# The concept of sustainable infrastructure: a content analysis of construction companies reports

**Silvia Gordano**[1,] Daniel Torchia [2] and Laura Corazza [3]

[1] Università degli Studi di Torino
silvia.gordano@unito.it

[2] Università degli Studi di Torino
[3]Università degli Studi di Torino

**Abstract.** In 2015, the 17 Sustainable Development Goal (SDGs) were introduced by the United Nations. Among them, SDG 9 (*Industry, innovation and infrastructure*) refers to the notion of 'resilient' and 'sustainable' infrastructure to promote the transition towards sustainable industrialisation. The notion of 'sustainable infrastructure' has been subject of debate over time. The variety of definitions and assessment frameworks used to categorise sustainability components by academics and professional bodies, call for the need to further investigate and reflect on the concept. Hence, this exploratory study aims to provide first evidence on how the term is conceived and interpreted by companies. To this goal, a manual content analysis on non-financial disclosures published by the top-10 European construction companies, is conducted. Findings suggest that firms largely refer to SI in relation to the early phases of the project lifecycle, while neglecting the ultimate stage (i.e., dismantling). Furthermore, there is not a consensus towards a unifying representation of the components enclosed in the notion of SI, although all companies appear to agree with its 'green' attributes (e.g., energy intensity, emissions, materials). Consistently, a prevailing use of environmental assessment criteria is testified. The emphasis placed on other sustainability-related issues (i.e., social and economic) and the broadness of stakeholders' interests addressed vary considerably across corporate reports, thus supporting that the concept of SI is still fragmented and in evolution.

**Keywords:** Sustainable Infrastructure, Resilient Infrastructure, Sustainable Construction, Sustainable Building, Sustainability Reporting, Content Analysis.

## 1 Introduction

The 2030 Agenda by the United Nations has introduced 17 Sustainable Development Goals (SDGs) striving for societies to reach peace and prosperity (United Nations, 2015). In particular, SDG 9 (*Industry, Innovation and Infrastructure*) focuses on infrastructure and promotes the concept of 'resilient' and 'sustainable' infrastructure to drive the transition towards sustainable industrialisation.

The construction sector is largely recognised as one of the most environmentally impactful industrial sectors. It is responsible for 30% of global energy consumption, 40% of raw material extraction, and 30% of carbon emissions (Choi, 2019). However, public expenditure in infrastructure is crucial to promote the economic wellbeing, growth, and social development of countries, by increasing employment, connectivity and ensuring adequate provision of critical utilities.

Given the relevant implications of infrastructural projects, and considering the profound, wide-ranging and lasting impacts that they generate on society and economy (Zeng et al., 2014), sustainability issues in infrastructure have drawn considerable academic attention in recent times.

Overall, there is no unequivocal consensus on how to cope with the sustainability assessment of infrastructure (Chang et al., 2022). As testified by the definition provided by the Inter-American Development Bank (2018), the concept of sustainable infrastructure (SI) is connected with the evaluation of a wide range of sustainable impacts over the entire life-cycle of the project. Therefore, sustainable project management of infrastructure requires reconciliating the conflicting, even though interconnected, dimensions of sustainability, in a multistakeholder and long-term context. Such complexity is made apparent by the large number of different assessment frameworks developed by professional bodies and authorities (including, CEEQUAL, NYSDOT, Greenroads, ISI, ISCA), as well as by scholars (Sahely et al., 2005, Dasgupta and Tam, 2005; Ugwu and Haupt, 2007; Shen et al., 2011; Chan et al., 2022), to measure the sustainability impacts and performance of infrastructure.

To deal with infrastructure through the lens of sustainability and sustainable development, further reflection on the still blurred concept of 'sustainable infrastructure' is required (Chang et al., 2022).

Therefore, the purpose of this study is to provide evidence on how the notion of SI is conceived and interpreted by companies in the construction industry, in order to contribute to the lively and ever-growing debate on sustainable infrastructure. To this aim, we carry out a content analysis on the latest-available non-financial disclosures published by the top 10 European construction companies.

Findings suggest that companies largely refer to SI in relation to the early phases of the project life-cycle (i.e., planning and execution), whilst the end of life stages are neglected (i.e., dismantling). Furthermore, there is not a widely shared representation of the components enclosed in the notion of SI, although all companies seem to agree with its environmental attributes (e.g., energy intensity, emissions, materials). To exacerbate such differences, the emphasis placed on social and economic issues and the breadth of stakeholders' interests addressed vary across corporate reports. Nonetheless, a prevailing use of environmental assessment criteria is observable.

## 2 Literature review and theoretical framework

When engaging with infrastructure and construction projects, it must be underlined the high degree of complexity that surrounds them (Zeng et al., 2014). Infrastructural projects impacts are wide-reaching, encompassing environmental, social and governance matters, which require urgent sustainability management (Flyvberg, 2014; Levitt, 2007; Zeng et al., 2014).

The environmental impacts enclose climate change, pollution, biodiversity, natural resources, and ecosystems, calling for the sustainable ways of managing waste and greenhouse gas emissions (GHG) across supply chains, designing infrastructure with increased resource-use efficiency and greater adoption of green technologies and processes (SDG 9). Such impacts are widely acknowledged by civil society, so that traditionally the notion of sustainability in infrastructure projects was (almost) exclusively associated with 'green' attributes of buildings and infrastructure (Berardi, 2013). Indeed, the review work carried out by Thomé et al. (2016) on the literature in sustainable infrastructure from 1995 to 2015, highlights that most studies conducted in the early stages of the field focused on materials for the greening of buildings, energy efficiency, and water management.

The social facet of infrastructure not only concerns the social impact of the construction activities on the community, but also the construction organisations' engagement with all stakeholders through the whole project life-cycle, such as suppliers and workforce (Valdes-Vasquez & Klotz Leidy, 2013). Health and safety and the high reliance on labour are hallmarks of the construction industry. Even though infrastructure can extensively improve the conditions of local community, especially in developing economies, negative externalities can stem, among others, from prolonged construction projects and the hazardous nature of activities on construction sites. Today, various social issues remain prominent, such as unequal treatment of workers and low working environment standards (Opoku et al., 2022)

Furthermore, governance has long been a recurrent topic in the construction sector, due to the size and inherent complexity of projects, competitive bidding processes, and the necessity to engage with both public and private stakeholders, along with the need of preventing bribery and corruption in supply chains.

Based on the above, it appears now widely acknowledged that the sustainable management of infrastructure requires consideration of a balanced development of sustainability along the 'triple bottom line' (TBL) (i.e., environmental, social, and economic sustainability) (Chan et al., 2022). This requires a marked shift from traditional conceptualisations embracing solely an environmental perspective, to account for the broad range of environmental, social and economic impacts generated, the multitude of stakeholders directly and indirectly involved, and the whole project life-cycle (Berardi, 2013; OECD, 2019).

To try evaluating and improving the environmental, social, and economic outcomes of infrastructure projects, a number of assessment frameworks have been therefore developed by professional bodies in the last two decades. Among them, it is worth mentioning the Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL), Envision, GreenLITES, Greenroads, and the IS rating scheme. However, while sharing several common components, noticeable differences and/or complementarities are observable across frameworks. Furthermore, several studies have criticised them for the overemphasis placed on environmental aspects, while neglecting projects' social return on investment (Shaw et al., 2012; Surbeck and Hilger, 2014).

By reviewing the major existing frameworks developed by professional bodies and assessment frameworks proposed by scholars across the academic literature, Chan et al. (2022) recently come up with a comprehensive assessment framework for sustainable infrastructure (see Table 1). Once again, the authors conclude that social and economic sustainability of infrastructure projects are not perceived as importantly as environmental matters.

**Table 1.** Assessment framework for sustainable infrastructure (Chan et al., 2022).

| Components of sustainable infrastructure | Subcomponents |
|---|---|
| Materials | Material quality control |
| | Materials reuse |
| | Local materials |
| | Innovative materials |
| | Material intensity |
| Waste | Divert from landfill |
| | Construction and operational waste |
| | Deconstruction |
| Energy and ecology | Energy use |
| | Air quality control |
| | Greenhouse gas emission control |
| | Protection of biodiversity |
| | Ecological connectivity |
| | Renewable energy |
| Water | Water use |
| | Protection of water quality |
| | Stormwater management |
| Community engagement | Tangible heritage management |
| | Public opinion |
| | Future visions |
| | Level of engagement |
| | Intangible heritage management |
| | Skill development opportunities |
| Health and safety | Occupational mental health |
| | Occupational physical health |
| | Public physical health |
| | Public mental health |
| | Safety |

| | |
|---|---|
| Corporate social responsibility | Anti-discrimination |
| | Anti-corruption |
| | Fair wage |
| Project management | Procurement and supply chain governance |
| | Type of contract |
| | Life-cycle cost management |
| | Environmental management |
| Environmental impact on local community | Vibration control |
| | Noise control |
| | Light pollution control |

## 3 Methodology

In order to investigate how companies interpret the concept of SI, we conduct a content analysis of corporate disclosures on sustainability-related topics published by the top 10 companies in the 2021 list of European Contractors by Construction Europe[1] (see Table 3, in Appendix). We choose this method of analysis as corporate narratives have been suggested to represent meaningful means for detecting how the discourse around social issues is constructed by organisations (Buhr and Reiter 2006; Tregidga and Milne 2006; Laine 2009; O'Connor and Shumate 2010; Beauchamp and O'Connor 2012).

In particular, the study applies both a qualitative and quantitative content analysis, to both facilitate the interpretation of data and objectively present facts from the text in the form of frequencies. Furthermore, the nature of our content analysis is both deductive and inductive. Indeed, we draw upon Chan et al.'s framework (2022), to analyse the components and subcomponents associated with the notion of sustainable infrastructure, to find out if those or other components of sustainable infrastructure emerged from corporate disclosures.

To carry out our analysis, we first screen sustainability-related information in corporate reports by entering a search query based on the following keywords: "*sustainable infrastructure*", "*sustainable construction*", "*sustainable building*", "*resilient building*", and "*SDG 9*". Subsequently, we extract information located in the same paragraphs where the identified keywords are mentioned and carry out a manual coding. Specifically, based on previous works in the SI field, the coding procedure aims to identify the following key aspects:

1) the project life-cycle phase(s) addressed (OECD, 2019);

2) the components (i.e., sustainability issues/topics) and sub-components (i.e., sustainability sub-topics) related to SI (Chan et al., 2022);

3) the metrics employed to assess SI.

[1] Available at: https://www.construction-europe.com/Files/Download/20210927-112301-CE-09-2021-CE100.pdf

# 4 Findings

The keyword-based search resulted in nine companies out of ten showing some kind of information associated with sustainable infrastructure. For such companies, therefore, key aspects related to SI are discussed in the following.

## 4.1 Project life-cycle phases

From the analysis, it emerges that the concept of SI is largely applied by companies in the *design* and *execution* phases of projects life-cycle (see Fig. 1). Considering sustainable impacts in the genesis of infrastructure project, is crucial, since decisions related to the early phases are highly risky and have profound and irreversible consequences (Ma et al., 2017). Even though project processes involve progressively decreasing levels of risk and uncertainty through time (Winch, 2001), the dismantling phase need to be addressed nonetheless, to implement circular economy practices.. However, recent works point out a substantial lack of tools and standards related to the ultimate life-cycle stages (Corazza et al., forthcoming).

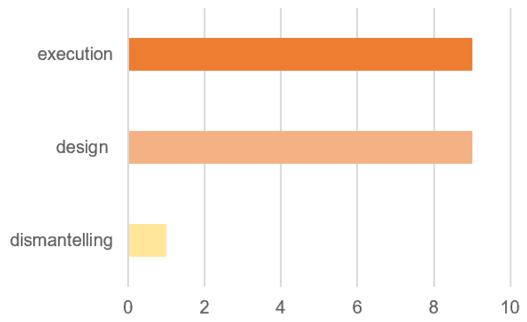


**Fig 1.** Project life-cycle phases addressed

## 4.2 Components and sub-components of SI

Frequencies of components detected from our analysis are shown in Fig 2. The component ‘Energy’ records the highest relative importance, appearing in all corporate reports. Companies widely attach sustainability attributes to low-carbon emission projects, capable of producing fewer GHG emissions compared to traditional infrastructure and positively contributing to climate neutrality. This is not surprising, given that the construction sector has been traditionally put under the spotlight by civil society for its high levels of energy consumption and GHG emissions. Energy-based criteria represent the most commonly employed measures to assess sustainability in buildings (Berardi, 2012), to the extent that the terms 'sustainable' and 'energy efficient' have been largely used as synonyms (Berardi, 2013). Accordingly, the analysis also shows that the majority of subcomponents concerns energy-efficiency instead of renewable energy investment.

The component 'Materials' is also recurrently anchored to the concept of sustainable infrastructure. Previous studies show that materials-related issues are noticeable in almost all existing assessment frameworks (Chan et al., 2022). Specifically, the analysis highlights that companies focus on reusing and recycling, turning to certified and low-energy-embodied materials. By contrast, the use of local materials appears not to be a prevailing option, as this practice may lead to higher costs and delays in building projects (Hayles and Kooloos, 2005).

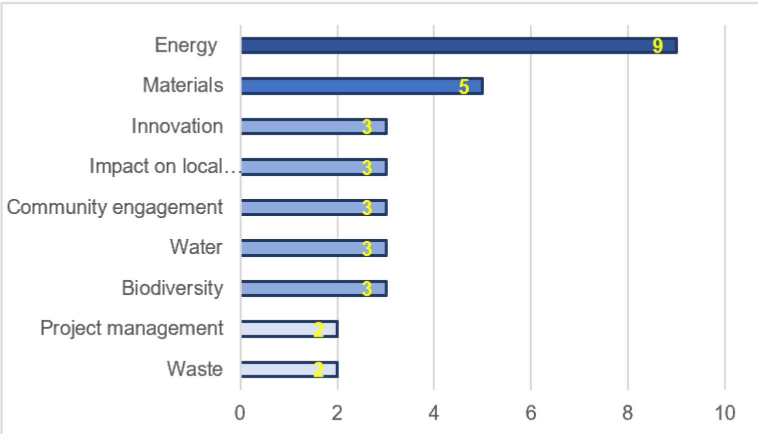


**Fig 2.** Components and sub-components of SI

Following, topics related to 'Water', 'Biodiversity', 'Community', and 'Innovation' appear to be equally associated with the notion of SI. Water management is usually connected to water use reduction and stormwater management, in line with the focus on storm water runoff shown by studies conducted in the first decade of the 2000s (Thomé et al., 2016). 'Biodiversity' is linked to SI mostly in terms of prevention of damages caused by natural forces, and ecosystem protection and restoration thus recalling the notion of 'green' infrastructure promoted by the European Union (EU) (EU, 2013).

The component related to community can be categorised into two categories, i.e., 'Impact on local community', which refers to reducing negative impacts falling over local communities (such as, noise, dust, and traffic), and 'Community engagement', which instead relates to company's engagement in initiatives for community wealth development (such as, information-sharing endeavours, seminars, workshops, educational events dedicated to youngsters, apprenticeship and work placement opportunities). In this light, intangible impacts of infrastructure, which have been indicated as a white spot in many existing assessment frameworks (Chan et al., 2022), appears to be addressed to some extent by companies. Furthermore, SI is also linked to innovation, in terms of ground-breaking project design and innovation sharing to improve people's life.

By contrast, consistently with the scarce consideration devoted to the disposal phase of infrastructure projects, waste management is rarely associated with SI, as well as economic issues related to project management.

In Table 2, a re-elaboration of Chan et al.'s (2022) framework is presented, based on the components and subcomponents that emerged from the content analysis. Components and subcomponents marked in bold indicate labels attributed by the authors that differ from Chan et al.'s (2022) framework.

Table 2. Components and subcomponents of sustainable infrastructure recognised by the authors.

| COMPONENTS | SUBCOMPONENTS |
|---|---|
| Materials | |
| | Material quality control |
| | Materials reuse |
| | **Materials recycling** |
| | Local materials |
| | Innovative materials |
| | Material intensity |
| Waste | |
| | Divert from landfill |
| | Construction and operational waste |
| Energy | |
| | Energy use |
| | Renewable energy |
| | Greenhouse gas emission control |
| **Biodiversity** | |
| | Protection/**restoration** of biodiversity |
| | Ecological connectivity |
| | |
| Water | |
| | Water use |
| | Stormwater management |
| Community engagement | |
| | Future visions |
| | Level of engagement |
| | Skill development opportunities |
| | **Quality relationship** |
| Project management | |

| | |
|---|---|
| | Procurement and supply chain governance |
| | Type of contract |
| | Environmental management |
| **Impact on local community** | |
| | Noise control |
| | **Traffic issues** |
| **Innovation** | |
| | **Design for change** |
| | **Innovation sharing** |

### 4.3 Assessment metrics

The analysis supports that companies manly rely on environmental assessment criteria to assess the sustainability of infrastructure, including revenues from projects with environmental certifications (such as, LEED, BREEAM, etc), indicators drawn from the Global Reporting Initiative (GRI) 302 (*Energy*) and 305 (*Emissions*), the percentage of sustainable materials (i.e., with an environmental certification) on sales, the R&D expenditures related to eco-projects.

These findings support scholars' criticism on the prevailing environmental focus of extant SI assessment frameworks and further advocate that companies adhere to such (mis)conception. Indeed, we found that the social sphere is seldomly recalled, with just few companies making references to the social value of projects in terms of its impact on local community. Yet, the economic pillar of sustainability is quite neglected, with sporadic use of assessment metrics drawn from the GRI 201 (*Economic performance*) and 203 (*Indirect economic impacts*).

## 5 Conclusions

Sustainable infrastructure has the potential to play a primary role in delivering long-term socio-economic benefits, as well as environmental ones (OECD, 2019). Over time, the sustainable infrastructure field has gradually broadened its scope from green infrastructure to the TBL of economic, social, and environmental sustainability (Berardi, 2013). However, the variety of components and the still prevailing environmental façade of SI in extant assessment frameworks (Chan et al., 2022), call for further investigation on the concept. Therefore, this exploratory study has aimed to add a company-centric perspective to the SI discourse, by analysing SI-related contents as disclosed by companies of the construction industry in their corporate reports.

Our findings support that firms largely refer to SI in relation to the early phases of the project life-cycle (i.e., planning and execution), whereas very little linkages to the final project stages are detectable. This can be explained by the paucity of assessment tools related to the deconstruction/demolition phase (Corazza et al., forthcoming). Furthermore, the analysis supports that the components and subcomponents associated with the concept of sustainable infrastructure/construction/building are not unanimously shared by companies. In particular, the components mostly associated with the notion of SI are those pertaining to the environmental dimension and involving actions with a restricted focus (predominantly internal to the organisation). Such components reflect corporate commitments that are aligned with business aspects largely acknowledged by the public as the most critical in the industry (for instance, the high levels of CO2 emissions, energy consumption and material use) (Opoku et al., 2022). More rarely, the SI concept embraces the social dimension and involves a broader spectrum of stakeholders, including natural ecosystems (Haigh and Griffiths, 2007), local community and society at large. Ultimately, the SI concept is very seldomly represented through an economic perspective, by referring to sustainable project management, mainly in terms of sustainable procurement and non-financial performance-based types of contracts.

The study is exploratory and, therefore, presents several limitations, which can also be intended as inputs for future developments. First of all, the empirical analysis has been conducted on a small sample of companies to provide first insights into the topic. Expanding the sample would certainly contribute to the generalisability and enrichment of our findings. Moreover, the manual text classification could be accompanied and complemented by deploying automatic text mining techniques, to analyse terms associations based on frequency support and statistical confidence (Wang et al., 2020). Further research is suggested to better define the concept of SI, which is still fragmented and deserves more attention from academics and practitioners.

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# Appendix

Table 3. List of companies considered for the analysis

| **Ranking by revenues** | **Company** |
|---|---|
| 01 | Vinci |
| 02 | ACS |
| 03 | Bouygues |
| 04 | Hochtief |
| 05 | Eiffage |
| 06 | Skanska |
| 07 | Strabag |
| 08 | TechnipFMC |
| 09 | Balfour Beatty |
| 10 | Saipem |