.1799589>.
- [6] Parliament European, Council. DIRECTIVE 2014/95/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups. 2014.
- [7] Tsalis TA, Malamateniou KE, Koulouriotis D, Nikolaou IE. New challenges for corporate sustainability reporting: United Nations' 2030 Agenda for sustainable development and the sustainable development goals. *Corporate Social Responsibility and Environmental Management* 2020. <https://doi.org/10.1002/csr.1910>.

- [8] Topple C, Donovan JD, Masli EK, Borgert T. Corporate sustainability assessments: MNE engagement with sustainable development and the SDGs. *Transnational Corporations* 2017;24:61–71. <https://doi.org/10.18356/2ae5911c-en>.
- [9] Beloff B, Tanzil D, Lines M. Sustainable development performance assessment. *Environmental Progress* 2004;23(4):271–6. <https://doi.org/10.1002/ep.10045>.
- [10] The Global Goals. "The Global Goals – Business Guide." The Global Goals. <https://business-guide.globalgoals.org/> [accessed 26/08, 2019].
- [11] Scott L, McGill A. *SDG Reporting Challenge 2018 - From promise to reality: Does business really care about the SDGs? And what needs to happen to turn words into action.* PWC; 2018.
- [12] Blasco JL, King A, Jayaram S. How to report on the SDGs What good looks like and why it matters. KPMG 2018:1–32.
- [13] Bebbington J, Unerman J. Achieving the United Nations Sustainable Development Goals," *Accounting, Auditing & Accountability Journal* 2018;31(1):2–24. <https://doi.org/10.1108/aaaj-05-2017-2929>.
- [14] van der Waal JWH, Thijssens T. Corporate involvement in Sustainable Development Goals: Exploring the territory. *Journal of Cleaner Production* 2020: 252. <https://doi.org/10.1016/j.jclepro.2019.119625>.
- [15] Kornieleva Y. Non-financial Reporting Challenges in Monitoring SDG's Achievement: Investment Aspects for Transition Economy. *International Journal of Economics and Business Administration* 2020;1. https://doi.org/10.35808/ijeba/409_VIII.
- [16] van Zanten JA, van Tulder R. Multinational enterprises and the Sustainable Development Goals: An institutional approach to corporate engagement. *Journal of International Business Policy* 2018;1. <https://doi.org/10.1057/s42214-018-0008-x>.
- [17] Verles M, Vellacott T. *Business and the Sustainable Development Goals: Best practices to seize opportunity and maximise credibility.* Gold Standard and WWF Report; 2018.
- [18] Stevens GC. Successful Supply-Chain Management. *Management Decision* 1990;28: 8. <https://doi.org/10.1108/00251749010140790>.
- [19] Porter ME. *Competitive Advantage: Creating and Sustaining Superior Performance* (The Free Press). The Free Press; 1985.
- [20] Mentzer JT, DeWitt W, Keebler JS, Min S, Nix NW, Smith CD, et al. Defining Supply Chain Management. *Journal of Business Logistics* 2001;22(2):1–25. <https://doi.org/10.1002/j.2158-1592.2001.tb00001.x>.
- [21] Porter ME, Reinhardt FL. A strategic approach to climate. *Harvard Business Review* 2007;85(10):22–6.
- [22] *The GHG Protocol for Project Accounting, Revised version*, 1-56973-598-0, The Greenhouse Gas Protocol. 2005 [Online]. Available: <https://ghgprotocol.org/corporate-standard>.
- [23] Corporate Value Chain (Scope 3) Accounting and Reporting Standard. WRI and WBCSD; 2011 [Online]. Available: <https://ghgprotocol.org/standards/scope-3-standard>.
- [24] Wang DD, Sueyoshi T. Climate change mitigation targets set by global firms: Overview and implications for renewable energy. *Renewable and Sustainable Energy Reviews* 2018;94:386–98. <https://doi.org/10.1016/j.rser.2018.06.024>.
- [25] Kesidou S, Sovacool BK. Supply chain integration for low-carbon buildings: A critical interdisciplinary review. *Renewable and Sustainable Energy Reviews* 2019; 113. <https://doi.org/10.1016/j.rser.2019.109274>.
- [26] Fuso Nerini F, Sovacool B, Hughes N, Cozzi L, Cosgrave E, Howells M, et al. Connecting climate action with other Sustainable Development Goals. *Nat. Sustain.* 2019;2(8):674–80. <https://doi.org/10.1038/s41893-019-0334-y>.
- [27] Wieser AA, Sherz M, Maier S, Passer A, Kreiner H. Implementation of Sustainable Development Goals in construction industry - a systemic consideration of synergies and trade-offs. *IOP Conf. Series: Earth and Environmental Science* 2019;323: 012177. <https://doi.org/10.1088/1755-1315/323/1/012177>.
- [28] Figueres C, Le Quéré C, Mahindra A, Bäte O, Whiteman G, Peters G, et al. Emissions are still rising: ramp up the cuts. *Nature* 2018;564:27–30. <https://doi.org/10.1038/d41586-018-07585-6>.
- [29] Rogelj J, Luderer G, Pietzcker RC, Kriegler E, Schaeffer M, Krey V, et al. Energy system transformations for limiting end-of-century warming to below 1.5 °C. *Nature Climate Change* 2015;5:519–27. <https://doi.org/10.1038/nclimate2572>.
- [30] Rockström J, Gaffney O, Rogelj J, Meinshausen M, Nakicenovic N, Schellnhuber HJ. A roadmap for rapid decarbonization – emissions inevitably approach zero with a "carbon law". *Science* 2017;355. <https://doi.org/10.1126/science.aah3443>. 6331:1269–1271.
- [31] Child M, Koskinen O, Linnanen L, Breyer C. Sustainability guardrails for energy scenarios of the global energy transition. *Renewable and Sustainable Energy Reviews* 2018;91:321–34. <https://doi.org/10.1016/j.rser.2018.03.079>.
- [32] Axon S, James D. The UN Sustainable Development Goals: How can sustainable chemistry contribute? A view from the chemical industry. *Current Opinion in Green and Sustainable Chemistry* 2018;13:140–5. <https://doi.org/10.1016/j.cogsc.2018.04.010>.
- [33] Vildåsen SS. Corporate sustainability in practice: An exploratory study of the sustainable development goals (SDGs). *Business Strategy & Development* 2018;1 (4):256–64. <https://doi.org/10.1002/bsd2.35>.
- [34] Morioka SN, Bolis I, Evans S, Carvalho MM. Transforming sustainability challenges into competitive advantage: Multiple case studies kaleidoscope converging into sustainable business models. *Journal of Cleaner Production* 2018;167:723–38. <https://doi.org/10.1016/j.jclepro.2017.08.118>.
- [35] Jha MK, Rangarajan K. The approach of Indian corporates towards sustainable development: An exploration using sustainable development goals based model. In: *Sustainable Development*; 2020. <https://doi.org/10.1002/sd.2053>.
- [36] Muñoz-Torres MJ, Fernández-Izquierdo MÁ, Rivera-Lirio JM, Ferrero-Ferrero I, Escrig-Olmedo E, Gisbert-Navarro JV, et al. An Assessment Tool to Integrate Sustainability Principles into Global Supply Chains. *Sustainability* 2018;10:535. <https://doi.org/10.3390/su10020535>.
- [37] Moldavskaya A, Welo T. Testing and Verification of a New Corporate Sustainability Assessment Method for Manufacturing: A Multiple Case Research Study. *Sustainability* 2018;10:11. <https://doi.org/10.3390/su10114121>.
- [38] Moldavskaya A, Welo T. A Holistic approach to corporate sustainability assessment : Incorporating sustainable development goals into sustainable manufacturing performance evaluation. *Journal of Manufacturing Systems* 2019;50:53–68. <https://doi.org/10.1016/j.jmsy.2018.11.004>.
- [39] Muff K, Kapalka A, Dyllick T. The Gap Frame - Translating the SDGs into relevant national grand challenges for strategic business opportunities. *International Journal of Management Education* 2017;15:363–83. <https://doi.org/10.1016/j.ijme.2017.03.004>.
- [40] Global Reporting Initiative, UN Global Compact. *SDG Compass: The guide for business action on the SDGs.* World Business Council of Sustainable Development; 2016 [Online]. Available: <https://sdgcompass.org/>.
- [41] Grainger-Brown J, Malekpour S. Implementing the sustainable development goals: A review of strategic tools and frameworks available to organisations. *Sustainability* (Switzerland) 2019;11:1381. <https://doi.org/10.3390/su11051381>.
- [42] Ramböll. Ramböll SDG Assessment Tool. <http://consulting.ramboll.com/action/me dia/18558/sdg-assessment-tool>. [Accessed 4 April 2019].
- [43] GMV Gothenburg Centre for Sustainable Development. *SDG Impact Assessments – Portal - SDSN Northern Europe.* <https://www.unsdn-ne.org/our-actions/initiatives/sdg-impact-tool/>. [Accessed 4 April 2019].
- [44] Karlsson I, Rootzén J, Johnsson F. Reaching net-zero carbon emissions in construction supply chains – analysis of a Swedish road construction project. *Renewable and Sustainable Energy Reviews* 2020;120:109651. <https://doi.org/10.1016/j.rser.2019.109651>.
- [45] Nilsson M, Griggs D, Visbeck M. Map the interactions between Sustainable Development Goals. *Nature* 2016;534:320–2. <https://doi.org/10.1038/534320a>.
- [46] Global Reporting Initiative and UN Global Compact. *Business Reporting of the SDGs - An analysis of the goals and targets.* 2017 [Online]. Available: https://www.globalreporting.org/resource/library/GRI_UNGC_Business-Reporting-on-SDGs_Analysis-of-Goals-and-Targets.pdf.
- [47] GRI G4 Sustainability Reporting Guidelines - Reporting Principles and Standard Disclosures. Initiative G. R.; 2016 [Online]. Available: <https://www2.globalreporting.org/standards/g4/Pages/default.aspx>.
- [48] PwC. *SDG Selector.* PwC. <https://dm.pwc.com/SDGSelector/>. [Accessed 4 April 2019].
- [49] PwC. *Navigating the SDGs: a business guide to engaging with the UN Global Goals.* PwC; 2016 [Online]. Available: <https://www.pwc.com/gx/en/sustainability/publications/PwC-sdg-guide.pdf>.
- [50] KPMG and UN Global Compact. *SDG Industry Matrix.* 2016 [Online]. Available: <https://home.kpmg/xx/en/home/about/our-role-in-the-world/citizenship/sdgindustry/matrix.html>.
- [51] Global Reporting Initiative and UN Global Compact. In: *Business Reporting on SDGs - Integrating the SDGs into Corporate Reporting: A Practical Guide*; 2018 [Online]. Available: <https://sdghub.com/project/integrating-the-sdgs-into-corporate-reporting-a-practical-guide/>.
- [52] PwC. *Exploring the SDGs important to your business - mapping the way.* PwC. <https://www.pwc.com/gx/en/services/sustainability/sustainable-development-goals/mapping-the-way.html>. [Accessed 4 April 2019].
- [53] PwC. *Global Goals Guide for Business - SDG 7: Affordable and clean energy.* 2016 [Online]. Available: <https://dm.pwc.com/SDGSelector/>.
- [54] PwC. *Global Goals Guide for Business - SDG 13: Climate action.* 2016 [Online]. Available: <https://dm.pwc.com/SDGSelector/>.
- [55] UN Global Compact and KPMG. *SDG Industry Matrix - Industrial Manufacturing.* 2016 [Online]. Available: <https://www.unglobalcompact.org/library/3111>.
- [56] UN Global Compact and KPMG. *SDG Industry Matrix- Energy, Natural Resources & Chemicals*; 2016 [Online]. Available: <https://www.unglobalcompact.org/library/3111>.
- [57] Porter ME, Kramer MR. *Creating shared value.* *Harvard Business Review* 2011;89: 1–2.
- [58] Davis SJ, Lewis NS, Shaner M, Aggarwal S, Arent D, Azevedo IL, et al. Net-zero emissions energy systems. *Science* 2018;360. <https://doi.org/10.1126/science.aas9793>.
- [59] Berndes G, Goldmann M, Johnsson F, Lindroth A, Wijkman A, Abt B, et al. *Forests and the climate - Manage for maximum wood production or leave the forest as a carbon sink? Kungliga Skogs- och Lantbruksakademien Tidskrift* 2018;6:157.
- [60] Sen S, Ganguly S. Opportunities, barriers and issues with renewable energy development – A discussion. *Renewable and Sustainable Energy Reviews* 2017;69: 1170–81. <https://doi.org/10.1016/j.rser.2016.09.137>.
- [61] Johnsson F, Kjærstad J, Rootzén J. The threat to climate change mitigation posed by the abundance of fossil fuels. *Climate Policy* 2018;19(2):258–74. <https://doi.org/10.1080/14693062.2018.1483885>.
- [62] Uyarra E, Flanagan K. Understanding the Innovation Impacts of Public Procurement. *Article (in English), Eur. Plan. Stud.* 2010;18(1):123–43. <https://doi.org/10.1080/09654310903343567>. Jan.
- [63] Wesseling JH, Edquist C. Public procurement for innovation to help meet societal challenges: a review and case study. (in English), *Sci. Public Policy*. Review 2018;45 (4):493–502. <https://doi.org/10.1093/scipol/scy013>. Aug.
- [64] Salvi BL, Subramanian KA. Sustainable development of road transportation sector using hydrogen energy system. *Renewable and Sustainable Energy Reviews* 2015; 51:1132–55. <https://doi.org/10.1016/j.rser.2015.07.030>.
- [65] Horan D. A New Approach to Partnerships for SDG Transformations. *Sustainability* 2019;11:18. <https://doi.org/10.3390/su11184947>.

- [66] SDSN Northern Europe. Ocean Solutions Report 2017;1 [Online]. Available: https://www.unsdsn-ne.org/wp-content/uploads/2017/05/Oceans-Solutions-Report_Pages_Web.pdf.
- [67] Lusseau D, Mancini F. Income-based variation in Sustainable Development Goal interaction networks. *Article Nat. Sustain.* 2019;2(3):242–7. <https://doi.org/10.1038/s41893-019-0231-4>. Mar.
- [68] Pradhan P. Antagonists to meeting the 2030 Agenda. *Nat. Sustain.*, Editorial Material 2019;2(3):171–2. <https://doi.org/10.1038/s41893-019-0248-8>. Mar.