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Measuring sustainability impacts through SROI: a case study of the Italian glass industry's contribution to the SDGs

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Abstract

Purpose – This study investigates the contribution of the Italian glass industry to sustainability, with a focus on its alignment with selected Sustainable Development Goals (SDGs), specifically SDGs 6, 7, 8, 12 and 13.
Design/methodology/approach – The research applies the Social Return on Investment (SROI) methodology to evaluate the socioeconomic and environmental impacts of the Italian glass supply chain from 2022 to 2050, with insights gained through extensive stakeholder engagement.
Findings – The results reveal a positive SROI ratio of 2.53, indicating substantial value creation across multiple dimensions. Social impacts emerge as the most significant, representing 44.2% of total value generated, primarily through employment creation. Economic impacts account for 39.5%, driven by energy and material savings, while environmental impacts contribute 16.3% through decarbonisation efforts and improved resource efficiency. The study demonstrates how the glass industry's sustainability initiatives align with and contribute to multiple SDGs while also highlighting the challenges in balancing environmental imperatives with socioeconomic outcomes.
Practical implications – The findings provide valuable insights for industry practitioners and policymakers on measuring and managing sustainability impacts in energy-intensive sectors, offering a replicable framework for evaluating progress towards SDG targets.
Originality/value – This study contributes to the limited literature on sustainability accounting in energy-intensive sectors by providing a comprehensive assessment of the Italian glass industry's contribution to SDGs. It offers a novel application of SROI methodology to evaluate long-term sustainability impacts while demonstrating how traditional industries can transform their practices to support SDGs.

Keywords Sustainability, Glass industry, Social Return on Investment (SROI),
Sustainable Development Goals (SDGs), Circular economy

Paper type Research paper

1. Introduction

In the 21st century, the development of environmentally sustainable techniques is imperative for managing the Earth's limited resources effectively. With the global population projected to

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reach 8.5 billion by 2030 (United Nations Department for Economic and Social Affairs, 2023), the challenge of intergenerational sustainability becomes increasingly pressing. This challenge involves making difficult trade-offs between immediate benefits and the long-term well-being of future generations (Shahen *et al.*, 2021a, b). There is a growing recognition among policymakers, intergovernmental bodies, corporate entities, and scholars of the importance of enhancing their capacity to identify, mitigate, and disclose social and environmental impacts (Serafeim, 2020; Busco, 2023; Busco *et al.*, 2020). This recognition is crucial, as growing evidence indicates that organisations often lack the mechanisms required to address these complex and multi-faceted issues (Korca *et al.*, 2021).

The grand challenges that characterise our era – including climate change, social inequality, and economic instability – are interwoven with the principles embodied by the United Nations Sustainable Development Goals (SDGs). These goals represent a comprehensive framework that seeks to synchronise economic growth with ecological and social imperatives (Miola and Schiltz, 2019; Smith *et al.*, 2021; Garg *et al.*, 2022). However, while the SDGs provide a robust platform for driving sustainable development, current accounting practices have been criticised for their limited impact on broader social and environmental ecosystems. They often focus predominantly on organisational benefits rather than systemic change (Bebbington *et al.*, 2020a, b; Hsiao *et al.*, 2022; Guthrie *et al.*, 2010; Gray, 2006, 2010). Industries across various sectors are deeply entangled in these grand challenges as they struggle to balance economic growth, resource efficiency, and environmental responsibility. The need for sustainable transitions is particularly urgent in energy-intensive and resource-dependent industries, where conventional accounting practices often fail to capture the broader social and environmental implications of their activities (Bebbington *et al.*, 2020a, b; Aureli *et al.*, 2023; Baker *et al.*, 2023).

Among energy-intensive industries, the Italian glass industry plays a key role in the country's economic landscape and sustainability transition. As Europe's second-largest glass producer and leading manufacturer of glass packaging in the region, Italy's glass sector has significant environmental and socio-economic impacts (Assovetro, 2023). The sector employs 30,000 people directly, with an equal number involved in the supply chain. The industry's geographical distribution reveals significant regional concentrations – 17.2% in Veneto, 13.6% in Lombardy, and 9.8% in Campania – creating distinct patterns of socio-economic impact. This regional dimension adds complexity to sustainability measurement, as impacts must be assessed at both local and national levels.

The industry's structure presents unique challenges for implementing and measuring sustainability initiatives. Dominated by Small and Medium Enterprises (18.5% microenterprises, 9.1% small-to-medium sized), with 88.7% of companies employing fewer than 10 people, the sector must balance the need for sustainable practices with economic viability. The industry's high energy consumption and significant reliance on natural resources present both challenges and opportunities for sustainability transitions.

The glass industry's operational characteristics create direct linkages to specific SDGs. Water usage in production processes connects to SDG 6 (Clean Water and Sanitation), with the industry's substantial water consumption requiring improved treatment and recycling systems (Kummerer *et al.*, 2018). The sector's energy-intensive nature aligns with SDG 7 (Affordable and Clean Energy), necessitating transitions to renewable energy sources and enhanced efficiency measures (Davis *et al.*, 2018; Waisman *et al.*, 2019). Employment patterns and economic contributions relate directly to SDG 8 (Decent Work and Economic Growth). The industry's potential for circular economy practices connects to SDG 12 (Responsible Consumption and Production), particularly through waste reduction and resource efficiency initiatives (Priyadarshini and Abhilash, 2020; Lacy and Rutqvist, 2015). Climate action efforts (SDG 13) represent perhaps the most significant challenge, requiring substantial investments in decarbonisation technologies and process improvements (Leach *et al.*, 2018; Leggewie and Messner, 2012).

Although the glass industry contributes to innovation (SDG 9) and sustainable cities (SDG 11) through its products, these impacts are broader in scope and less directly measurable within

the SROI framework, reinforcing the study's focus on SDGs 6, 7, 8, 12, and 13. This specific focus is based on three key criteria: (1) these SDGs have the most direct and measurable connection to the industry's core operations and environmental footprint, (2) they represent areas where the industry's impact can be more precisely quantified through the SROI methodology, and (3) they align with the primary sustainability challenges facing energy-intensive manufacturing sectors.

As Guthrie *et al*. (2010) emphasise, it is necessary to shift accounting practices from a segregated approach to one that is more integrated, thus highlighting the interdependence of social, economic and ecological aspects. Other studies also say we have to think about more than just money when we judge what a company does right or wrong. For example, Baker *et al*. (2023) say companies should focus on more than how much money they make and think about how their decisions affect sustainability and the Sustainable Development Goals (SDGs). The idea of a "circular economy", where we don't waste resources and harm the environment, also means we need to think differently about how we measure and manage what a company does. Aureli *et al*. (2023) say we need to change how we talk about money and work with other people to get the right information about the effects of a business model that uses fewer resources. Emerging integrated thinking and reporting frameworks, such as the International Integrated Reporting Council's (IIRC) Integrated Reporting (IR), seek to connect financial and non-financial performance, promoting integrated reporting across various types of capital (financial, manufactured, intellectual, human, social and relationship, and natural) (Busco *et al*., 2018). However, these frameworks currently have limitations in effectively quantifying long-term sustainability impacts and predictive functions (Busco *et al*., 2018). From a macro-level perspective, while the UN SDGs provide organisations with a comprehensive framework for aligning sustainability efforts with global priorities, measuring organisational contributions to these goals remains challenging, particularly in resource-intensive industries. This necessitates the development of more sophisticated measurement tools capable of capturing the complex interdependencies of environmental and socio-economic factors (Miola and Schiltz, 2019; Smith *et al*., 2021; Garg *et al*., 2022).

The Social Return on Investment (SROI) methodology offers a promising solution by providing a structured approach to measuring both social and environmental impacts alongside financial returns. SROI's ability to monetise non-financial outcomes while maintaining their qualitative significance addresses a crucial gap in current accounting practices (Nicholls *et al*., 2012). This approach aligns with recent developments in dialogic accounting, which emphasises the need for more participatory and stakeholder-inclusive forms of accountability (Brown *et al*., 2015; Cooper and Owen, 2007).

However, despite these methodological advances, significant gaps remain in our understanding of how sustainability impacts can be effectively measured and managed in practice. While recent accounting studies have emphasised the need for more integrated approaches to sustainability measurement (Baker *et al*., 2023; Aureli *et al*., 2023), three key gaps remain unaddressed. First, current accounting practices often fail to capture the full spectrum of sustainability impacts in energy-intensive sectors, particularly in relation to SDG achievement (Bebbington *et al*., 2020a, b). Second, existing measurement frameworks struggle to balance short-term operational metrics with long-term sustainability outcomes, especially in hard-to-abate sectors like glass production (Leach *et al*., 2018). Third, there is limited empirical evidence demonstrating how traditional industries can effectively measure and manage their contributions to multiple SDGs simultaneously over extended time periods (Miola and Schiltz, 2019). This study addresses these gaps by examining how the Italian glass industry, through the application of SROI methodology, can comprehensively assess its sustainability impacts while contributing to multiple SDGs during 2022–2050.

To address these gaps and advance our understanding of sustainability measurement in practice, this study addresses two primary research questions:

(1) How does the Italian glass industry contribute to advancing selected SDGs through its sustainability practices?

(2) What are the long-term socio-economic and environmental impacts of these practices from 2022 to 2050, and how can the SROI framework enhance accountability in this context?

By addressing these questions, this study responds to calls for more integrated approaches to accounting and sustainability (Bebbington *et al.*, 2020a, b; Guthrie *et al.*, 2024), while offering practical insights into measuring and managing sustainability impacts in energy-intensive sectors.

This study is structured as follows. Section 2 presents the theoretical framework connecting SROI methodology with sustainability accounting literature. Section 3 outlines our research methodology and evaluation framework, detailing the application of SROI in the glass industry context. Section 4 reports our findings on the socio-economic and environmental impacts of the industry's sustainability initiatives. Section 5 discusses the implications of these findings for theory and practice, connecting them to broader debates in sustainability accounting. The study concludes with limitations and suggestions for future research.

2. Theoretical background

The integration of sustainability within accounting practices has constituted a significant challenge for scholars and practitioners alike. The traditional frameworks of accounting have historically concentrated on financial performance, with the social and environmental dimensions either addressed separately or entirely overlooked (Gray, 2010; Guthrie *et al.*, 2010). This compartmentalisation has limited organisations' abilities to holistically account for their broader impacts, particularly when long-term sustainability outcomes are considered (Bebbington *et al.*, 2020a, b; Hsiao *et al.*, 2022). As global challenges such as climate change, resource depletion, and social inequality become more pressing, there is a growing need for accounting systems that can capture the interdependencies between economic, social, and environmental dimensions (Miola and Schiltz, 2019; Shahen *et al.*, 2021a, b).

Recent scholarship has emphasised the need to bridge the gap between accounting practices and sustainability imperatives. Baker *et al.* (2023) argue for a rapprochement between accounting and sustainability, suggesting that while these domains have historically been viewed as incompatible, their integration is crucial for driving sustainable development. This is particularly evident in hard-to-abate sectors where traditional accounting metrics struggle to capture complex sustainability impacts. Aureli *et al.* (2023) extend this argument by advocating for a dialogic approach to management accounting, especially in the context of circular economy initiatives. Their research demonstrates how management accounting systems must evolve beyond traditional boundaries to support stakeholder collaboration and capture multi-dimensional impacts.

One of the key conceptual advancements in this space is Emerson's (2003) concept of blended value, which argues that value creation must transcend purely economic metrics to include social and environmental outcomes. This concept underpins modern discussions on organisational accountability, offering a more integrated view of how businesses generate value (Stiglitz *et al.*, 2009). The blended value framework has gained traction in sectors where both financial and non-financial impacts are critical, influencing methodologies like SROI, which attempts to capture this full spectrum of value creation (Nicholls *et al.*, 2012).

Originally developed in the non-profit sector, SROI has since been adopted across various industries, offering a comprehensive tool for evaluating the multidimensional impacts of investments. Unlike traditional techniques such as Net Present Value or Internal Rate of Return, which primarily focus on economic returns, SROI expands the scope of assessment by integrating social and environmental outcomes into its calculations (Nicholls and Emerson, 2015a, b). This methodology enables organisations to quantify the broader impacts of their activities in monetary terms, providing a more comprehensive view of value creation.

However, the practical application of SROI is not without its challenges. Critics like Cooney (2017) point to the methodology's reliance on financial proxies to estimate non-monetary impacts, which can oversimplify the complexities of social and environmental outcomes. This can lead to what is described as an "illusion of precision", where complex outcomes are reduced to simplistic metrics that may not fully capture their depth (Arvidson *et al.*, 2013). The scarcity of reliable proxies for certain sustainability outcomes, such as long-term decarbonisation or resource efficiency, further complicates SROI's application in industries like glass production, where socio-economic and environmental variables are deeply intertwined (Higham *et al.*, 2018; Lophongpanit *et al.*, 2019).

Despite these critiques, SROI remains an invaluable tool for understanding the full impact of sustainability initiatives, particularly in sectors with significant environmental and social footprints. The Italian glass industry – the second-largest in Europe – offers a fitting context for exploring the potential of SROI to evaluate sustainability initiatives. The industry faces critical sustainability challenges related to energy consumption, water use, and emissions, all of which align with key SDGs, such as SDGs 6, 7, 8, 12, and 13 (UN-Water, 2021; Davis *et al.*, 2018). For example, the industry's energy-intensive production processes and substantial water use underscore the need for improved resource efficiency, aligning with SDG 7 (affordable and clean energy) and SDG 6 (clean water and sanitation) (Waisman *et al.*, 2019; Kummerer *et al.*, 2018). Similarly, the potential for circular economy practices within the sector aligns with SDG 12 (responsible consumption and production), while decarbonisation efforts are central to SDG 13 (climate action) (Leach *et al.*, 2018).

The integration of SROI with integrated thinking and reporting frameworks offers potential solutions to these measurement challenges. As Busco *et al.* (2018) argue, integrated thinking enables organisations to actively reconsider relationships between different forms of capital and their various operating units. The SROI methodology complements this approach by providing a structured way to evaluate impacts across multiple capitals while maintaining stakeholder engagement throughout the assessment process. This combination is particularly valuable for forward-looking analysis, as it enables organisations to predict and evaluate long-term sustainability impacts while considering multiple stakeholder perspectives (Bebbington *et al.*, 2020a, b).

In addition to offering a framework for capturing blended value, SROI aligns with broader shifts in accounting towards integrated thinking and reporting. Busco *et al.* (2019) emphasise the need for accounting systems that align financial performance with long-term sustainability goals, fostering a more holistic approach to organisational accountability. IR seeks to synchronise corporate strategies with the SDGs, enabling organisations to balance short-term financial goals with long-term environmental and social outcomes (Serafeim, 2020). This approach is particularly critical in industries like glass production, where the long-term effects of sustainability investments – such as decarbonisation technologies and resource-efficient processes – may only be fully realised over decades.

The recent literature on future-oriented accountability further reinforces the significance of predictive tools like SROI in assessing long-term sustainability impacts. Granà *et al.* (2024) highlight the potential of integrating empirical and predictive data, such as Earth Observation (EO) technologies, to enhance accountability in environmental reporting. Such forward-looking approaches allow organisations to base their sustainability strategies on robust empirical data, making it possible to account for future impacts in real-time. This shift towards future-oriented accountability is particularly relevant in industries with significant environmental footprints, where the effects of today's decisions may not manifest until far into the future (Frey-Heger and Barrett, 2021; Vollmer, 2021).

By applying SROI in the context of the Italian glass industry, this study seeks to provide a comprehensive evaluation of the sector's long-term social, economic, and environmental impacts. The predictive capabilities of SROI, combined with a future-oriented approach to sustainability accounting, offer valuable insights into how industries can align their operations with global sustainability goals while maintaining accountability to both present and future

stakeholders. This research contributes to the evolving discourse on IR, blended value, and future-oriented accountability, offering a nuanced understanding of how SROI can enhance long-term sustainability efforts in resource-intensive sectors like glass production.

3. Methodology and evaluation framework

This study applies the SROI methodology to assess the sustainability impacts of the Italian glass industry, integrating social, environmental, and economic dimensions. Grounded in the blended value framework discussed earlier, the SROI approach allows for the quantification of both financial and non-financial returns generated by the glass sector's investments in sustainability initiatives. By capturing the multidimensional value of these initiatives, the SROI model addresses the need for comprehensive sustainability accounting, particularly in resource-intensive industries such as glass production (Emerson, 2003; Nicholls and Emerson, 2015a, b).

3.1 SROI methodology application

The SROI methodology was selected due to its capacity to extend traditional financial metrics by integrating social and environmental outcomes. It offers a robust framework for evaluating long-term impacts, making it particularly suited for industries like glass production that face significant sustainability challenges. This study applies the predictive SROI approach, which estimates future returns based on expected outcomes during 2022–2050. This predictive application aligns with recent calls for more forward-looking accounting systems (Busco *et al.*, 2019).

The SROI process follows six key steps (Nicholls *et al.*, 2012): (1) defining the scope and identifying stakeholders, (2) mapping outcomes, (3) evidencing outcomes and their value, (4) establishing the impact, (5) calculating the SROI ratio, and (6) reporting and embedding the results. Each of these steps is essential in capturing the broader societal and environmental impacts alongside the economic benefits of sustainability initiatives.

3.2 Stakeholder engagement and data collection

A critical component of this study was the involvement of key stakeholders through a collaborative engagement process led by Assovetro, the Italian Association of Glass Producers. Assovetro represents 68 companies from various segments of the glass industry, including primary and secondary production. Focus groups were conducted with Assovetro's board members to define the scope, identify stakeholders, and map outcomes (steps 1 and 2 of the SROI analysis), as well as to review the results of subsequent SROI steps.

The focus group participants included the President, Director, two representatives from the Economy and Enterprise Area, the Technical Area Manager, and rotating representatives from associated enterprises (each meeting included three representatives for both Hollow and flat glass, with 20% of the represented companies participating). Participation was most extensive during the first two steps of the analysis and more selective for steps 3 to 6, depending on specific technical discussion topics.

The focus groups were held weekly from May 2022 to February 2023, with an average duration of two hours per session. This stakeholder-driven process ensured that the hypotheses developed for the SROI analysis were grounded in industry-specific knowledge and aligned with broader sustainability goals.

Through this stakeholder consultation, four primary areas of investment were identified: decarbonisation, energy efficiency of the building stock, reuse of materials, and production structure enhancement. These areas reflect both the industry's regulatory environment and its alignment with key SDGs, particularly SDGs 6, 7, 8, 12, and 13. The stakeholder-driven process ensured that the hypotheses developed for the SROI analysis were grounded in industry-specific knowledge and aligned with broader sustainability goals.

3.3 Hypotheses and investment areas

Based on the stakeholder engagement, the study focused on four key investment areas that align with both the industry's operational needs and sustainability goals:

(1) Decarbonisation: Investments aimed at reducing CO_2 emissions through energy efficiency improvements, process electrification, and the adoption of cleaner energy carriers like hydrogen and biomethane. Carbon capture technologies also play a critical role in this area.

(2) Energy Efficiency of Building Stock: This area emphasises the role of the glass supply chain in promoting energy-efficient buildings. Increasing demand for flat glass in energy-efficient windows and photovoltaic glass will contribute to reducing greenhouse gas emissions and generating economic savings.

(3) Reuse of Materials: In line with circular economy principles, this investment focuses on increasing the recycled content in glass production, thereby reducing the demand for virgin raw materials and lowering emissions related to material extraction and processing.

(4) Production Structure Enhancement: This area covers the anticipated growth in the production of flat and hollow glass, with a strong emphasis on job creation, capacity expansion, and the socio-economic benefits derived from scaling up the sector's infrastructure.

3.4 Outcome variables and evaluation framework

The long-term impacts of these investments were evaluated by mapping each investment category to specific outcomes across environmental, social, and economic dimensions.

In the environmental dimension, key outcomes include significant reductions in CO_2 emissions driven by investments in decarbonisation and energy efficiency. Metrics for these outcomes include tons of CO_2 avoided, improvements in energy efficiency (measured in megawatt-hours, MWh), and the share of production powered by renewable energy sources. Additionally, outcomes related to the reduction of harmful pollutants, such as nitrogen oxides (NOx) and sulphur dioxide (SO_2), are critical environmental metrics.

In the social dimension, the primary outcome is the creation of jobs, both direct and indirect, as a result of the industry's investment in production structure enhancement. The expansion of flat and hollow glass production facilities is expected to generate employment, contributing to the socio-economic development of local communities. The broader social impacts of this job creation are reflected in the increased capacity of the glass industry to support inclusive economic growth, in alignment with SDG 8.

In the economic dimension, the key outcomes are linked to energy savings and resource efficiency. The adoption of photovoltaic glass panels and the replacement of inefficient windows are expected to result in significant energy savings, reducing both operational costs and reliance on external energy sources. The increase in recycled content in glass production will reduce the industry's dependence on virgin raw materials, further enhancing its economic sustainability. These outcomes not only align with SDG 12 but also support the broader goal of promoting sustainable production and consumption patterns.

The evaluation framework developed in this study is rooted in these metrics, forming the foundation for calculating the SROI ratio. By applying financial proxies and assumptions, the framework translates the impacts of sustainability investments into monetary terms, providing a comprehensive understanding of the value generated for each euro invested. Further details on the proxies and assumptions used can be found in the Appendix.

3.5 Financial proxies and mitigation variables

The calculation of the SROI ratio requires the use of financial proxies to assign monetary values to social, environmental, and economic outcomes. For instance, the reduction in CO_2

emissions is monetised using the social cost of carbon, estimated at 160 € per ton of CO_2 avoided. Similarly, the financial benefits of energy savings are captured through proxies related to reduced energy consumption, with photovoltaic glass panels providing economic savings of approximately 150 € per megawatt-hour of energy generated.

Mitigating factors, such as deadweight and attribution, are applied to ensure the SROI calculations remain conservative and realistic. Deadweight, set at 33%, accounts for outcomes that would have occurred without the intervention, while attribution, set at 10%, reflects the contributions of other actors to the observed outcomes. These mitigation variables help refine the estimates and provide a more accurate assessment of the actual impact generated by the industry's sustainability investments.

The details of the financial proxies and the mitigation variables used in this analysis, along with their rationale, are elaborated in the Appendix. This ensures transparency in the evaluation process and offers a clear understanding of how different factors were accounted for in the SROI calculations.

4. Results

The application of the SROI methodology enabled a comprehensive assessment of the Italian glass industry's contributions to sustainability across environmental, social, and economic dimensions from 2022 to 2050, addressing the two key research questions outlined in the Introduction section. Regarding the first question of SDG alignment, the analysis reveals that the glass industry's sustainability initiatives contribute positively to the achievement of the selected SDGs, namely SDGs 6, 7, 8, 12, and 13. The industry's efforts in areas such as water management, energy efficiency, employment generation, circular economy practices, and decarbonisation demonstrate a strategic focus on aligning operations with these global sustainability targets (UN, 2015). In relation to the second research question, the SROI analysis quantifies the long-term socio-economic and environmental impacts of the industry's sustainability practices. The final SROI ratio was calculated at 2.53, signifying that for every euro invested, the industry generates €2.53 in societal value. This finding highlights the effectiveness of SROI as a tool for capturing the multi-dimensional value created by sustainability initiatives (Nicholls *et al.*, 2012).

Breaking down the SROI results, the social dimension emerged as the most significant, representing 44.2% of the total value generated. By 2050, the direct and indirect job creation effects are expected to generate approximately €12 billion in societal value. This contribution underscores the glass industry's role in supporting stable and highly specialised employment in Italy. It also highlights the sector's importance in contributing to inclusive economic growth, aligning with SDG 8, which emphasises decent work and economic growth.

In terms of the economic dimension, the glass industry is projected to generate over €10 billion by 2050, accounting for 39.5% of the total value. This contribution stems primarily from energy and material savings, with investments in energy-efficient building materials, such as flat glass in windows and photovoltaic glass, playing a crucial role. The economic savings from reduced energy consumption and increased use of recycled materials help to position the industry as a key driver of sustainable development in Italy, particularly in alignment with SDGs 7 (affordable and clean energy) and 12 (responsible consumption and production).

Lastly, the environmental dimension, although the smallest in terms of total impact, still contributed significantly, accounting for 16.3% of the overall value, or around €4.5 billion. This impact is primarily driven by the industry's efforts in decarbonisation, which accounted for over 60% of the environmental benefit. Decarbonisation initiatives, such as the introduction of green energy carriers, carbon capture, and process electrification, contributed substantially to the reduction of CO_2 emissions. The glass industry's environmental efforts, including its focus on water recycling and the reduction of other harmful pollutants (such as nitrogen oxides and sulphur dioxide), are aligned with SDGs 6 (clean water and sanitation) and 13 (climate action).

The distribution of the impact among the investment categories reveals those efficient buildings – driven by the demand for flat glass and energy-saving technologies – are a key factor in economic and environmental value generation. These investments accounted for 68% of the economic dimension and 14% of the environmental dimension. Re-use of materials contributed significantly to both the economic and environmental dimensions, particularly through the reduction of virgin raw materials and associated emissions. Finally, the decarbonisation efforts, while contributing significantly to the environmental dimension, had a lower relative impact in the economic dimension due to the high upfront costs of implementing green energy carriers. The distribution of value across the different investment categories highlights the interconnected nature of the glass industry's sustainability impacts. These findings underscore the potential for integrated strategies that simultaneously advance multiple SDGs (Schaltegger *et al.*, 2022).

The results also illustrate the interconnections between the glass industry and other sectors, particularly in the buildings, automotive, and agri-food sectors, where glass products contribute to the greening and circular transformation of these industries. By providing innovative and sustainable glass solutions, the industry contributes to the greening and circularity of these value chains, amplifying its impact beyond its direct operations (Schaltegger *et al.*, 2022). This highlights the glass industry's broader role in facilitating sustainability transitions across the Italian economy, in line with European sustainability goals and the United Nations SDGs.

5. Discussion

This study's findings reveal the complex role of the Italian glass industry in contributing to sustainability across environmental, social, and economic dimensions. Through the application of the SROI methodology, it becomes evident that the glass sector is positioned at a critical juncture within Italy's broader sustainability framework. Its alignment with key SDGs, particularly SDGs 6, 7, 8, 12, and 13, underscores its potential to facilitate sustainable transitions. However, the findings also highlight the inherent trade-offs and challenges that industries such as glass face in balancing environmental imperatives with socio-economic outcomes.

The investment in decarbonisation, despite being substantial, presents a critical example of such trade-offs. While decarbonisation initiatives are central to the industry's alignment with SDG 13 (climate action), they also represent a significant financial burden, with the return on investment in this category being lower than that of other areas. This aligns with the broader discourse on the "hard-to-abate" sectors, such as glass, cement, and steel, which require high energy inputs and face significant technological barriers to achieving deep decarbonisation (Leach *et al.*, 2018). The glass industry's environmental impact, while meaningful, is constrained by the very nature of its production processes, thus requiring substantial technological innovation to overcome these challenges.

From an economic perspective, the findings highlight that energy efficiency and material reuse generate considerable returns, reflecting the industry's capacity to adapt to circular economy principles. However, the social dimension – primarily represented by job creation – emerges as the most significant contributor to the overall impact, accounting for 44.2% of the total value. This underscores a fundamental trade-off: while decarbonisation is essential for long-term environmental sustainability, immediate socio-economic benefits are derived from investments that foster employment and economic growth, reflecting SDG 8's emphasis on decent work and economic opportunity (D'Amato *et al.*, 2020). The findings align with integrated thinking and reporting concepts. As Busco *et al.* (2018, 2020) highlight, integrated thinking allows for a reconsideration of relationships between capitals and business units. The SROI analysis identifies connections between environmental investments, social outcomes, and economic benefits, reinforcing sustainability by aligning discourses and practices across multiple dimensions.

Moreover, the SROI methodology addresses limitations of traditional sustainability accounting, as noted by Bebbington *et al.* (2020a; b) and Baker *et al.* (2023). By capturing impacts across various capitals and stakeholders, it moves beyond siloed approaches. However, while the glass industry has made strides in social and economic contributions, its environmental progress remains constrained by its energy-intensive nature, necessitating further technological innovation and policy support.

The SROI analysis demonstrates how quantitative impact measurement can enhance accountability by providing clear metrics for tracking progress across multiple sustainability dimensions. The results highlight the methodology's ability to capture and monetise diverse impacts – from job creation (44.2% of total value) to environmental improvements (16.3%) – offering stakeholders concrete measures of the industry's contribution to sustainable development. This aligns with Busco *et al.*'s (2018, 2020) emphasis on making sustainability meaningful through a clear alignment of discourses and practices.

Such trade-offs also extend to the tension between immediate environmental objectives and broader systemic changes. The glass industry's alignment with circular economy principles – through increased material reuse – demonstrates its capacity to reduce reliance on virgin raw materials, thereby contributing to SDG 12 (responsible consumption and production). However, the relative difficulty of decarbonising an energy-intensive sector poses challenges to achieving ambitious climate goals, especially in the absence of widespread adoption of advanced technologies such as carbon capture and storage (CCS) and the integration of renewable energy carriers like hydrogen and biomethane (Waisman *et al.*, 2019). Thus, while the glass industry's contributions to reducing material waste are notable, the decarbonisation of production remains an unresolved challenge that requires significant policy intervention and technological advancements.

Furthermore, the results demonstrate the importance of stakeholder engagement in shaping the sustainability strategies of the glass sector. The collaborative process led by Assovetro, involving key actors from the industry, reflects the value of inclusivity and knowledge sharing in identifying investment priorities such as energy efficiency and production structure enhancement. This stakeholder-driven approach is crucial for ensuring that sustainability initiatives are not only responsive to regulatory pressures but also reflective of the industry's operational realities and long-term goals. This corresponds with existing literature, which emphasises the importance of inclusive governance mechanisms in driving sustainability transitions (Bebbington *et al.*, 2020a; b).

The findings contribute to the broader discourse on the role of resource-intensive industries in sustainability transitions. Although traditionally energy- and resource-intensive, the glass industry demonstrates its capacity to drive sustainability beyond its own operations by enabling greener technologies in sectors such as construction, automotive, and agri-food. Through products like energy-efficient windows and photovoltaic glass, the industry supports the achievement of SDG 7 (clean energy) and SDG 9 (industry and innovation). However, these contributions must be balanced against the inherent trade-offs faced by "hard-to-abate" sectors, where the environmental benefits of decarbonisation and material efficiency must be reconciled with economic viability, especially under increasing regulatory scrutiny to reduce greenhouse gas emissions (Leggewie and Messner, 2012).

Finally, the study highlights the potential for future shifts in sustainability accounting practices, particularly in hard-to-abate sectors like glass. The use of the SROI methodology provides a valuable framework for capturing the multidimensional impacts of sustainability initiatives, yet it also reveals the limitations of current financial proxies, which can oversimplify complex socio-environmental outcomes (Cooney, 2017). As the glass industry continues to grapple with the challenges of decarbonisation and material efficiency, there is a need for more refined tools that can capture the full spectrum of trade-offs inherent in balancing economic, social, and environmental objectives.

In sum, while the Italian glass industry is making significant strides towards sustainability, particularly in terms of social and economic contributions, its environmental impact remains

constrained by the structural limitations of an energy-intensive sector. The future of the industry's sustainability efforts will likely depend on technological innovation and stronger regulatory frameworks that support decarbonisation while balancing the socio-economic imperatives that are critical to its operational success. The path forward requires a nuanced understanding of the trade-offs between short-term economic gains and long-term environmental goals, as well as a commitment to addressing the challenges unique to hard-to-abate sectors.

6. Conclusion

This study advances our understanding of how sustainability accounting can evolve to capture complex industrial impacts through predictive measurement frameworks. By applying the SROI methodology to the Italian glass industry from 2022 to 2050, we demonstrate how traditional accounting limitations in measuring sustainability can be addressed through integrated approaches. The findings reveal a positive SROI ratio of 2.53, with value creation distributed across social (44.2%), economic (39.5%), and environmental (16.3%) dimensions, illustrating the industry's contribution to specific SDGs. The SROI ratio demonstrates how integrated thinking can support what Busco *et al.* (2018) describe as making sustainability meaningful through the alignment of discourses and practices. By considering multiple capitals simultaneously, our analysis demonstrates how the glass industry's sustainability initiatives create value across different dimensions, moving beyond siloed approaches to accountability.

Our research addresses critical gaps in the sustainability accounting literature (Bebbington *et al.*, 2020a; b; Baker *et al.*, 2023) by demonstrating how energy-intensive industries can measure and manage their sustainability transitions. While social impacts, particularly through employment, emerge as the most significant, the analysis reveals ongoing challenges in balancing environmental imperatives with socio-economic outcomes, especially in decarbonisation efforts. These findings support recent arguments for more sophisticated measurement approaches that can capture multiple capitals and stakeholder impacts (Busco *et al.*, 2019; Aureli *et al.*, 2023).

The study provides a replicable framework for evaluating sustainability impacts while highlighting opportunities for enhancing accountability through integrated measurement. Future research should explore comparative analyses across sectors, examine the role of technological innovation in sustainability transitions, and develop refined proxies for long-term impact measurement. Ultimately, this study contributes to advancing dialogic approaches to sustainability accounting (Brown *et al.*, 2015) while providing practical insights for industrial sustainability measurement.

7. Limitations and future research agenda

This study has provided a comprehensive assessment of the Italian glass industry's contributions to sustainability using the SROI methodology. However, several limitations inherent to the methodology, as well as contextual challenges specific to the glass industry, should be acknowledged. These limitations affect the generalisability of the findings and offer a foundation for future research.

One of the primary limitations lies in the application of the SROI framework itself. As noted in the literature (Cooney, 2017; Higham *et al.*, 2018), SROI's reliance on financial proxies to quantify social and environmental impacts can lead to an "illusion of precision". While this methodology is effective in integrating multiple dimensions of value, it can oversimplify complex social and environmental outcomes. For example, long-term environmental benefits, such as the decarbonisation of the glass industry, may not be fully captured by the financial proxies used in this study. The difficulty in obtaining reliable and standardised proxies for all sustainability dimensions further exacerbates this challenge,

particularly in hard-to-abate sectors like glass manufacturing. Future research should focus on improving the development of more context-specific and accurate proxies, potentially integrating additional tools such as Life Cycle Assessment (LCA) and Multi-Criteria Decision Analysis (MCDA) to offer a more nuanced understanding of industrial impacts.

Moreover, while the predictive application of SROI allows for forward-looking analysis, it also introduces uncertainties. The study's findings are based on projections from 2022 to 2050, during which external factors such as technological advancements, regulatory shifts, and economic fluctuations could significantly alter the anticipated impacts. The assumptions regarding mitigation variables like deadweight and attribution, which were grounded in current industry trends and stakeholder input, are susceptible to change over time. As such, future research could benefit from incorporating dynamic modelling approaches that allow for the adjustment of assumptions based on evolving market and policy conditions.

Another critical limitation pertains to the inherent trade-offs faced by the glass industry. While the study highlights significant investments in decarbonisation and energy efficiency, these efforts come at substantial economic costs. The findings illustrate that while decarbonisation is essential for long-term environmental sustainability, its return on investment is lower compared to other areas such as energy efficiency or material reuse. This aligns with broader discussions in the literature regarding the economic viability of decarbonising hard-to-abate sectors, where substantial technological innovation is required to reduce greenhouse gas emissions effectively (Leach *et al.*, 2018; Leggewie and Messner, 2012). Future studies should explore the economic trade-offs in greater detail, particularly in relation to the evolving landscape of carbon pricing, emissions trading systems, and other regulatory instruments designed to incentivise decarbonisation.

Additionally, this study underscores the critical role of stakeholder engagement in shaping sustainability initiatives within the glass sector. However, the stakeholder consultation process was limited to key industry actors, particularly through Assovetro, the Italian Association of Glass Producers. While this approach provided valuable insights into the sector's priorities, it did not encompass the full spectrum of stakeholders, including civil society, local communities, or public sector representatives, who are also impacted by the industry's sustainability performance. Future research could expand the stakeholder base to include a more diverse array of perspectives, particularly those that capture the social dimensions of sustainability more comprehensively.

Finally, this study has focused on the Italian glass industry, a sector that is particularly relevant given Italy's position as the second-largest producer of glass in Europe. However, the findings may not be entirely generalisable to other countries or sectors. The specific regulatory environment, economic structure, and industrial dynamics of Italy have shaped the outcomes observed in this study. Comparative studies across different countries and sectors would be beneficial to examine how contextual factors influence the effectiveness of sustainability investments and the resulting social, economic, and environmental impacts.

Building on these limitations, several avenues for future research emerge. First, there is a need to develop more refined tools for assessing the trade-offs inherent in sustainability transitions. While SROI provides a valuable starting point, it should be complemented with additional methodologies that capture the full spectrum of sustainability challenges faced by hard-to-abate sectors. For example, the integration of LCA and MCDA could provide a more comprehensive assessment of both short-term and long-term impacts, particularly as they relate to decarbonisation and circular economy practices.

Second, future research should focus on the role of technological innovation in facilitating industrial transitions, especially for energy- and resource-intensive industries like glass. The adoption of advanced technologies such as CCS, green hydrogen, and biomethane will likely be critical in reducing the glass industry's environmental footprint. Investigating the economic, regulatory, and technical barriers to the large-scale implementation of these technologies will provide valuable insights for policymakers and industry stakeholders alike.

Moreover, as European regulatory frameworks such as the Corporate Sustainability Reporting Directive continue to evolve, future studies should examine the implications of these regulations on sustainability practices within the glass industry and other sectors. Understanding how firms adapt to these regulations, and whether they lead to substantive changes in corporate behaviour, will be critical for shaping effective policy interventions.

Lastly, the cross-sectoral impacts of the glass industry on related sectors such as construction, automotive, and agri-food warrant further exploration. While this study highlighted the role of the glass industry in facilitating sustainability transitions in these sectors, future research should quantify these spillover effects more precisely. By deepening our understanding of how sustainability innovations in one sector can drive changes in others, researchers can contribute to the broader discourse on industrial sustainability transitions.

In conclusion, while the Italian glass industry is making significant strides towards sustainability, particularly in terms of social and economic contributions, the environmental challenges remain considerable. Addressing these challenges will require a combination of technological innovation, stakeholder engagement, and regulatory support. Future research should continue to explore the complex trade-offs faced by hard-to-abate sectors, while also developing more sophisticated tools for capturing the full range of social, economic, and environmental impacts.

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Supplementary material

The supplementary material for this article can be found online.

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