Journal of Environmental Management 391 (2025) 126370

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Effects of voluntary certifications on sustainable development goals

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A R T I C L E I N F O

Keywords:
Voluntary certifications
Sustainable development goals
Content analysis
Qualitative research

A B S T R A C T

Sustainability implies a development model that involves businesses and consumers, shifting attention to production systems which implement criteria of greater responsibility in social, environmental and economic terms. So far, many companies are adopting voluntary certifications (VCs) which confirm that they have carried out the certification procedures and that the product, process, or service requirements comply with specified requirements. VCs provide a detailed specification of the environmental and social standards that must be respected in the production processes. This paper aims to evaluate which sustainable development goals (SDGs) are most affected by VCs and analyzes the ways they support sustainable development. Using qualitative content analysis, the study explores the mechanisms behind VCs' role in promoting these global goals, offering insights into their strategic impact on a sustainable future. Our results indicate that there is a significant and positive relationship among VCs and SDGs, and specific SDGs are identified. This research provides useful insights to support governmental organizations for policy interventions in creating an enabling environment for the use of VCs in both developed and developing countries.

1. Introduction

Sustainable development has gained increasing attention globally, particularly with the adoption of the 2030 Agenda by 193 UN member countries. This framework comprises 17 Sustainable Development Goals (SDGs) and 169 targets addressing environmental, social, and economic dimensions. Notably, the Agenda highlights the essential role of businesses in achieving these goals, particularly through SDG 17, which calls for partnerships involving public and private actors.

Businesses have responded by adopting voluntary certifications (VCs), which demonstrate compliance with specific sustainability standards. Unlike mandatory regulations, VCs are adopted voluntarily and certified by third parties. They offer both reputational and economic advantages, such as improved efficiency, enhanced customer trust, and increased employee satisfaction (Ikram et al., 2021). Thus, VCs represent a strategic opportunity to support sustainable development through market-based mechanisms.

This study aims to critically assess how VCs contribute to the SDGs. Using qualitative content analysis, it investigates which goals are most impacted by VCs and explores the mechanisms through which they align with sustainable development. The methodology involves inductive coding of scientific literature to identify recurring themes and patterns (Hsieh and Shannon, 2005; Graneheim et al., 2017).

Findings provide insights into how VCs influence firm behavior and broader sustainability outcomes. They also offer guidance for policymakers and businesses to enhance the effectiveness of VCs in advancing the SDGs. While VCs show strong potential, significant knowledge gaps remain regarding their direct impact on specific goals. This research contributes to a more integrated understanding of private-sector engagement in sustainability, identifying both opportunities and limitations of VCs. It supports future research and policy design by highlighting how voluntary actions by firms can complement public policies, especially in sectors where regulation is limited (Carrico, 2022; Xue et al., 2025). The current study aims to fill the existing research gap by addressing the barriers to adoption and equitable implementation of VCs, particularly in developing countries and among small producers, while also examining how VCs can be better aligned with the SDGs through improved governance and stakeholder collaboration.

The remainder of this paper is organized as follows. Section 2 presents the literature review, Section 3 describes the method as well as the data, followed by the empirical results and discussion in Section 4. Section 5 concludes the paper.

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https://doi.org/10.1016/j.jenvman.2025.126370
Received 10 February 2025; Received in revised form 26 May 2025; Accepted 24 June 2025
Available online 2 July 2025

2. Background

2.1. Literature review

Firms increasingly seek sustainable integration into the economy amid pressing environmental and social challenges. VCs have emerged as potential contributors to the SDGs. Unlike mandatory certifications, they are adopted voluntarily and validated by third parties. VCs vary in design, even within the same product category, and function as key communication tools, signalling a firm's commitment to sustainability to stakeholders including consumers, regulators, and partners (Marx et al., 2024; Dietz and Grabs, 2022).

VCs act as a form of social contract, enabling consumers to reduce the environmental and social impacts of their purchases, while producers align with sustainable and socially just practices. Each certification addresses specific sustainability challenges, allowing firms to demonstrate responsibility and improve their economic, social, and environmental impacts (Boonaert et al., 2024; Prell et al., 2020). Since the early 2000s, VCs have spread globally across industries. However, research on their alignment with the SDGs is limited and presents mixed results. Schleifer et al. (2022) find VCs strongly support SDGs related to production and labour but are weakly connected to goals like SDG 10 (reduced inequalities). De Alba Verduzco et al. (2024) show agri-food VCs in Brazil and Mexico align well with SDGs 2, 5, 10, and 12, though barriers such as high costs persist. Bennett (2018) highlights limited VC support for living wages and collective bargaining.

Other studies find conditional benefits. Bray and Neilson (2017) note positive impacts on human and social capital among coffee farmers, dependent on factors like education and institutions. Martins et al. (2022) find VCs appeal most in markets prioritizing sustainability. Rector et al. (2023) and Cammarata et al. (2024) show that VCs, especially in aquaculture and carbon markets, can complement regulation and support climate and agricultural goals.

2.2. The contribution of VCs to sustainability

The International Trade Centre standard map (2024), in its Standard Map containing reliable and neutral information on VCs worldwide, currently lists 356 certifications which focus on specific sustainability topics, i.e., human and labor rights, due diligence, environment and climate change, gender, sustainable business, quality, food safety, traceability, and credibility. They are transversal because they are designated for a specific good or service, but their impact is broader and can affect multiple sectors (Table 1).

Table 1
Number of VCs operating across specific sectors.

Sectors	VCs
Manufacture of products	191
Agriculture	185
Floriculture & Horticulture	118
Textiles	102
Livestock	78
Clothing	74
Fisheries	72
Processed food	59
Services	52
Forestry	50
Tourism	48
Mining	46
Energy	42
Aquaculture	41
Culture	38
Retail	36
Education	34
Finance	27
Chemicals	12

Source: International Trade Centre standard map (2024)

Most VCs concern the manufacturing of products (191) and agriculture (185), because these sectors have direct and significant impacts on various aspects of sustainability, such as the environment, social, management and ethics, and quality.

For instance, there are numerous VCs for cotton, which represent about a quarter of textile fibres globally and whose cultivation has various environmental and social impacts (Zhang et al., 2023). Environmental impacts are linked to cotton cultivation and depend on water consumption and the use of pesticides and fertilizers. At the textile manufacturing stage, impacts depend on production techniques and energy used. Social impacts refer to low farmers' incomes, the use of child labour, inequalities and discrimination, health and safety problems in the agricultural sector. Depending on the country where it is produced and processed, impacts can have different weights. VCs intervene to mitigate these impacts. Among these, the Better Cotton system verifies whether farmers comply with global standards, with the aim of promoting more sustainable and conscious cotton cultivation in some countries (Zulfiqar and Thapa, 2016). Better Cotton certification does not have an external certification mechanism, unlike other VCs, so, in many cases, it is combined with other VCs, such as Fairtrade certification. Fairtrade is based on the use of standards and a price floor, and it consists in the empowerment of small farmers and artisan workers in the South of the World, in fair trade, with positive effects on incomes and the environment (Johannessen and Wilhite, 2010; Meemken et al., 2019). Cotton made in Africa, for sustainable cotton from Africa, seeks to protect workers in the cotton production process by ensuring compliance with specific environmental and social conditions (Voora et al., 2023). In many cases, VCs are combined to address the weaknesses of individual systems, providing stronger guarantees that environmental and social standards are supported throughout the production process, ensuring sustainable development.

The Floriculture & Horticulture sectors involve 118 VCs which mainly address pest and disease control for safety and health of people working with flowers and plants, minimizing the environmental impact and ensuring good agricultural practices, gender equality in the value chain, and living wages (Gebreeyesus, 2015).

The textile sector contributes significantly to water, air, and solid waste pollution. Textiles are considered unsustainable because their entire life cycle produces significant amounts of toxic waste and greenhouse gas emissions. The textile sector involves 102 of 356 VCs, and the Eco Label certifications are probably the most used within the sector, such as EU ecolabel. The EU ecolabel criteria promote the production and consumption of more sustainable product options, reflecting the best environmental performing products on the textile market (Nakaishi and Chapman, 2024).

According to the International Trade Centre standard map (2024), the SDGs most widely covered by VCs are SDG 8 (Decent Work and Economic Growth) with 352 VCs, SDG 12 (Responsible Consumption and Production) with 345 VCs and SDG 2 (Zero Hunger) with 342 VCs. Those with fewer links are SDG17 (Partnerships for the goals), SDG14 (Life below water) and SDG9 (Industry, innovation and infrastructure) (Fig. 1).

It is important to underline that VCs are linked to multiple SDGs, given the multidimensionality of sustainability. For example, some VCs that aim to support gender equality and women's empowerment (SDG 5) contribute at the same time to the promotion of economic growth and decent work for all (SDG 8), and so on.

Evidence of the environmental, social and economic impacts of VCs is currently ambiguous. Part of the problem is that it is difficult to determine the causal effects of VCs and isolate their impacts, as outcomes are often influenced by multiple factors. Companies that adopt VCs may also be subject to rigorous standards in regulated markets. Some VCs do not have an external certification mechanism, making it difficult for stakeholders to verify product compliance, or lack a traceable labelling system, and so on. Furthermore, VCs are, in many cases, combined with each other, to fill the weaknesses that some of them

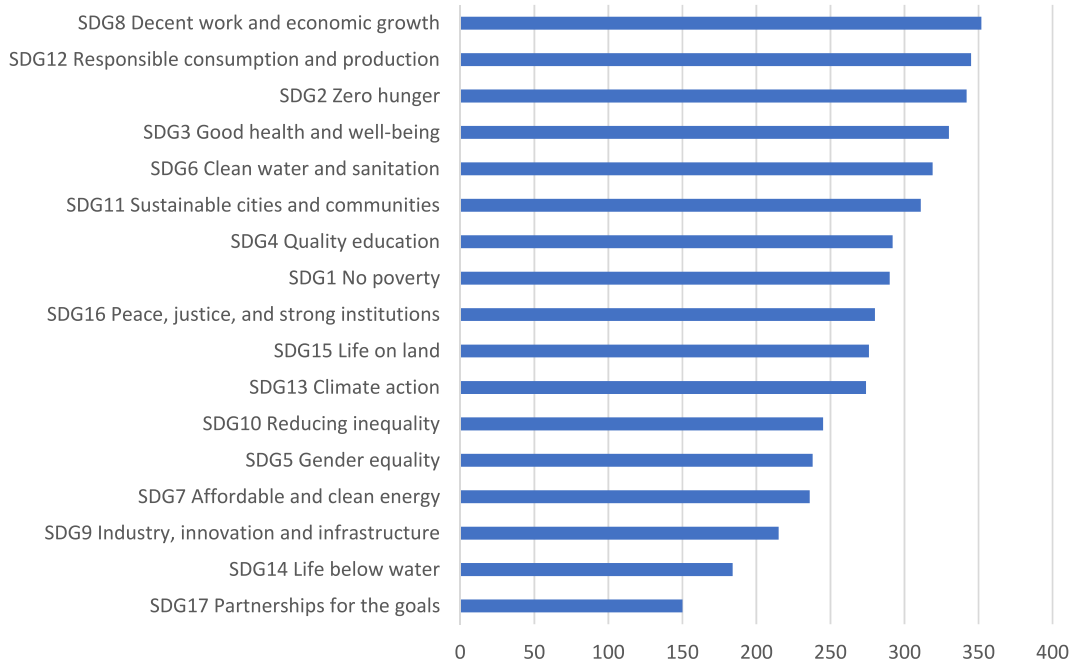

Fig. 1. Number of VCs contributing to specific SDGs.
Source: International Trade Centre standard map (2024)

might have in terms of environmental and social standards that must be respected, and this also contributes to determining and isolating the impacts of VCs (Makita, 2016).

Considering these challenges, our analysis seeks to examine, through content analysis, the extent to which VCs directly contribute to the achievement of the SDGs.

3. Method and data

3.1. Content analysis

Qualitative research allows to gain a deep understanding of a specific phenomenon, focusing on exploring the texts. Content analysis is a method that goes beyond word counting, as it aims to connect the results to the context in which they are produced. It allows us to understand a phenomenon in depth (Mayring, 2015), providing in-depth insights for the quantitative findings of the investigation.

Content analysis has traditionally been used to analyze newspapers and other media for assessment of verbal contents and nonverbal messages of communication. In recent years, there has been a trend towards the use of content analysis in various research fields including economics.

Content analysis involves the creation of codes which are the most important analysis tools. They are assigned by the researcher to everything that is considered relevant to the research question, whether it is one or more words or segments of text. In qualitative content analysis, a code is a string that contains a certain number of characters, and, depending on the context of reference, can play a key role in the research. Thus, texts are analyzed by coding the content into these predefined categories (Carley, 1993).

The use of qualitative content analysis is particularly valid and appropriate in this study because, given the complexity and multidimensionality of the topic, i.e., to what extent VCs contribute to the achievement of the SDGs, it is possible to systematically examine a large corpus of scientific texts, identifying recurrences, conceptual categories and thematic connections in a rigorous but flexible way. Besides, content analysis allows to integrate qualitative and quantitative data, favoring a transversal reading of scientific contributions and facilitating the identification of emerging patterns.

The research approach used in this paper is illustrated in Fig. 2.

3.2. Data sampling and analysis

The data search was conducted in December 2024 using Web of Science and Google Scholar, focusing on publications from 2015 onward to align with the SDGs' adoption. Search terms included "voluntary certificat," "voluntary program," "voluntary sustainability standard," and combinations with "SDG." After screening 83 titles and abstracts, 54 articles were selected. Qualitative content analysis was performed using MAXQDA software, coding both explicit and implicit content. Keywords were based on the UN Global Indicator Framework and prior studies (Mishra et al., 2024; Pakkan et al., 2023), with additions for diversity, social inclusion, and indigenous perspectives.

Given the vast number of keywords per SDG, only the most specific and relevant were selected. While additional proxy codes could be used, this research focused on a predefined set of 33 analytical codes (see Table 2), which were reviewed in context to ensure alignment with sustainability themes.

4. Results and discussion

The codes chosen in the analysis and their frequencies with the sampled documents are shown in Table 3.

According to the frequencies of codes, waste, biodiversity, gender, poverty, and marine are among the most important themes. This means that in the sample, all these codes are reported for 46.50 %. This result indicates that the VCs discussed in the papers are closely aligned with these specific themes. The correlation between these themes and the SDGs suggests that the SDGs most relevant to the implementation of the VCs are SDGs 12, 14, 15, 5, and 1. Thus, the SDGs mostly linked to VCs refer to the economic dimension of sustainable development (SDG 12), the environment (SDG 14 and 15), and social issues (SDG 1 and 5). The high linkage between the SDG 12 and VCs might seem rather obvious, since SDG 12 explicitly requires governments to ensure that consumption and production practices are sustainable, and VCs arise first and foremost precisely to promote sustainable consumption and production

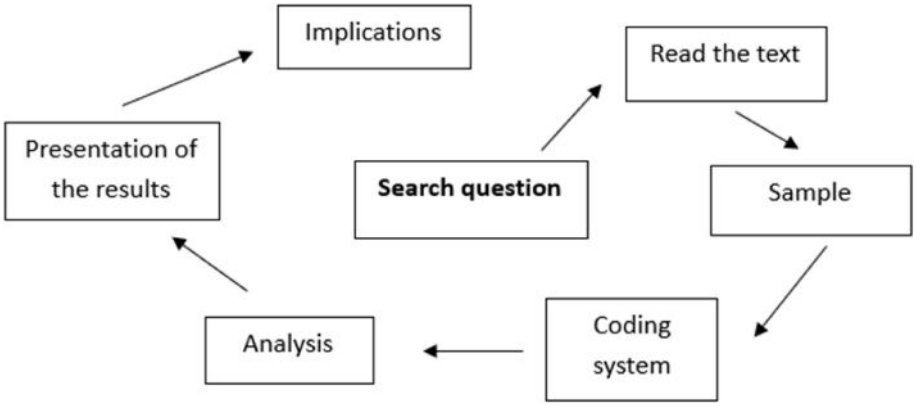

Fig. 2. The content analysis process.

Table 2
Total extracted codes.

SDGs	Themes of SDGs	Total extracted codes in themes
1	No poverty	2
2	Zero hunger	3
3	Good health and well-being	2
4	Quality Education	1
5	Gender equality	2
6	Clean water and sanitation	2
7	Affordable and clean energy	2
8	Decent work and economic growth	2
9	Industry, innovation and infrastructure	2
10	Reduced inequalities	1
11	Sustainable cities and economies	2
12	Responsible consumption and production	3
13	Climate action	3
14	Life below water	1
15	Life on land	2
16	Peace, justice and strong institutions	3
	Total	33

Table 3
Frequency of codes in the sampled documents.

Codes System	Frequency	Codes System	Frequency
no poverty (SDG1)	14	industrialization (SDG 9)	18
poverty (SDSG1)	333	inequality (SDG10)	192
zero hunger (SDG2)	50	sustainable cities (SDG11)	35
food security (SDG2)	206	green buildings (SDG11)	46
nutrition (SDG2)	113	responsible consumption (SDG12)	50
good health (SDG3)	39	responsible production (SDG12)	7
well-being (SDG3)	121	waste (SDG12)	493
quality education (SDG4)	56	global warming (SDG13)	16
gender (SDG5)	447	greenhouse gas (SDG13)	94
gender equality (SDG5)	125	climate action (SDG13)	94
clean water (SDG6)	53	biodiversity (SDG14, SDG15)	472
sanitation (SDG6)	89	marine (SDG14)	267
renewable (SDG7)	142	deforestation (SDG15)	178
clean energy (SDG7)	42	peace (SDG16)	72
decent work (SDG8)	97	social justice (SDG16)	17
economic growth (SDG8)	157	human rights (SDG16)	19
infrastructure (SDG9)	186	Total	2270

by facilitating the identification of sustainable practices along global supply chains. Regarding SDG 14 and 15, the number of valuable forests and marine areas to be protected has increased in recent years. Even though the numbers are still small, in 2022 protected areas account for almost 15 % of the planet's land, while marine areas protection stands at around 8 % (Bascomb, 2024). Our data, indicating the presence of numerous VCs associated with these themes, indicates that they serve as a valuable complement to formally protected areas. With reference to SDG 1, the link indicates that VCs can contribute to fighting poverty by improving, for instance, the livelihoods of farmers who represent a large portion of the world's poverty. For instance, VCs provide access to improve farmers' skills so they can grow better and more sustainable products. This can lead to higher and more stable incomes for farmers (Elder et al., 2021). Regarding gender equality (SDG 5), while achieving women's economic empowerment requires changes that extend beyond market mechanisms, VCs can still play a key role in fostering an inclusive, gender-responsive work environment, promoting women's participation in the labor market, and creating opportunities for economic growth (Raynolds, 2021).

Code frequency is central to the analytical process of content analysis because it provides information, albeit general, on the relevance of a topic. Indeed, frequency, indicating the intensity and relative importance of the keyword, allows to make predictions regarding the most important topics on which VCs operate (Strijbos et al., 2006). This first analysis suggests the SDGs that could be most connected to VCs, those with respect to which VCs operate most.

However, it is important to note that the analysis cannot rely solely on the frequency of codes, as frequency may not necessarily reflect the true significance of a theme. It is also possible that the higher frequency of a term in a paper could be influenced by various factors unrelated to its importance (Vaismoradi et al., 2013). To provide a more nuanced understanding, it is crucial to examine the number of documents in which each code appears (Fig. 3).

The results from this approach differ, with the poverty code appearing in the most documents (43 papers), followed by biodiversity (40), infrastructure (39), waste (38), gender (38), renewable (34), economic growth (34), well-being (32), inequality (30), greenhouse gas (29), gender equality (29), sanitation (27), nutrition (27), food security (27), peace (26), decent woark (25), clean water (22), climate action (21), deforestation (20), quality education (19), zero hunger (18), good health (18), responsible consumption (17), clean energy (17), marine (16), sustainable cities (15), industrialization (14), no poverty (10), social justice (8), human rights (7), global warming (7), green buildings (6), responsible consumption (4). This last analysis indicates that the main codes appearing in most documents are poverty, biodiversity, infrastructure, waste, and gender, which correspond to SDGs 1, 14, 15, 12, and 5, respectively.

By comparing the frequency of codes with the number of documents in which the codes appear, the most important codes (and then themes) that emerge in both analyses are poverty, gender, waste, and biodiversity. This result is particularly interesting as it highlights and confirms the importance of these themes within the sample considered. The SDGs

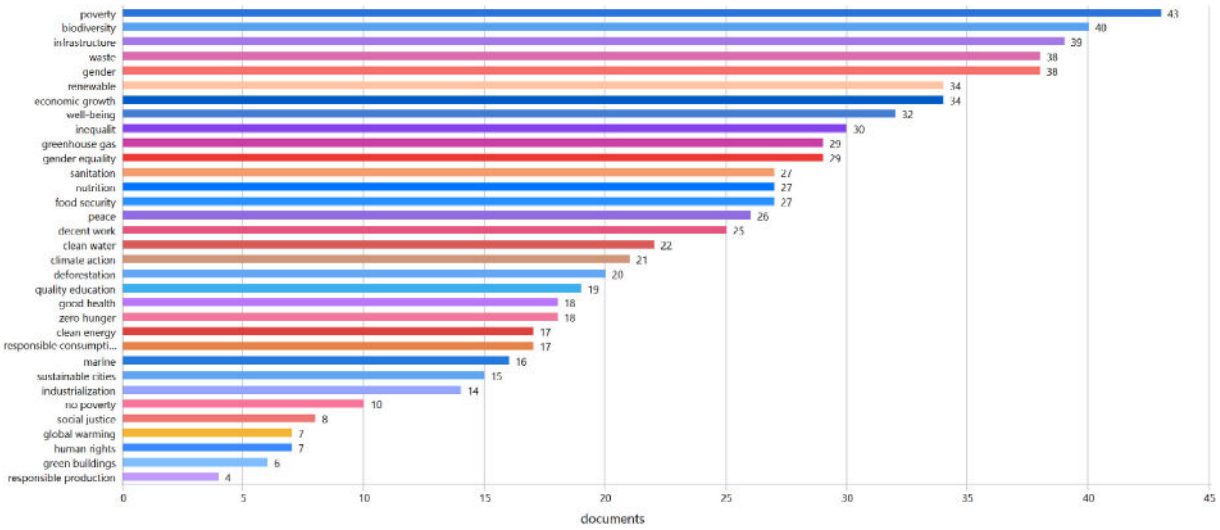

Fig. 3. Number of documents in which each code appears.

associated with these themes are therefore SDGs 1, 5, 12, 14, and 15.

Subsequently, a co-occurrence analysis has been conducted that focuses on the relationships between words rather than only counting their occurrences (Klarin, 2024).

Co-occurrence illustrates the significance of terms and their interconnections, revealing and mapping patterns of how often they appear together within the text. The co-occurrence analysis allows to examine how frequently a given word (i.e., a code) appears alongside other words (codes) within documents (Lozano et al., 2019). The result represents the number of times a code co-occurs with another code. The frequencies with which the codes o-occur throughout the whole sample analyzed are shown in Tables A1, A2, A3 in the Appendix. The fact that codes co-occur suggests that there is a strong connection between some concepts in the sample of documents analyzed. This, from the point of view of the analysis of VCs and how they contribute to achieving the SDGs, shows that many SDGs are strongly linked to each other, and that therefore, aiming, through VCs, to achieve a specific goal, facilitates the achievement of other goals as well.

We next focused on the codes where 80 %, 60 %, and 40 % of the co-occurrences occur.[1] To graphically display co-occurrences between codes, we use a code map according to which the selected codes are arranged in a circular pattern on the workspace. Then, the vertices are the codes, and the frequency of co-occurrence is indicated on the connecting lines. The more marked connecting lines and the bigger font size indicate the higher frequency in terms of co-occurrences.

Our results indicate that the 80 % frequency of code co-occurrence across the entire sample involves 13 codes (Fig. 4). A closer look at the co-occurrences of codes shows a strong connection between the SDGs related to such keywords which in this case are SDGs 14, 15, 12, 5, 1, 8, 10, 3, 2 and 16, respectively.

Restricting the analysis to the codes that represent 60 % of the co-occurrences (Fig. 5), 8 codes are involved which refer to the SDGs 12, 14, 15, 5, 1, 9, 7, 8 and 3, respectively.

Fig. 6 highlights codes representing 40 % of co-occurrences, revealing strong links to SDGs 1, 5, 8, 9, 14, and 15. Notably, "poverty" co-occurs frequently with "biodiversity," "economic growth," "gender," and "infrastructure," indicating strong interconnections. These results suggest, for instance, that biodiversity (SDGs 14, 15) supports SDG 1 by providing resources in rural areas, and that poverty is linked to gender inequality and economic growth. Similarly, infrastructure development is vital to reduce poverty through better access to health, education, and economic opportunity. SDGs 1, 5, 9, 12, 14, and 15 emerged as the most addressed by VCs. Compared to prior studies that emphasize SDGs 8, 12, and 2, our findings reveal broader VCs contributions. These differences may reflect the evolving scope of VCs and increasing corporate engagement in diverse sustainability dimensions. Promoting VCs can thus enhance firm contributions to the SDGs. While the study adds value by identifying key SDGs influenced by VCs, limitations include language bias and the subjective nature of coding. Nonetheless, careful alignment with literature-supported keyword-SDG linkages enhances the robustness of the analysis.

5. Conclusions

5.1. Theoretical/analytical implications

This study explores the role of VCs in advancing the achievement of the SDGs using content analysis. Through this method, it is possible to examine how certain concepts are addressed in different contexts, revealing relationships among topics that may not be immediately apparent. We have examined 54 studies dealing with VCs and SDGs and we have identified 33 codes. The results of our research show that several studies link the concept of VCs to its potential role in advancing the SDGs outlined in the 2030 Agenda. They can be used as a tool to achieve sustainability objectives, to the extent that they add to and therefore integrate mandatory environmental and social standards. Mapping the links between VCs and SDGs, we find that VCs are particularly significant for SDGs that address production and consumption patterns, worker and community wellbeing, and the health of terrestrial and aquatic ecosystems.

Our research uncovers a relevant insight: while numerous studies have explored the concept of VCs, our work uniquely demonstrates their pivotal role as a transformative tool for advancing the SDGs outlined in the 2030 Agenda. For the first time in literature, we establish a clear link between VCs and critical sustainability objectives, highlighting how they can actively drive progress by integrating essential environmental and social standards. Our novel mapping reveals that VCs are especially impactful for SDGs focused on reshaping production and consumption patterns, enhancing worker and community wellbeing, and safeguarding terrestrial and aquatic ecosystems. This novel perspective positions VCs not just as supportive elements, but as strategic catalysts in the global pursuit of sustainable development. The main SDGs addressed and supported by VCs among the sampled papers are SDGs 1, 5, 9, 12, 14, and 15, which refer to no poverty, gender equality, industry

[1] The map showing all the co-occurrences is provided in Appendix, jointly with the explanation of Figs. 4–6 construction.

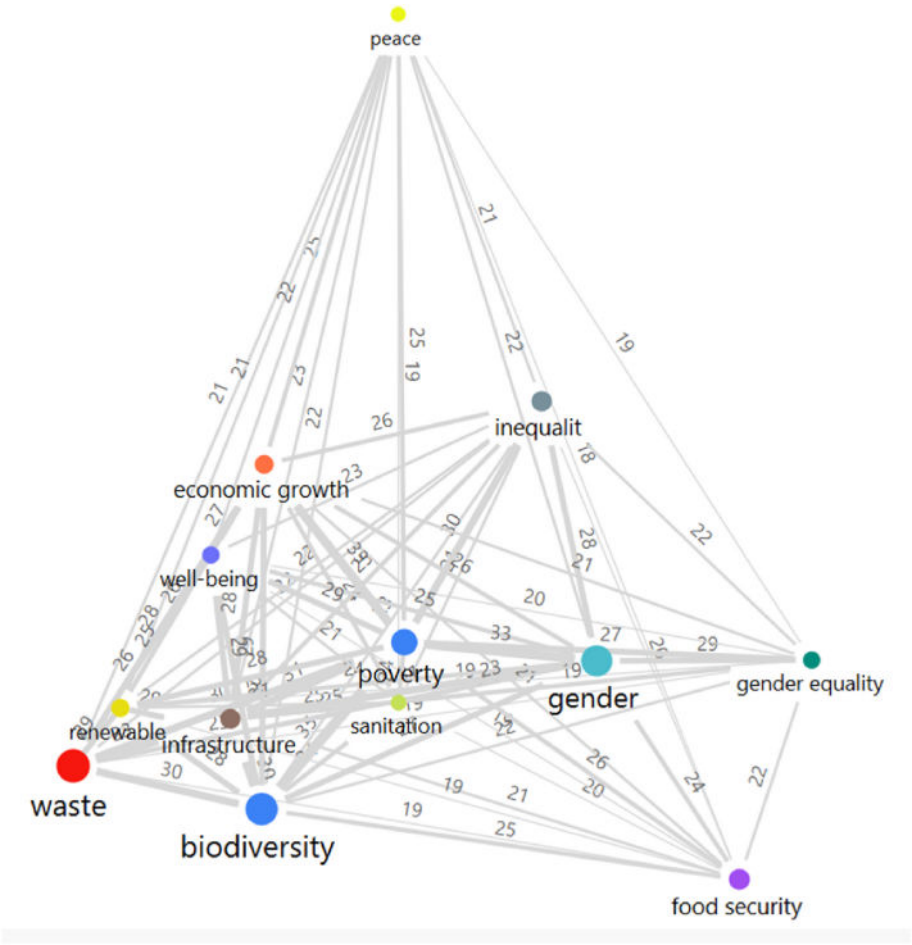

Fig. 4. Analysis map of co-occurrence frequencies of codes (80 %).

innovation and infrastructure, responsible consumption and production, life below water, and life on land, respectively. The findings introduce significant theoretical advancements by demonstrating that VCs can effectively integrate and strengthen mandatory sustainability standards. This reveals new perspectives on private and voluntary governance mechanisms as powerful tools for advancing sustainable development, emphasizing their capacity to promote economic, social, and environmental goals concurrently. From an analytical standpoint, employing content analysis proves particularly innovative in examining the conceptual frameworks within VCs related literature. This approach allows for a detailed identification of key themes and SDG related concepts, uncovering the underlying conceptual structures, frequency patterns, co-occurrences, and latent connections between themes. Consequently, this analysis not only highlights which SDGs are most emphasized in the literature, showing thematic priorities, but also reveals gaps related to less explored SDGs, offering fresh insights into the current research.

5.2. *Practical/managerial contributions*

As awareness of environmental and social issues grows, pressure is mounting across the entire supply chain for more responsible and ethical business practices. In this framework, VCs have emerged as vital tools, guiding businesses toward more sustainable and transparent trade practices. They enable firms to showcase their commitment to key areas such as process and product quality, sustainability, social responsibility, and adherence to industry-specific standards. VCs also help facilitate international trade by promoting the export of certified products. This occurs because compliant producers can gain a competitive advantage by differentiating their products in the market and reducing information asymmetries between buyers and sellers. However, VCs still have high compliance and monitoring costs that exclude small-scale producers. For example, in the case of small farmers, obtaining certifications remains expensive, but they are nevertheless key stakeholders in sustainability. Considering, for instance, oil palm plantations, which have a significant impact on deforestation, such impact could be mitigated, albeit to a limited extent, by including smallholder oil palm farmers in certification schemes. Thus, despite their potential to drive sustainability, VCs are still adopted only on a limited scale, particularly in developing countries where the costs and technical barriers associated with certifications restrict access for small businesses and smallholders, who are often the most affected by sustainability issues. The interactions between VCs and SDGs revealed in our study underscore the critical role that companies play in advancing sustainability through VCs. This highlights the necessity of creating an appropriate framework that encourages companies to adopt VCs, both in developed and developing countries. Attention towards VCs and their effective management are crucial factors in achieving the SDGs and ensuring a sustainable future. The challenges in VCs management require a coordinated and integrated approach that involves stakeholders from various sectors, in particular governments, international organizations, and industry. It is crucial to recognize the link between VCs and SDGs, as it represents a key issue for advancing towards the achievement of the SDGs.

Overall, the research highlights the importance of creating an enabling environment in which companies are encouraged to adopt VCs that go beyond mere legal requirements. VCs, by promoting sustainable practices to tackle challenges related to sustainable development, represent a beneficial tool not only for companies, who can continuously improve and meet the highest international standards, but also for

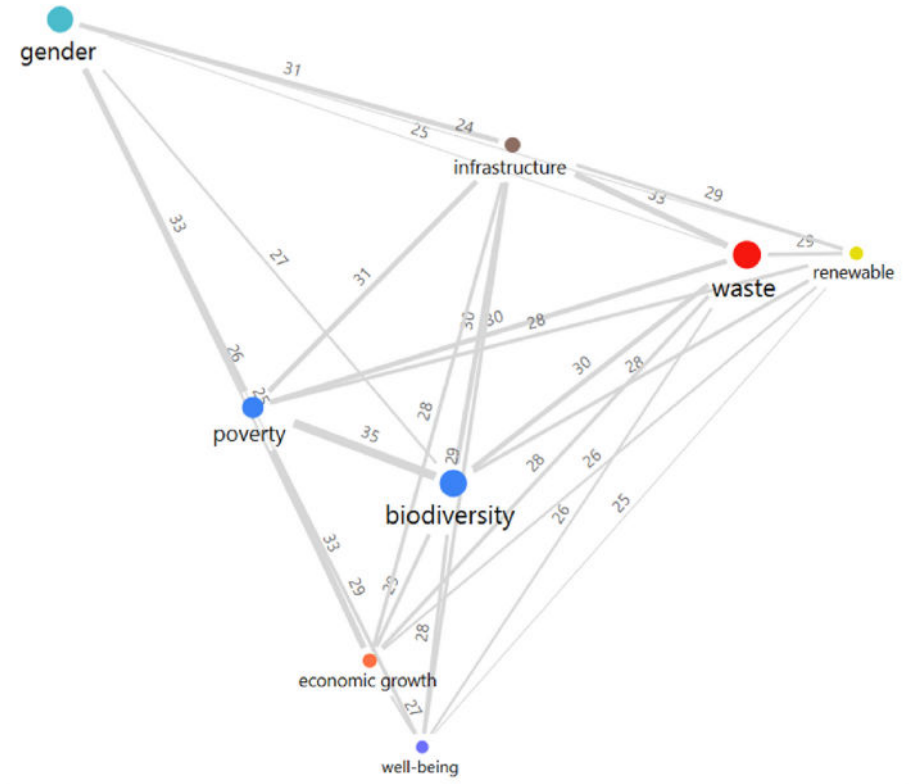

Fig. 5. Analysis map of co-occurrence frequencies of codes (60 %).

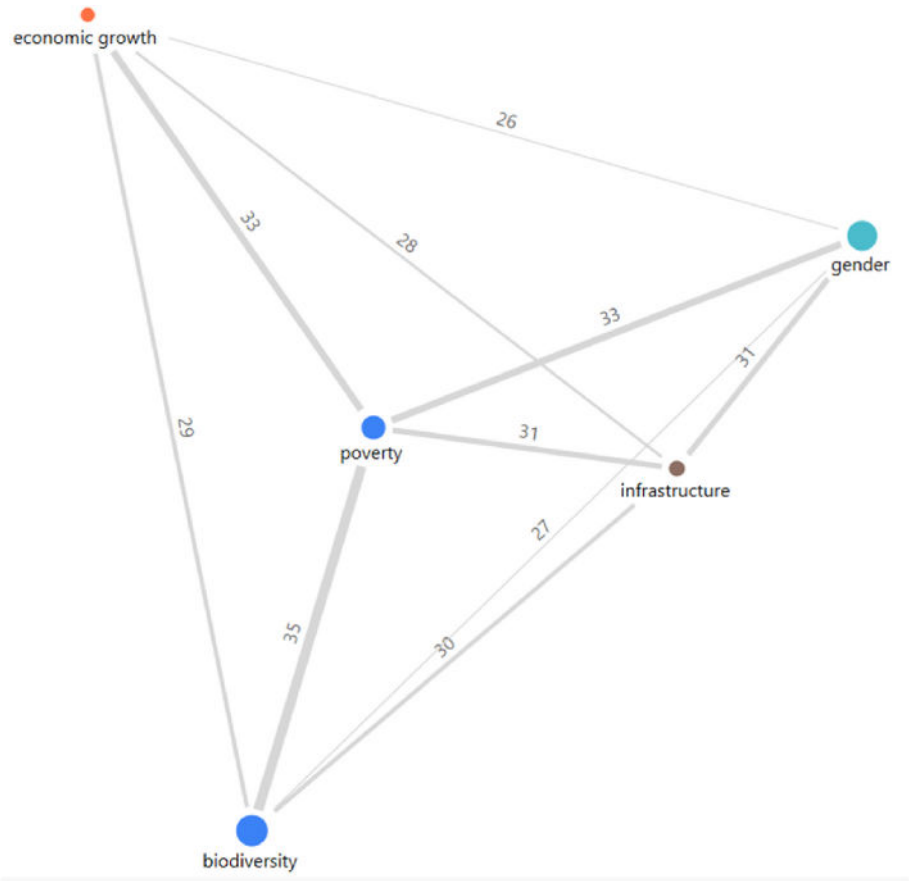

Fig. 6. Analysis map of co-occurrence frequencies of codes (40 %).

consumers, who can support businesses committed to tangible sustainability efforts, and for society.

5.3. Limitations

A potential limitation of this study relates to the size of the sample analyzed. Given the breadth and complexity of the subject matter, the strength of the findings is based on the selected papers examined through content analysis. As such, the conclusions provide valuable insights which have to be considered mainly within the scope of the documents reviewed. Additionally, incorporating a greater number of proxy variables could further enhance the investigation of the relationship between VCs and the achievement of the SDGs.

5.4. Future research directions

Future research should aim to broaden its scope by incorporating a wider array of studies across diverse geographical regions and industries. By assembling a larger and more heterogeneous sample, more robust and generalizable conclusions can be drawn, uncovering complex sector-specific trends in how VCs influence progress toward the SDGs.

Additionally, exploring the differential impact of VCs on SDG achievement across regions (particularly contrasting developing and developed countries) could yield valuable insights into contextual barriers and opportunities. For instance, understanding the unique challenges faced by small-scale producers in developing nations, such as higher certification costs and technical hurdles, can inform targeted strategies to enhance sustainability outcomes.

Moreover, expanding the set of proxy variables to capture the multifaceted effects of VCs on SDGs, by including both qualitative and quantitative indicators, would deepen our understanding of the social, environmental, and economic impacts. This comprehensive approach promises to illuminate the complex ways in which venture capital can serve as a catalyst for sustainable development worldwide.

CRediT authorship contribution statement

Simona Bigerna: Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Writing – original draft, Visualization, Software, Resources, Project administration. **Silvia Micheli:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Funding acquisition, Data curation, Software, Project administration, Investigation, Formal analysis, Conceptualization. **Paolo Polinori:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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.

Acknowledgement

Research founded by the Ministry of University and Research; PRIN Project CUP: H53D23002300006.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2025.126370.

Data availability

Data will be made available on request.

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