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Intellectual capital through decarbonization for achieving Sustainable Development Goal 8: a systematic literature review and future research directions

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Abstract

Purpose – The aim of this study is to review the literature on how intellectual capital (IC) contributes to the decarbonization efforts of firms. It explores how carbon accounting can measure the components of IC in decarbonization efforts to balance profitability with environmental and social goals, particularly in promoting decent work and economic growth (Sustainable Development Goal [SDG] 8 and its targets [2, 5, 6, 8]). Moreover, it emphasises the importance of multi-stakeholder partnerships for sharing knowledge, expertise, technology, and financial resources (SDG17-Target 17.G) to meet SDG8.

Design/methodology/approach – As a consolidated methodological approach, a systematic literature review (SLR) was used in this study to fill the existing research gaps in sustainability accounting. To consolidate and clarify scholarly research on IC towards decarbonization, 149 English articles published in the Scopus database and Google Scholar between 1990 and 2024 were reviewed.

Findings – The results highlight that the current research does not sufficiently cover the intersection of carbon accounting and IC in the analysis of decarbonization practices. Stakeholders and regulatory bodies are increasingly pressuring firms to implement development-focused policies in line with SDG8 and its targets, requiring the integration of IC and its measures in decarbonization processes, supported by SDG17-Target 17.G. This integration is useful for creating business models that balance profitability and social and environmental responsibilities.

Originality/value – The integration of social dimension to design sustainable business models for emission reduction and provide a decent work environment by focusing on SDG17-Target 17.G has rarely been investigated in terms of theory and practice. Through carbon accounting, IC can be a key source of SDG8-Targets 8.[2, 5, 6, 8] and SDG17-Target 17.G. Historically, these major issues are not easily aligned with accounting research or decarbonization processes.

Keywords Intellectual capital (IC), Decarbonization processes,
Decent work and economic growth (SDG8-Targets 8.[2, 5, 6, 8]), Carbon accounting,
Partnerships (SDG17-Target 17.G)

Paper type Research paper

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1. Introduction

Climate change is a global issue that requires firms to make major changes to improve their ecological and social systems, as its effects, including extreme weather patterns, can be disastrous. As part of the environment, firms are influenced by both climate change and institutional pressure (Lebelhuber and Greiling, 2022). To limit the increase in the global temperature, the Paris Agreement forces firms to contribute to economic and social transformations in terms of decarbonization. Realising the need for immediate climate action, institutions are pressurising firms to implement short- and long-term decarbonization policies (Linton *et al.*, 2020). In this regard, the institutional theory is idealised to explain and theorise the idea of decarbonization using new technologies and renewable resources (Schildt, 2022).

Firms face institutional and stakeholder pressures to adopt effective decarbonization practices to respond to the social and environmental aspects of sustainability (Grecu, 2023). Focusing on intellectual capital (IC), effective decarbonization practices, including the adoption of green technology and renewable resource to mitigate carbon emissions, depend on the operational processes of firms. Thus, to increase their effectiveness in the use of technologies as enablers of decarbonization, firms can take advantage of IC components, namely human, structural, and relational capital, as essential sources of economic growth towards the transformation of a low-carbon environment and sustainable development (Goklany, 2007; Kornilova and Klymenko, 2014). Therefore, firms must utilise their capital resources to acquire technological innovation and obtain a competitive edge (Xiao and Yu, 2020) without neglecting the IC components, which contribute to long-term value creation. This is essential for sustainability in advancing decent work and economic growth (Sustainable Development Goal [SDG] 8), in accordance with the United Nations (UN) 2030 Agenda (Ali and Anwar, 2021).

Similarly, some scholars define IC as a collection of skills and experiences held by employees that may yield long-term financial gains for firms (Alvino *et al.*, 2020). Therefore, to decarbonize, the operations of firms must depend on new technologies, renewable resources, and IC, especially structural and human capital, which can support an eco-friendly climate, decent work, and economic growth (SDG8). On the other hand, changes in operational processes due to decarbonization from technology affect productivity from innovation, gender, people with disabilities involved in operational processes, training, and the safety and security of working environments for all workers, that is, SDG8-Targets 8.2, 8.5, 8.6, and 8.8.

Green IC (GIC), which encompasses knowledge, experience, and intellectual property related to environmentally sustainable practices can play a pivotal role in achieving SDG8 by fostering innovation that leads to sustainable economic growth and decent work. For instance, the development and application of green technologies and sustainable business models can create new employment and enhance operational efficiency, thereby contributing to the economic growth aspect of the SDG (Astuti *et al.*, 2022; Wei *et al.*, 2023). However, the pursuit of economic growth, as traditionally measured, may conflict with environmental sustainability. Advocating for a framework that ensures welfare provisioning independent of growth, Kreinin and Aigner (2022) proposed the concept of “sustainable work and economic growth”, which suggests a revaluation of the dependence on economic growth. This highlights the need for GIC to support growth and redefine it in a manner that aligns with strong sustainability principles.

Both institutional change and the advancement of low-carbon technologies are significantly influenced by human capital development. As human capital accumulates, individuals adopt energy-efficient technologies that improve firm efficiency and lower carbon emissions. Theoretically, increasing human capital levels may promote institutional innovation and technological advancement in the structure and efficiency of firms, which would reduce carbon emissions and thus promote SDG8 and its targets [2, 5, 6, 8] (Zhang *et al.*, 2023). To lessen detrimental effects on the environment, firms can manage their plans and create business models in accordance with environmental regulations by incorporating IC (Di Vaio *et al.*, 2024a). Furthermore, the growing concern of institutions and stakeholders has encouraged firms to adopt carbon accounting as a managerial accounting tool to measure their carbon performance (Gibassier and Schaltegger, 2015). However, the idea of transparency has changed over the past few decades, shifting from a more accountability-focused perspective to one that is more inclusive and includes an increasing emphasis on sustainable performance. Therefore, to maintain sustainability, firms must extend their scope of accountability to include stakeholders' needs and expectations (Granà *et al.*, 2024).

Regarding the sustainable performance of firms, more than 10 years ago, Stechemesser and Guenther (2012) clarified that efforts to incorporate climate change mitigation into accounting procedures are referred to as carbon accounting. Through carbon accounting, effective structural capital makes it easier for firms to gather, process, and report carbon emission data in a systematic manner while maintaining accuracy and regulatory compliance. This infrastructure consists of cutting-edge information technologies that facilitate smooth data flow and real-time monitoring by integrating carbon accounting into larger financial and operational frameworks (Mahmood and Mubarik, 2020). In addition, the carbon accounting process is streamlined by well-established internal rules and processes, which lower implementation hurdles and improve firm readiness (Schaltegger and Csutora, 2012). Human capital may effectively manage carbon accounting procedures using training programmes and knowledge repositories, which are essential parts of structural capital (Amores-Salvadó *et al.*, 2021). According to Mahajan *et al.* (2023), the consistent application of the stakeholder theory fosters sustainability reporting, precise decision-making, conscientious strategy adoption regarding sustainable performance, and technological adoption that protect stakeholder validity. In this regard, the resource-based view (RBV) theory focuses on examining the resources owned by firms (Hsu and Wang, 2012).

The UN 2030 Agenda strongly supports social rights, including zero hunger, clean water, gender equality, and maintaining a decent work environment for all employees (Kaan *et al.*, 2014). This study focuses on SDG8, which calls for decent work, that is, safe and secure working environments for all workers, education, or training on technological upgrading without gender diversity, including persons with disabilities (SDG8-Targets 8.[2, 5, 6, 8]). The necessity of addressing the different and varied experiences in the workplace is acknowledged in the International Labour Organization's (ILO) fundamental standards:

> To promote decent and productive work for women and men in conditions of freedom, equity, security and human dignity. All workers have the right to decent work, not only those working in the formal economy, but also the self-employed, casual, and informal economy workers, as well as those, predominantly women, working in the care economy and private households. (ILO, 2012, p. V).

To achieve SDG8-Targets 8.[2, 5, 6, 8], firms can establish partnerships to obtain resources and expertise. This aligns with the UN 2030 Agenda and SDG17-Target 17.G, which emphasises collaboration through multi-stakeholder partnerships for sharing knowledge, expertise, technology, and financial resources to achieve the SDGs, particularly SDG8-Targets 8.[2, 5, 6, 8] in this study (Linton *et al.*, 2020). However, the transformation towards decarbonisation to solve the problems of climate change has been controversial (Smith, 2010). In addition, this transformation requires major investment, and partnerships between governments, non-governmental organisations (NGOs), for-profit organizations, and not-for-profit organisations play a key role in sustainable development (Shahbaz *et al.*, 2020).

Previous studies have rarely addressed the relationship between IC and the adoption of decarbonization processes for achieving SDG8-Targets 8.[2, 5, 6, 8]. Carbon accounting is useful for providing information on the processes and structural and human capital to ensure the balance between profit, environmental concerns, and social goals, and between IC components (i.e. relational capital, decarbonisation, and SDG17-Target 17.G). Thus, this study examined the linkages between these issues on the basis of institutional, RBV, and stakeholder theories. These theories highlight that firms agree on a social contract between themselves and society for its benefits. Institutional and stakeholder theories guarantee that the operations of firms are within societal norms, accepted by all stakeholders, and based on institutional pressure (Paoloni *et al.*, 2023). Hence, this study contributes to the literature by focusing on the development of business models for firms to balance their profits, with the surety of SDG8 and some of its targets. IC should be incorporated into decarbonization efforts to leverage new technologies and renewable resources. This integration is supported by SDG17-Target 17.G. In addition, IC should be utilised in carbon accounting to address institutional pressures and maintain a balance between profit and environmental and social goals.

This study employed the transparent and scientific systematic literature review (SLR) proposed by Tranfield *et al.* (2003). SLR is an ideal methodological approach to better explain how IC and its components in decarbonization processes can be measured and reported through carbon accounting, thus creating an information base to achieve SDG8, particularly the targets identified in this study. SLR is useful for demonstrating how partnerships that share knowledge, expertise, technology, and financial resources can support not only decarbonization efforts but also the broader pursuit of SDG8, along with firms' profitability and social and environmental aspects of sustainability. Moreover, SLR contributes to the existing literature on how previous studies address various research questions (RQs). SLR helps to identify and analyse the linkage examined in the literature, provides academic and managerial implications, introduces new conceptual frameworks, and highlights future avenues for research (Burritt *et al.*, 2023; Damschroder *et al.*, 2022). Using the VOSviewer (Visualization of Similarities Viewer) programme version 1.6.5, we assessed 149 articles published between 1990 and 2024, mainly in English, in the Scopus database and Google Scholar (GS) through descriptive, bibliometric, and network analyses, exporting the publication metadata to Microsoft Excel 2019 (Waltman *et al.*, 2010). This study provides a thorough overview of academic networks using bibliometric analysis to assist researchers in determining "how" to situate themselves in research areas and in charting the main evolutionary trajectories (Krishen *et al.*, 2021).

The roadmap for this study is as follows: Section 2 presents the theoretical background of the study. Section 3 describes the methodology of this study. Section 4 presents the results, Section 5 discloses the discussion and introduces a new conceptual framework, and Section 6 highlights the conclusions drawn from this study.

2. Theoretical background

2.1 IC in decarbonization processes for achieving SDG8

The RBV theory is an emerging approach to understanding the behaviour and competitive resources of firms (Barney, 1991). It argues that firms can evaluate their resource weaknesses and strengths by selecting an appropriate strategy to accomplish their environmental and social goals (Hsu and Wang, 2012). To improve environmental quality, firms must frame and implement innovative strategies by adopting decarbonization practices that help them transition to sustainability (Linton *et al.*, 2020). Decarbonization strategies have drawn increasing attention since the Paris Agreement was announced (Adebayo *et al.*, 2021). While decarbonisation, particularly through the adoption of new technologies and renewable resources, is critical, it raises concerns regarding structural and human capitals because changes in operational processes affect IC resources and structures.

The term *intellectual capital* was first coined by Machlup (1962) to highlight the importance of general knowledge as a fundamental basis for growth and development. In recent years, IC has emerged as the focus of scholars and researchers (Hsu and Wang, 2012). It supports firms in making effective decisions regarding the transformation of business models according to societal values and cultures (Komm *et al.*, 2021). To increase firm performance, business models must be based on firms' human and structural resources, which are the two components of IC and are good adaptors to eco-friendly environments (Teece, 2007). Moreover, to meet institutional requirements, firms must ensure decent work for all employees, the human capital involved in decarbonisation processes, through the adoption of new technologies (Thirgood *et al.*, 2017). This includes providing work conditions that are free from gender discrimination and include workers with disabilities, security, and skills development and training, which strengthen a firm's reputation (Ryder, 2015).

The current literature focuses on how IC promotes innovation and enhances firm effectiveness. However, the literature is noticeably lacking in terms of elucidating the precise role of IC components (human and structural capitals) in the adoption of decarbonisation processes. In their studies, Dumay (2016) and Marr (2010) provided a thorough summary of IC management but failed to address the ways in which these intangible assets support environmental sustainability programs. Thus, a crucial need for further studies remains in this field owing to the dearth of empirical studies connecting IC to decarbonization activities (Joshi *et al.*, 2010; Zeghal and Maaloul, 2010) and their effects on the involvement of all human and structural resources that allow for the pursuit of SDG8-Targets 8.[2, 5, 6, 8]. To fill this gap, we propose the first RQ to offer important insights into how firms can use IC to fulfil profit, environmental, and social objectives.

RQ1. How is IC examined in academic research regarding the implementation of decarbonization processes for climate change mitigation, with a focus on ensuring decent work in accordance with SDG8, particularly targets 8.[2, 5, 6, 8] and achieving a balance between profitability and environmental and social goals?

2.2 Utilising measures related to human and structural capitals in carbon accounting to achieve SDG8-Targets 8.[2, 5, 6, 8]

Regulatory bodies examine the practices of firms to align them with environmental policies to support the sustainability transition (Singh *et al.*, 2021). However, despite the increasing attention to sustainability reporting worldwide, no current study has related human and structural capital with carbon accounting (Bananuka *et al.*, 2023). In particular, IC enables firms to report their emissions and improve their economic, environmental, and social performance (de Villiers and Sharma, 2020). In addition, according to the institutional theory, institutional forces pressure firms to engage such human capital, which encompasses knowledge, skills, and expertise, to support carbon accounting practices, enhancing the operational efficiency of the firms (Chigbu and Nekhwevha, 2023). Furthermore, structural capital, which includes operational processes and technology adoption, ensures firm compliance with carbon accounting practices (Chigbu and Nekhwevha, 2023). The incorporation of strong structural capital not only supports the technical components of carbon accounting but also cultivates a sustainable culture in organisations, which leads to a more efficient and broad adoption of carbon accounting (Amores-Salvadó *et al.*, 2021). Firms may better negotiate the complexity of carbon accounting and ensure compliance and strategic alignment with environmental goals by utilising structural capital. To address social, economic, and environmental issues, human capital is a crucial source for improving long-term quality of life and the environment (Sharma *et al.*, 2021). Therefore, to facilitate smooth operations, firms must provide employees with a sustainable environment, in accordance with SDG8 (i.e. technological upgrading and innovation, men and women, and persons with disabilities) (Payab *et al.*, 2023).

In this study, to better analyse SDG8, we selected targets 8.[2, 5, 6, 8]. The Paris Agreement, which replaced the Kyoto Protocol, encourages firms to decarbonize their regular operations, resulting in a shift towards sustainability by adopting carbon accounting (Schaltegger and Castura, 2012). Carbon accounting, along with the institutional theory, supports firms in reducing carbon emissions to bring innovation in response to institutional pressure (Gunarathne *et al.*, 2021). When using renewable energy resources, firms face the biggest challenge in terms of carbon emissions. In this regard, to reduce industrial waste, skilled human and structural capitals are prerequisites at the operational level for achieving sustainable development growth (Payab *et al.*, 2023). Apart from the importance of IC in enhancing firm performance, the literature highlights a research gap in determining how human and structural capitals can be successfully incorporated into carbon accounting, providing little information to promote sustainability goals, especially SDG8 and its targets. Therefore, we propose the following second RQ:

RQ2. How does carbon accounting measure and report the contributions of human and structural capitals in the decarbonization processes via new technologies and renewable resources to achieve SDG8?

2.3 SDG17-target 17.G for decarbonization processes to meet SDG8-Targets 8.[2, 5, 6, 8]

Effective stakeholder interactions foster transparency and trust, which facilitate the sharing of best practices and collaboration that lead to long-term sustainable economic growth (Mahmoudian *et al.*, 2021). Studies have discussed relational capital, which, together with structural and cognitive capitals, is part of the social capital theory (Adler and Kwon, 2002; Nahapiet and Ghoshal, 1998; Chowdhury *et al.*, 2023). Chowdhury *et al.* (2023) clarified that collaboration between partners, especially in the supply chain, facilitates the implementation of sustainability practices. However, decarbonization efforts contribute significantly to environmental sustainability. Chowdhury *et al.* (2023) also highlighted that firm orientation towards partnerships is influenced by the context. Di Vaio *et al.* (2023a) analysed partnerships in the cruise sector using the stakeholder theory based on resource dependence. Likewise, the present study clarifies how decarbonization processes require know-how, expertise, and financing to achieve the availability of resources (i.e. new and renewable technologies), human capital training, and the organisation and management of structural capital. Therefore, in partnerships, the third IC component, relational capital, becomes critical. Hence, IC in its entirety enables firms to decarbonise to meet SDG8-Targets 8.[2, 5, 6, 8] through SDG17-Target 17. Establishing an additional prerequisite, alongside the information from carbon accounting and IC data, ensures a balance between profit and environmental and social goals. By encouraging this cooperative strategy, the creation of resilient, inclusive economies advances and promotes SDG8 (Eberth *et al.*, 2023). In addition, SDG17 efficiently facilitates the transition of technological advancements and the effective employment of IC resources to reduce carbon emissions (Kim and Perron, 2009).

Although studies have examined SDGs, they lack a focus on partnerships that support economic, social, and environmental issues in parallel (Milwood, 2020). Therefore, on the basis of the stakeholder theory, we formulated our third RQ:

RQ3. How do partnerships, in accordance with SDG17, particularly target 17.G, leverage relational capital to facilitate the decarbonisation process and ensure the achievement of SDG8?

The conceptual foundation of this study is illustrated in Figure 1.

3. Methodology

This study employed the transparent, scientific, and replicable methodology of SLR, as outlined by Tranfield *et al.* (2003). To address the RQs and using the theoretical background of sustainable development, organisational resources, accounting, and business strategy domains, this study focused on the following concepts: “intellectual capital”, “SDG8”,

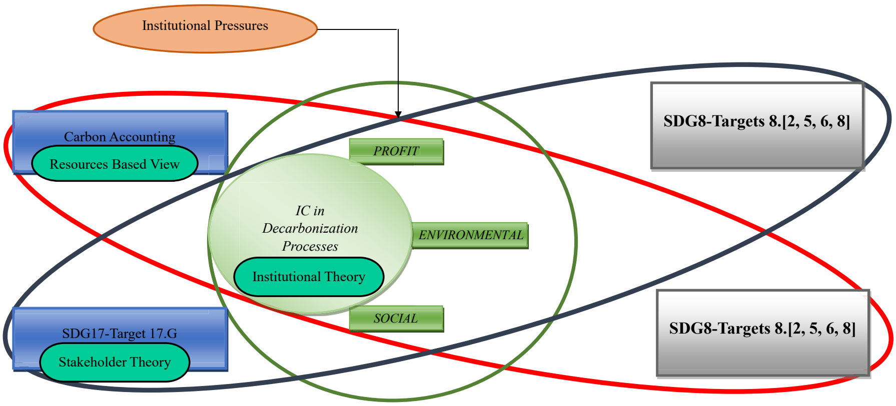


Figure 1.
Conceptualization of the study

Source(s): Authors' presentation

"SDG17", "accounting systems", "innovation", "new technology", "renewable energy resources", "climate change", "decarbonization", "profitability", and "environmental and social impacts". Synonyms were defined in addition to the main concepts.

Hardies *et al.* (2023) suggested that SLR is an appropriate methodology that effectively compiles all available evidence on under-researched topics in the field of accounting research. Hence, the decision to use SLR in this context was motivated by the potential to advance knowledge in the research area under investigation by comprehensively understanding the specific topics addressed within our theoretical framework. Therefore, previous findings and evidence enable a comprehensive interpretation of earlier scientific discoveries by considering new conceptual frameworks and lines of enquiry (Cosa *et al.*, 2023). To introduce a systematic map of a still-fragmented research field, it is necessary to identify the research gaps that currently hinder a specific research topic (Dana *et al.*, 2024; Tranfield *et al.*, 2003). SLR as a methodology enables the collection of systematic information on research topics, adds value by addressing pertinent issues, and reveal potential directions for additional research based on contentious issues (Snyder, 2019; Wee and Banister, 2016).

One-way bibliometric analysis is useful in developing new conceptual frameworks by identifying key topics and research areas within a field. By analysing the most cited articles, authors, and institutions, a bibliometric analysis can provide a comprehensive overview of the current state of research and help researchers identify areas that require further investigation. This information can be used to develop new RQs, hypotheses, and theories to form the basis of a new conceptual framework (Donthu *et al.*, 2021; Krishen *et al.*, 2021). Bibliometric analysis has recently emerged as a prominent and rigorous methodology for investigating and scrutinising literature across various academic disciplines (Öztürk *et al.*, 2024). By employing bibliometric techniques, researchers can identify patterns, trends, and gaps in the scholarly landscape, which can inform the creation of frameworks that encapsulate current knowledge and address unexplored areas (Chhabra *et al.*, 2021). While bibliometric analysis is instrumental in mapping the intellectual structure of a field, it also reveals the interconnectivity of concepts through citation and co-authorship networks. This can lead to the discovery of influential works and authors, and the identification of seminal papers that have shaped the discourse, thus providing a solid empirical foundation for the development of new theories and models (Di Vaio *et al.*, 2021).

The database considered for this study was Scopus, which has been used by several researchers (Mishra *et al.*, 2017; Secundo *et al.*, 2020; Waltman, 2016). Scopus is widely recognised globally as one of the largest databases of peer-reviewed literature. Compared with Web of Science (WoS), Scopus contains more articles, as it includes most publications listed in WoS (Dana *et al.*, 2024). To ensure comprehensiveness, the search process was supplemented with searches on GS to examine the citations of additional studies published in high-impact journals and thereby guarantee that no relevant articles were inadvertently overlooked in our study (Martín-Martín *et al.*, 2017).

First, we searched for articles using predetermined search strings (Table 1) in the Scopus database and GS. In line with previous research, we framed our search strings on the basis of the primary keywords from our RQs because papers containing these keywords represent a research domain (Hossain *et al.*, 2020; Liñán and Fayolle, 2015). Our search strings were based on a narrow-down philosophy. For example, search string 1 was broader and returned all papers related to IC and SDG. The subsequent search strings retrieved databases specific to the RQs. For instance, regarding RQ1, the specific keywords used in the first stage in combination with the research theme included "intellectual capital", "decent work", "economic growth", "profitability", and "social and environmental effect" (search strings 2 and 3). Regarding RQ2, the keywords "human capital" and "structural capital" were combined with "carbon", "accounting", "new technology", and "renewable resources" (search strings 4 and 5). Search strings 6 and 7 present the database queries for RQ3, combining the keyword "partner*" with the keywords "relational capital", "carbon", "decent work", and "economic growth".

Our study focused on the concepts of IC, carbon accounting, decarbonization, and SDG8-Targets 8. [2, 5, 6, 8] and SDG17-Target 17.G. As described earlier and following the work of scholars for selecting specific keywords for a database search (Hardies *et al.*, 2023; Hossain *et al.*, 2020) to extract the exhaustive list of papers for SDG8 and SDG17, we used the keywords "decent work and economic growth" (SDG8) and "partner*" (SDG17) along with other related keywords. From this list, we manually filtered the papers for SDG8-Targets 8.[2, 5, 6, 8] and SDG17-Target 17.G. Thus, this step also enabled us to obtain relative knowledge of the weightage of the thrust given to the chosen specific SDG targets in scholarly research vis-a-vis the other targets.

We used specific inclusion and exclusion criteria for shortlisting articles from the identified databases and search strings. Table 2 presents the inclusion and exclusion criteria, followed by a shortlist of the database of articles from Scopus and GS. This step yielded 1,123 articles. Next, duplicate and extraneous articles were removed, resulting in 633 articles. In the penultimate stage, the authors selected the final articles through a manual content analysis. In this step, the authors read the article titles and abstracts of the papers to identify their relevance to the research objectives (questions) related to the relationships between the

S. No.	Keywords and search strings
1	Intellectual capital AND ("SDG" OR "sustainable development goal")
2	Intellectual capital AND ("decent work" OR "economic growth")
3	Intellectual capital AND ("decent work" OR "economic growth") AND ("social" OR "environment*" OR "profit" OR "income")
4	("human capital" OR "structural capital") AND "carbon" AND "accounting" ("SDG" OR "sustainable development goal")
5	("human capital" OR "structural capital") AND "carbon" AND "accounting" ("innovate" OR "green technology" OR "diversify" OR "new technology" OR "renewable resource*" OR "technology")
6	Partner*AND "carbon" AND ("decent work" OR "economic growth")
7	Partner*AND ("relational capital") AND "carbon" AND ("decent work" OR "economic growth")

Source(s): Authors' elaboration

Table 1. Keywords and search strings used to search the Scopus database and Google Scholar

chosen variables in the study: SDG8, SDG17, accounting systems, IC, new technology, renewable resources, business strategy, climate change, and decarbonization. We detected inadequacies and inconsistencies in the article selection process. The articles that comprised the final dataset were chosen on the basis of their theoretical or empirical contributions to the research field related to the previously mentioned subjects. The Appendix 1 shows our final dataset comprised 149 articles published from 1990 to the first half of 2024. The first study was published in 2005.

Next, we analysed these studies using an integrated approach that combined quantitative (bibliometric analysis) and qualitative (content analysis) analysis strategies to fulfil the objectives of the SLR.

For the bibliometric analysis, the publication metadata were exported to MS Excel. We ran queries in the bibliometric software on the most prolific authors, popular keywords, popular source titles, and keyword co-occurrence analyses using the VOSviewer application version 1.6.19 (Van Eck and Waltman, 2014). In the co-occurrence analysis of keywords, the relatedness of the items was determined on the basis of the number of documents in which they occurred. This analysis helped us identify concepts ("intellectual capital", "SDG8", "SDG17", "accounting systems", "innovation", "new technology", "renewable energy resources", "climate change", "decarbonization", "profitability", and "environmental and social impacts") and their interrelatedness based on the RQs. Through this quantitative analysis, we shortlisted papers for each RQ. Next, we conducted a manual content analysis of the shortlisted articles. Scholars have frequently performed content analyses to identify evolving trends in a research field and to examine the intellectual structure of a specific area in the existing literature (Donthu *et al.*, 2021). We read the papers to identify answers to our three RQs and to understand the existing gaps and prospects of the research field. In addition, a manual content analysis was performed using MS Excel (Microsoft, Rochester, NY, USA) to sort the data, concepts, and themes.

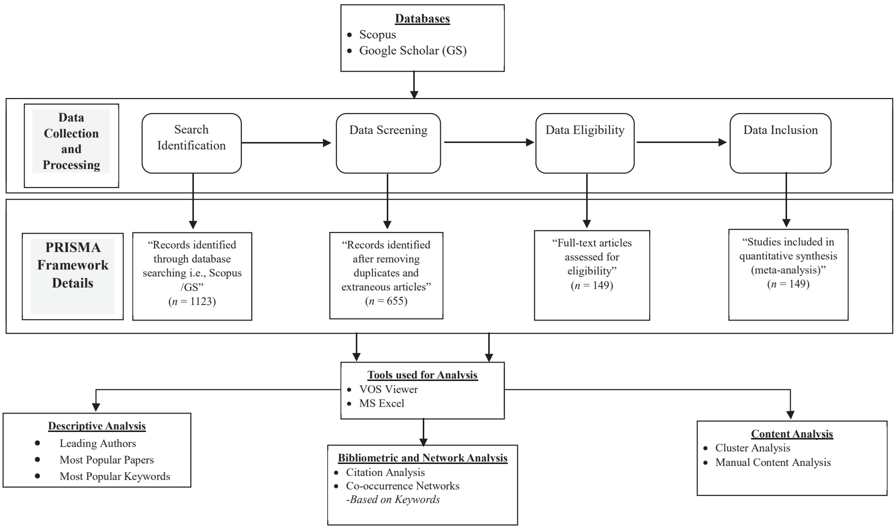
Heuristics was applied for data organisation and interpretation, and no preset instructions were used for the data analysis (Chhabra, 2021). Interrelated codes were clubbed together to help identify key concepts. The researchers performed open coding, and the emerging variances were set off after mutual consensus and discussion. This was further succeeded by axial coding to generate second-order themes and codes, and by the identification of the relationship between sub-categories at a conceptual level. The result is a script that encloses the findings in the form of answers to the RQs (Vindrola-Padros and Johnson, 2020). Thus, this study delineates the discoveries derived from bibliometric examinations and content analyses by applying a combination of visual representations, charts, and textual data based on the outcomes produced using VOSviewer and MS Excel.

Figure 2 shows the approach for implementing the aforementioned data collection processes and reporting all SLR phases, providing insights into the identification, screening, and inclusion of pertinent data, including the PRISMA flowchart (Page *et al.*, 2021).

Table 2.
Criteria used to include retrieved studies in the literature review

Feature	Inclusion criteria
Discipline	"Business, Management and Accounting," "Social Sciences," "Economics, Econometrics and Finance," and "Environmental Science."
Source type	Peer Reviewed Journal Articles from Scopus and Google Scholar
Language	English

Source(s): Authors' elaboration



Source(s): Authors' presentation

Figure 2. Study's research design and methodology

4. Results

The investigation was condensed, and the spatiotemporal attributes of the information obtained from the selected publications were emphasised through the utilisation of bibliometrics, which were employed to conduct state-of-the-art statistical and visual classification examinations. The results of the bibliometric analysis are discussed in the following sub-sections.

4.1 Most prolific authors

Table 3 lists the most prolific authors in research on "intellectual capital", "SDG8", "SDG17", "new technology", "renewable energy resources", "decarbonization", "profitability", and "environmental and social impacts".

4.2 Most popular papers

Reference citations play a vital role in research assessment, as they demonstrate the degree to which a piece of literature has utilised the concepts, findings, and resources of other works. Consequently, the influence of a research endeavour is closely linked to the number of references it integrates (Liñán and Fayolle, 2015). The most frequently cited authors and articles are listed in Table 4. The article "Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is?" by Hao *et al.* (2021) was the most cited paper in the selected database. The results derived from theoretical and empirical investigations suggest that in the Group of 7 nations, there is a reduction in CO_2 emissions due to environmentally adjusted multifactor productivity growth, which is known as green growth. Furthermore, environmental taxes, investment in human capital, and the utilisation of renewable energy sources have diminishing effects on CO_2 emissions.

The second article on the list is 'Public-private partnerships investment in energy as new determinant of CO_2 emissions: The role of technological innovations in China' by Muhammad Shahbaz, Chandrashekar Raghutla . . . *et al.* (2020). The empirical findings demonstrated that investment in energy through public-private partnerships hindered environmental quality by amplifying carbon emissions. Conversely, these showed that technological advancements

Table 3.
Most prolific authors

Author	NP	TC	PY_start
Kirikkaleli, D.	7	453	2021
Adebayo, T. S.	4	345	2021
Ahmad, M.	4	274	2020
Liu, Y.	4	319	2018
Yang, S.	3	114	2018
Zhang, X.	3	148	2021
Khan, Z.	2	522	2021
Ahmed, Z.	2	340	2019
Abbas, Q.	2	257	2020
Anser, M. K.	2	166	2021
Cai, X.	2	126	2018
Al-Mulali, U.	2	69	2022
Ibrahim, R. L.	2	69	2022
Isiksal, A. Z.	2	50	2021
Joof, F.	2	50	2021
Khan, A.	2	38	2022
Li, J.	2	33	2021
Han, J.	2	31	2019
Ali, M.	2	21	2022
Li, S.	2	2	2023

Note(s): Abbreviations: TC, total number of citations; NP, Number of Publications
*Total Number of Documents = 149
Total Number of Authors = 503
Source(s): Authors' presentation using VOSviewer and MsExcel

had adversely affected carbon emissions. The relationship between economic advancement and carbon emissions displays a curvilinear pattern, commonly referred to as the environmental Kuznets curve theory. The third popular study is "Identifying the impacts of human capital on carbon emissions in Pakistan" by Sadio Bano *et al.* (2018). The researchers examined the impact of human capital on carbon emissions over an extended period in Pakistan from 1971 to 2014. Their results indicated a substantial enduring association between human capital and carbon emissions, which suggests that enhancing human capital can lead to a decrease in carbon emissions without compromising economic growth. Managing carbon emission investments in human capital is crucial for effective carbon accounting and management. However, the literature suggests a clear need for improved training and education to address knowledge gaps and ensure consistent and accurate carbon accounting practices across various sectors (Schaltegger and Csutora, 2012; Stechemesser and Guenther, 2012).

IC is regarded as a strategic asset that plays a significant role in the attainment of SDGs for climate change mitigation (World Bank, 2023). Human capital, which encompasses knowledge, expertise, and inventiveness, is pivotal in the development of novel approaches to address climate change and its repercussions on human advancement (Lybecker and Lohse, 2015). The studies in the top-most cited list and other studies have indicated that IC can be considered a strategic resource for achieving SDGs in climate change mitigation (World Bank, 2023). Human capital, which includes knowledge, skills, and creativity, is crucial for developing innovative solutions to address climate change due to decarbonization processes and its impact on human development. IC, defined as the combination of knowledge, skills, and innovative potential, can improve the workforce's productivity and adaptability, which lead to better working conditions and job creation (Hayton, 2005). However, the relationship between IC and economic growth is not straightforward. One study indicated that IC, particularly when

Author*, year, journal**	Article title	Total citations	TC per year
Hao L. N., 2021, Sci. Total Environ.	Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is?	418	104.50
Shahbaz M., 2020, Energy Econ.	Public-private partnerships investment in energy as new determinant of CO2 emissions: The role of technological innovations in China	361	72.20
Bano S., 2018, J. Clean Prod.	Identifying the impacts of human capital on carbon emissions in Pakistan	277	39.57
Ahmed Z., 2019, Environ. Sci. Pollut. Res.	Investigating the impact of human capital on the ecological footprint in India: An empirical analysis	253	42.17
Wang R., 2020, J. Environ. Manage.	The nexus of carbon emissions, financial development, renewable energy consumption, and technological innovation: What should be the priorities in light of COP 21 Agreements?	243	48.60
Hayton J. C., 2005, R D Manage.	Competing in the new economy: the effect of intellectual capital on corporate entrepreneurship in high-technology new ventures	227	11.35
Lin B., 2022, Technol. Forecast. Soc. Change	Green technology innovations, urban innovation environment and CO2 emission reduction in China: Fresh evidence from a partially linear functional-coefficient panel model	201	67.00
Byrnes L., 2013, Renew. Energy	Australian renewable energy policy: Barriers and challenges	182	15.17
Kirikkaleli D., 2021, Environ. Sci. Pollut. Res.	Do public-private partnerships in energy and renewable energy consumption matter for consumption-based carbon dioxide emissions in India?	178	44.50
Zhang L., 2021, Sci. Total Environ.	Caring for the environment: How human capital, natural resources, and economic growth interact with environmental degradation in Pakistan? A dynamic ARDL approach	166	41.50
Secundo G., 2020, Technol. Forecast. Soc. Change	Sustainable development, intellectual capital and technology policies: A structured literature review and future research agenda	157	31.40
Ahmad M, 2022, J. Environ. Manage.	Combined role of green productivity growth, economic globalization, and eco-innovation in achieving ecological sustainability for OECD economies	147	49.00
Yao Y., 2020, Energy Econ.	Human capital and CO2 emissions in the long run	146	29.20
Caglar A. E., 2022, Sustainable Energy Technol. Assess.	Determinants of CO2 emissions in the BRICS economies: The role of partnerships investment in energy and economic complexity	137	45.67

Note(s): *Only first author name is presented; **Journal abbreviations have been used
Total Number of papers = 149
Total Number of Citations = 5,969
Source(s): Authors' presentation using Vosviewer and MsExcel

Table 4.
Most popular articles

recognised on balance sheets, may not have a direct impact on firm performance (Boekestein, 2006). Nevertheless, another study highlighted the transformative potential of IC to generate wealth for firms and countries (Zeghal and Maaloul, 2010). Furthermore, the influence of IC on economic growth can vary across different sectors and regions, as demonstrated by various scholars (Xiao and Yu, 2020; Xu *et al.*, 2021). Hence, IC has the potential to support decent work and economic growth by enhancing innovation and productivity (Secundo, 2020). The studies have further posited that by promoting cooperation among various entities such as governmental bodies, corporate entities, academic establishments, and non-profit organisations, collaborative efforts have the potential to expedite the advancement and distribution of cutting-edge technologies and methodologies aimed at addressing climate change through decarbonisation processes (Lybecker and Lohse, 2015).

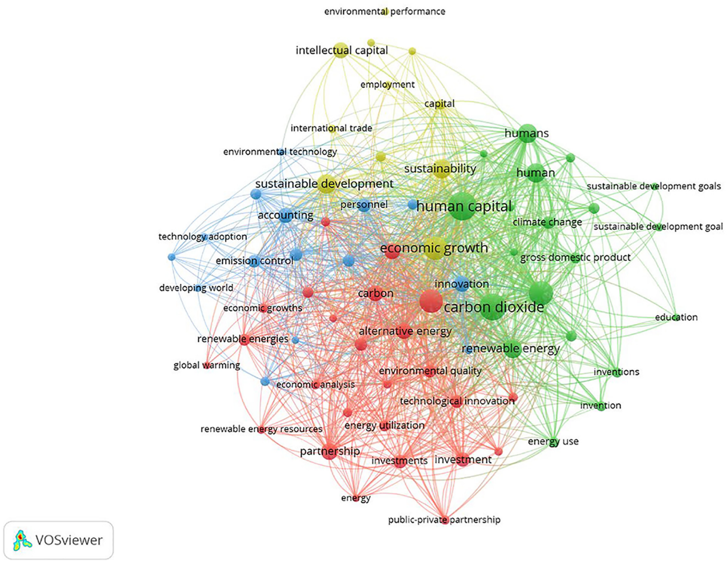
4.3 Keyword analysis

The bibliometric networks presented in this section consisted of multiple papers collected using the text-mining function of VOSviewer 1.6.19. These results have been validated in recent bibliometric studies (Marzi *et al.*, 2017). The text-mining technique establishes connections between keywords by calculating their distances. The closer the distance between the two terms, the stronger their association due to higher co-occurrence (Van Eck and Waltman, 2014). The keywords analysed in this bibliometric study for "author terms" were those that appeared at least five times in the database. A manual selection was performed to ensure data reliability. Specific keywords such as "content analysis", article', and "research method" were excluded. Consequently, 50 of the 964 keywords were found to be relevant to the analysis. Using a bibliometric analysis, we constructed a conceptual map to illustrate the connections between the keywords within the database. The size of the words in the graphical analysis corresponded to the frequency of the occurrence of each keyword. A larger circle indicated that the selected keywords occurred more frequently. According to the statistics, the keywords "human capital" ($n = 75$), "economic development" ($n = 52$), "sustainable development" ($n = 33$), "partnership" ($n = 25$), "intellectual capital" ($n = 23$), "accounting" ($n = 21$), "economic and social effects" ($n = 13$), and "public-private partnership" ($n = 8$) are the top keywords relevant to our RQs. Table 5 lists the prominent keywords used by previous authors, and the visualisation is presented in Figure 3. The visuals in Figures 3a and 3e demonstrate the overlay representation of keywords categorised

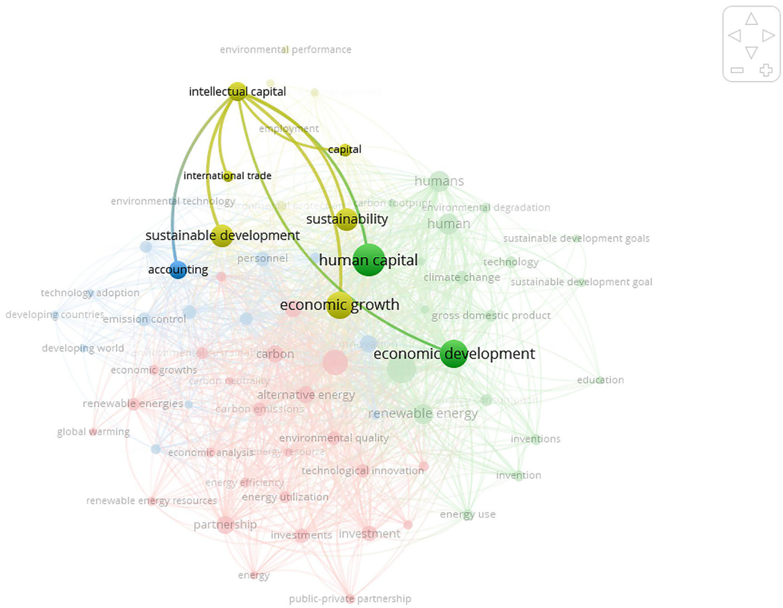
Keyword	Occurrences	Total link strength
Human capital	75	593
Economic development	52	545
Carbon emission	51	494
Economic growth	50	461
Sustainable development	33	321
Renewable energy	30	367
Partnership	25	262
Alternative energy	24	293
Innovation	23	242
Intellectual capital	23	42
Accounting	21	154
Investments	16	171
Personnel	16	197
Technological innovation	15	193
Climate change	14	147
Emission control	14	118
Environmental quality	14	148
Economic and social effects	13	170
Gross domestic product	12	149
Public-private partnership	8	98

Note(s): Total Number of Keywords = 964
Total Keyword Occurrences = 1,300
Source(s): Authors' presentation using Vosviewer and MsExcel

Table 5.
Most popular keywords



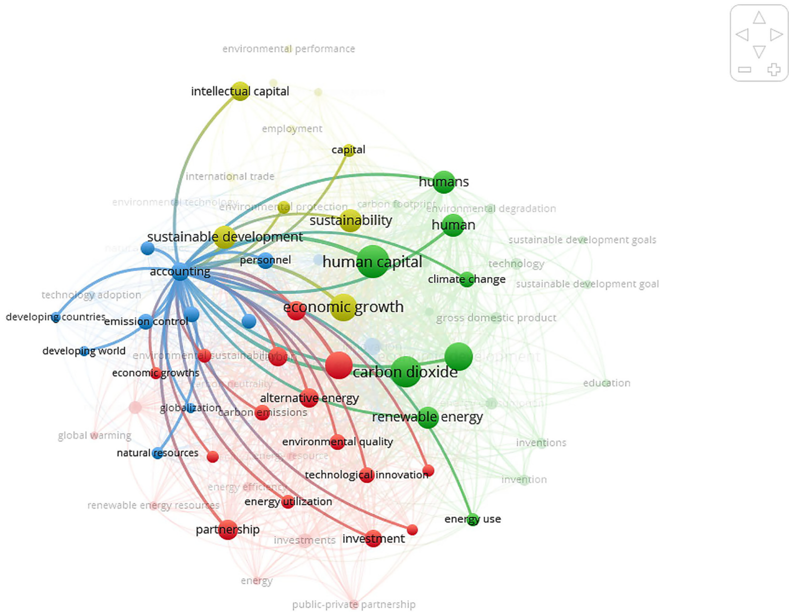
(a)



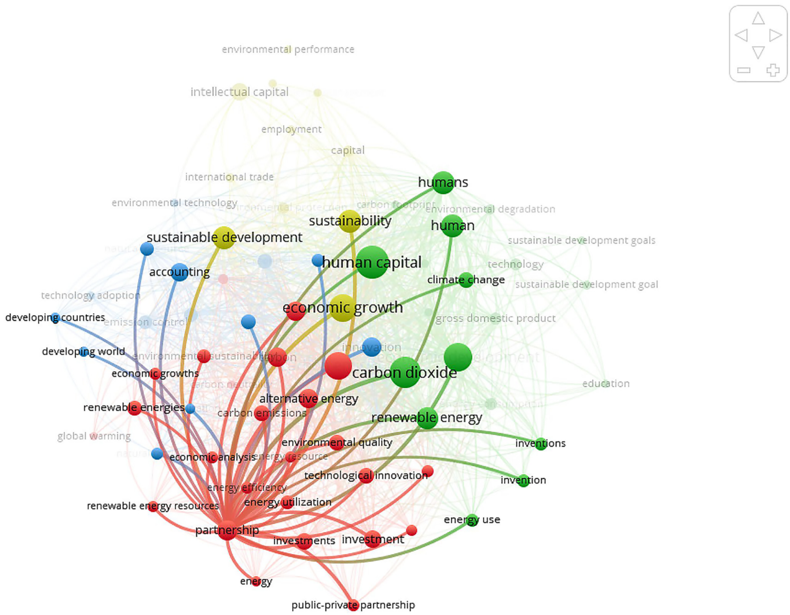
(b)

Figure 3.
(a) – 3 (e) VOSviewer visualization of a term co-occurrence network based on keywords analysis

(*continued*)



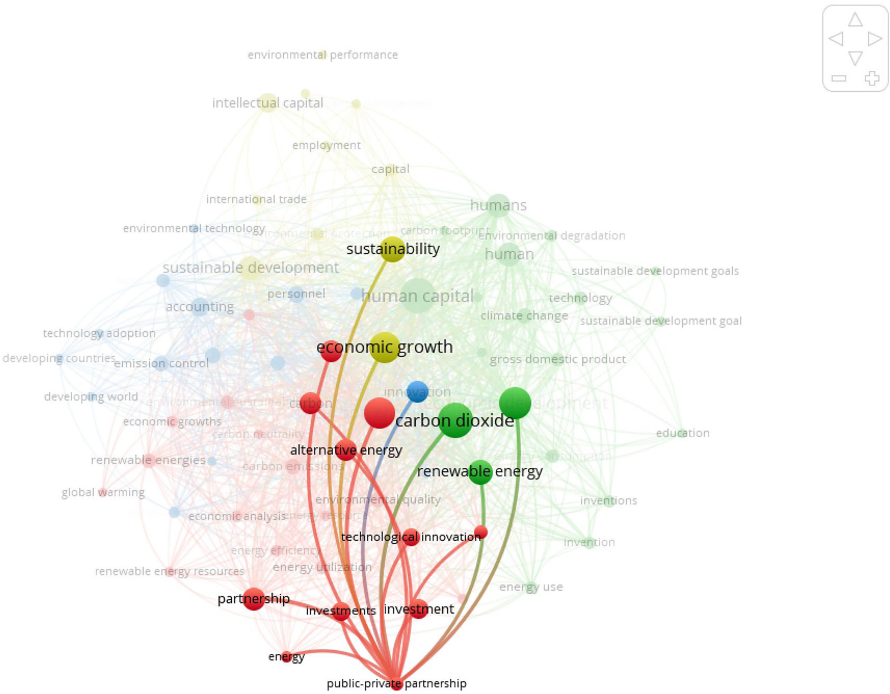
(c)



(d)

Figure 3.

(*continued*)



(e)

Source(s): Authors' presentation using Vosviewer

Figure 3.

based on their colour correspondence. These figures visually depict the connection through colour, where the frequency index of word repetition over time is computed.

When the keyword "intellectual capital" is linked to the keywords "economic growth" (SDG8) and "sustainable development", it is also linked with "accounting" (Figure 3b). Figure 3d shows that when the keyword "partnership" is linked with "human" and "humans", it is also linked with "economic growth", "investments", "technological innovation", and "sustainability". Furthermore, when "accounting" is linked with "intellectual capital" and "human capital", it is also linked to "economic growth" and "climate change" (Figure 3c). Hence, the researchers were guided by these connections in concepts that have been identified through bibliometric networks.

The manual content analysis of the 149 articles helped us decipher the queries for the three RQs. For instance, studies in our database highlighted that partnerships have the potential to serve as a potent mechanism for bolstering IC for the attainment of SDGs in the realm of climate change mitigation. Through the cultivation of partnerships and the exchange of expertise among various actors, collaborations can expedite the advancement and widespread adoption of pioneering climate change solutions and methodologies, thereby playing a significant role in fostering a sustainable future for humanity (Han and Cai, 2024; Jahanger *et al.*, 2023). Furthermore, the analysis results highlighted that human and structural capitals can contribute to achieving SDG8 through the implementation of sustainable practices and technologies that are likely to be part of a carbon accounting framework. For instance, the adoption of circular economy principles (Gunarathne *et al.*, 2021) and the integration of the digital economy (Zhong *et al.*, 2022) can contribute to economic growth and decent work while potentially reducing carbon emissions.

The results of our SLR were categorised into 2 decades: 2005–2014 and 2015–2024. As the first study of our database was published in 2005, we chose to present our results for manual content analysis in this temporal order to better understand how scholars' attention has moved over the years with respect to the issues discussed in our study.

In the decade from 2005 to 2014, regarding RQ1, our results highlight that IC can minimise risks and maximise returns on innovative investments from the perspective of RBV (Hayton, 2005). Another study highlighted the importance of intellectual human capital in improving firm performance (Kornilova and Klymenko, 2014). de Leaniz and del Bosque (2013) found that relational capital based on the knowledge-based theory is eligible to attain competitive advantage and is an important source for economic growth. Regarding climate change, Goklany (2007) examined the use of technology with trained human capital resources to achieve environmental goals. Concerning RQ2, scholars have revealed that effective regulatory frameworks can support efficient resource allocation to reduce carbon emissions. The lack of support from policymakers regarding emerging technologies and skilled human capital is the main barrier to achieving emission reduction goals (Byrnes *et al.*, 2013). Goklany (2007) suggested that human capital, health, and education are indicators of sustainable development. With reference to RQ3, scholars have encouraged partnerships between two firms to reduce CO_2 emissions, which are important for achieving long-term economic growth (De Batz, 2009). Other scholars have specifically targeted the tourism industry and revealed the importance of partnerships that involve a multi-stakeholder approach by targeting different economic sectors, including transport, travel agents, accommodation, and food, to participate in economic development (Raicevic *et al.*, 2013).

During the decade of 2015–2024, the issues highlighted in our study have received much attention. Therefore, our database, which consisted of 139 articles, is mainly dependent on this decade. Our RQ1 is supported by the study of Sun *et al.* (2023), who found that human capital, along with transformation from traditional fossil fuel resources to technological renewable resources, helps firms to effectively manage their sustainable resource management, which leads to SDG8-Target 8.4, that is, improve resource efficiency in consumption and production. The same study emphasised that a lack of effective human capital results in negative environmental effects and misuse of natural resources (Sun *et al.*, 2023), as shown in our bibliometric results (Figure 3c and d) that indicate a direct relationship between humans, inventions, renewable energy, and climate change. Our results further indicate that stakeholder engagement is important in promoting IC for significant achievements (Nupap *et al.*, 2016).

Another group of scholars have shed light on human and structural capital by stressing that investments should be increased in both resources to create an effective, competitive market (Mustafin *et al.*, 2016). Mačerinskienė and Aleknavičiūtė (2017) realised the importance of human, structural, and relational capital as key determinants of economic growth. Another study stressed that educational investments in human capital are important to consider, as less educated and trained human capital dealing with renewable energy resources is the major cause of environmental degradation (Khan, 2020). In 2020, studies were more focused on human capital regarding the training, skills, and education of human resources in firms, which can be a valuable resource for achieving SDGs (Vorontsova *et al.*, 2020). Specifically, regarding the SDG8-Target 8.6, Kuzkin *et al.* (2019) found that education, as an enabler of human capital, is a key factor of economic growth. Ali and Anwar (2021) also highlighted that IC (human, relational, and structural capitals) is a great source of economic growth based on resource- and knowledge-based theories. Concerning RQ2, scholars have highlighted that a country's economic growth depends on technological innovation and IC (Dumay, 2016; Liu *et al.*, 2017).

Another important study supports our results, although it did not exclusively target SDG8 but examined the intersection of augmented accounting practices with technological innovation as novel forms of IC to achieve SDGs (Al-Htaybat *et al.*, 2019). They further linked technological IC with organisational knowledge and integrated thinking to achieve sustainable business models. Specifically, supporting our study, the existing literature shows that if firms have a competitive IC in all its forms, they can efficiently deal with income inequality issues and provide their employees with career success in the long run; therefore, investors should invest in improving IC to achieve SDG8 (Lasisi *et al.*, 2023).

Švarc *et al.* (2020) empirically investigated that national IC and its dimensions, which include human, social, structural, relational, and developmental capitals, support digital transformation. Another study found that human capital and carbon pricing can increase economic growth because carbon pricing covers the cost of carbon emissions paid by carbon emitters (Borissov *et al.*, 2019). Referring to RQ3, Adebayo *et al.* (2021) stressed that investments in technological innovation and energy resources by public-private partnerships can upgrade environmental sustainability. Other studies have also suggested that increases in public-private partnership investments in renewable energy resources and technological innovation can positively impact CO_2 emissions (Caglar *et al.*, 2022; Kirikkaleli and Adebayo, 2021; Shahbaz *et al.*, 2020). Almost all the results of the studies from our database indicate the importance of public-private collaborations, specifically in the energy sector, in reducing carbon emissions via technological adaptation and the effective use of renewable resources (Caglar *et al.*, 2022; Lu *et al.*, 2022).

5. Discussion

Our SLR results suggest the opportunity to link IC with decarbonization processes to achieve SDG8, ensuring a balance between profit and environmental and social goals. In this regard, to justify our RQ1, "How is IC examined in academic research regarding the implementation of decarbonization processes for climate change mitigation, with a focus on ensuring decent work in accordance with SDG8, particularly targets 8.[2, 5, 6, 8] and achieving a balance between profitability and social and environmental objectives?" Our results highlight that IC has the potential to achieve a sustainable competitive advantage that can support technological development and economic growth (Hayton, 2005). The literature also endorses that supported by the RBV, firms can achieve their sustainability goals efficiently if they have strong internal capital resources (Bananuka *et al.*, 2023). Our results contribute to the literature by clarifying that IC can positively subsidise economic and social developments through innovation and creativity. The literature emphasises that human capital enables firms to leverage structural capital to develop processes that generate stakeholder value (Secundo *et al.*, 2020). Furthermore, structural capital enables human capital to generate profitability in firms by simplifying the adoption of managerial processes (Berger *et al.*, 1997). Therefore, it is essential to develop and retain a skilled workforce to design, implement, and maintain low-carbon technologies and practices (Stefanescu-Mihăilă, 2015).

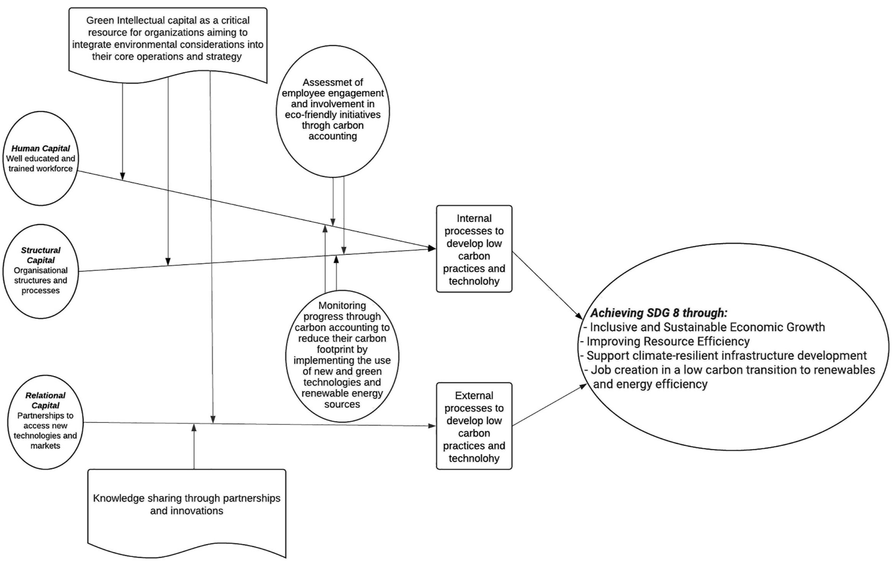
This research highlights that a well-educated and trained workforce can lead to increased productivity and innovation, which are critical for a successful transition to a low-carbon economy (Hayton, 2005; Švarc *et al.*, 2020). Another study argued that firms should invest in the training and education of their human capital regarding the use of renewable resources to reduce carbon emissions by increasing environmental awareness (Khan, 2020). Our study reveals that the literature acknowledges the importance of human capital in decarbonisation processes but lacks evidence of its measurement and internal reporting through the same managerial accounting tools used for measuring carbon reduction. However, our analysis revealed that this aspect has been sparsely addressed in the literature and requires increased scholarly attention. In addition, our results show that no single study in the literature has examined the impacts of human and structural capitals on SDG8, specifically targets 8.[2, 5, 6, 8].

With respect to RQ2, "How does carbon accounting measure and report the role of human and structural capital in the decarbonisation process via new technologies and renewable resources to achieve SDG8?", the literature posits that skilled human capital can increase the performance and standard of life of firms (Payab *et al.*, 2023). Khan (2020) stressed that unskilled human resources decrease productivity and create an unhygienic working environment in firms by increasing industrial waste due to inadequate knowledge about technology. This issue gained more attention from Siddiqui *et al.* (2022), who aimed to provide technical training to the workforce to secure the ecosystem. In this regard, structural capital is also vital for forming sturdy organisational structures that bolster sustainable innovation (Kianto *et al.*, 2017). The existing literature has examined how to monitor emissions reductions and link them to investments in human and structural capitals, suggesting that it is critical to have strong carbon accounting frameworks. By encouraging sustainable economic growth and decent work, these frameworks ensure that firms align their operational activities with SDG8 to make transparency and accountability easier (Hsu and Wang, 2012). The literature indicates that proficient carbon accounting not only gauges environmental consequences but also influences strategic choices, cultivating an organisational ethos that prioritises sustainability and ingenuity, thereby harmonising financial, societal, and ecological goals (Burritt and Schaltegger, 2010).

Carbon accounting can support firms in monitoring their progress towards reducing their carbon footprint using green technologies and renewable energy sources to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work (Mustafin *et al.*, 2016; Wei *et al.*, 2023). The institutional theory provides as a comprehensive framework for understanding the effects of institutional pressure and logic on the adoption and implementation of sustainability reporting, particularly in the realm of carbon accounting (Gunarathne *et al.*, 2021). Likewise, carbon accounting is designed as a system that collects, processes, and evaluates data about carbon emissions through accounting methods and procedures to support managers' decision-making and meet external stakeholders' needs (He *et al.*, 2022; Tang, 2017). Therefore, carbon accounting can play a crucial role in monitoring training and development programs designed to improve employees' proficiency in green technologies, renewable energy, and sustainable practices. It also helps firms in ensuring that their workforce is well prepared to support decarbonization initiatives (Zhong *et al.*, 2022). Carbon accounting assesses employee engagement and involvement in eco-friendly initiatives, including energy conservation, waste minimisation, and recycling. In doing so, it fosters a sustainable work environment within firms (Wei *et al.*, 2023). In conclusion, carbon accounting offers a system for measuring and internal reporting about the involvement of human and structural resources in the reduction processes of carbon emissions towards SDG8 and for providing information to management to ensure the balance between profit and environmental and social goals.

Concerning RQ3, "How do partnerships, in accordance with SDG17, particularly target 17.G, leverage relational capital to facilitate the decarbonisation process and ensure the achievement of SDG8?", our results indicate that relational capital, which refers to networks, relationships, and SDG17-Target 17.G, which facilitates knowledge sharing and collaboration, is essential for the successful implementation of decarbonisation strategies (De Leaniz and Del Bosque, 2013; Mačerinskienė and Aleknavičiūtė, 2017). Relational capital encourages joint ventures and partnerships to improve environmental stewardship and corporate social responsibility (Edvinsson and Malone, 1997). Firms that incorporate sustainability into their basic strategies can achieve long-term economic gains, social equality, and environmental protection. This also includes the development of partnerships between governments, businesses, and civil society organisations to share knowledge, technologies, and best practices for low-carbon development (Lu *et al.*, 2022; Shahbaz *et al.*, 2020). Furthermore, scholars have found that partnerships, especially in the energy sector, are vital for technological innovation to reduce emissions and increase economic growth (Cheng *et al.*, 2021; Shahbaz *et al.*, 2020). As highlighted by other scholars, networks, partnerships, and collaborations fall under the category of relational capital, which is vital for exchanging the information, resources, and technology needed for decarbonisation (Patala *et al.*, 2016). Studies have found that collaboration facilitates the sharing of knowledge and capital, fostering creativity and the adoption of sustainable technology and renewable energy sources (Roehrich *et al.*, 2014). Furthermore, partnerships support efforts aimed at increasing workforce skill sets, fostering decent working conditions and developing capacity. The development of relational capital through international networks and alliances hastens the adoption of sustainable business models and best practices, promoting economic expansion while maintaining social and environmental sustainability (Siegel *et al.*, 2003). Therefore, it is essential to use partnerships to leverage relational capital to achieve integrated and sustainable development goals. The results of our study highlight that relational capital must be encouraged to reduce emissions by sharing resources between firms (Adebayo *et al.*, 2021; Ali *et al.*, 2023; Caglar *et al.*, 2022; Kirikkaleli and Adebayo, 2021; Liu *et al.*, 2023), specifically to achieve SDG8 (Lasisi *et al.*, 2023). Keeping in mind the role of relational capital, the stakeholder theory emphasises the importance of multi-stakeholder partnerships that mobilise and share knowledge, expertise, technology, and financial resources to facilitate the decarbonization process, which is essential for sustainable economic growth and decent work, in accordance with SDG8 (Liu *et al.*, 2023).

On the basis of these results, we propose a conceptual framework for "intellectual capital for decarbonization for achieving SDG8" for businesses (Figure 4). In the first step, investing in human capital through education, skill development, training, and knowledge management is essential for the transition of businesses to low-carbon business models.



Source(s): Authors' processing

Figure 4. Conceptual framework for "Intellectual capital through decarbonization for achieving SDG8"

Second, the key aspects of structural capital that support low-carbon business practices include effective knowledge management, innovative financing instruments, policy alignment, robust climate information architecture development, and private capital mobilisation from diverse sources. Third, a successful transition to a low-carbon practice involves not only technological innovation but also the coevolution of institutions, business strategies, and user practices, all of which are underpinned by the relational dynamics of the business (Mehdi and Reza, 2012). All three aspects are supported by GIC and collective partnerships. Green human capital comprises employees' knowledge, skills, and abilities related to environmental issues. Green structural capital encompasses organisational capabilities, knowledge management systems, and operational processes that support environmental protection behaviours. It involves interactive relationships with customers, suppliers, and partners, and focuses on environmental protection and green management issues. Collectively, these GIC components can foster businesses to develop sustainable practices, drive green innovation, and enhance competitiveness in a low-carbon economy (Astuti *et al.*, 2022). Furthermore, businesses should encourage partners to share their knowledge and expertise to create a culture of knowledge sharing and innovation.

The efficacy of both internal and external processes can be assessed using carbon accounting measurement and monitoring tools with the aid of new technologies such as artificial intelligence and blockchain technology, which constitute the "new intellectual capital" of businesses. Low-carbon practices and technology can contribute to achieving SDG8 by fostering sustainable economic growth, creating decent work opportunities, and minimising environmental degradation. The adoption of such practices and technologies can lead to the development of new industries and job markets, particularly in sectors such as renewable energy, which can offer a range of employment opportunities (Paoloni *et al.*, 2023). In brief, low-carbon strategies and technologies can significantly contribute to achieving SDG8 by promoting economic growth that is separate from environmental degradation (Zhang *et al.*, 2021). This is accomplished by businesses by generating new employment prospects in sustainable sectors, enhancing resource productivity, and cultivating innovation and adaptability in response to environmental obstacles.

5.1 Theoretical implications

The emphasis of this study on IC as a sustainability approach contributes to institutional, stakeholder, and RBV theories by promoting a collaborative and integrative approach to sustainable development. To achieve SDG8, the integration of carbon accounting into the routine operations of firms demands skilled human capital, advanced information systems, comprehensive internal policies, and strong stakeholder engagement. The literature provides insignificant evidence that link IC with decarbonization practices for meeting institutional pressures in adopting sustainable methods to achieve SDG8-Targets 8.[2, 5, 6, 8]. Furthermore, to achieve SDG8 and its targets, this study focused on IC in decarbonization processes using SDG17-Target 17.G, on which there is little information in the literature. Offering details on the application of green technology and renewable resources to reduce carbon emissions improves the understanding of IC and contributes to the field of study. Also, it underlines the social and environmental effects of firm operations.

5.2 Managerial implications

The proposed framework provides management guidelines for the adoption of decarbonization practices and highlights that firms are accountable to their stakeholders. Moreover, institutional pressures urge firms to work with NGOs, government agencies, and private sector companies to strategically partner to advance SDG8-Targets 8.[2, 5, 6, 8] using carbon accounting and decarbonization strategies. Firms should integrate emission measurement systems (i.e. carbon accounting) with human and structural capital data to effectively handle resource use in decarbonization efforts. This holistic approach enhances decision-making and supports the achievement of sustainability targets (i.e. targets 8.[2, 5, 6, 8]. By implementing these strategies, managers can draw on eco-aware investors and clients while cutting operational costs through better resource management and energy efficiency. Partnerships under target 17.G aim to strengthen the Global Partnership for Sustainable Development by leveraging multi-stakeholder cooperation to advance SDG achievements. This approach enhances relationship capital, benefiting both economic performance and environmental sustainability through effective decarbonization efforts. Collaborative efforts not only create a safe and supportive work environment but also provide technological training, stimulate inclusive economic growth, generate green jobs, and support sustainable livelihoods.

5.3 Policy recommendations

By establishing financial incentives, enabling investments in partnerships, and establishing supportive regulatory frameworks, policymakers and regulatory bodies can assist firms in implementing carbon accounting and decarbonisation techniques to achieve SDG8-Targets 8.[2, 5, 6, 8]. Specific regulations that require firms to disclose their carbon emissions to ensure transparency must be properly introduced and implemented. Policymakers can ease the financial burden of firms by enacting tax cuts, grants, and subsidies for green activities towards the transition to sustainable practices. They can also set precise rules and specifications for carbon accounting to guarantee responsibility and openness. Policymakers should encourage cooperation among firms, NGOs, and community groups to promote the sharing of resources and best practices. By assisting firms in investing in sustainable technology, this multi-stakeholder strategy helps achieve SDG8-Targets 8.[2, 5, 6, 8] by improving employment training and economic opportunities.

5.4 Recommendations and scope for future research

From our SLR, we found that this research area is underexplored. Therefore, the results of this study may be used as a first initiative for future research in this field. This study highlights that scholars should focus on incorporating policies related to a balanced sustainable business model between profitability and the social and environmental aspects of sustainability. Furthermore, the adoption of carbon accounting in the measurement of IC can support firms in mitigating climate change and increasing their financial performance. In addition, to meet the current needs of adopting new technologies and renewable resources to justify institutional pressures, the implementation of partnerships in decarbonization processes acts as a key source of SDG8-Targets 8.[2, 5, 6, 8]. By addressing our RQs, this study suggests that firms should utilise their human, structural, and relational capitals at their best to meet environmental challenges. Furthermore, firms should incorporate carbon accounting into their decision-making processes to develop ways to cut emissions and increase resource efficiency. As these assets help firms achieve a competitive advantage, they will lead to positive environmental performance. Therefore, firms must introduce educational programs, training, and skills to boost their employees' knowledge and expertise in sustainable practices. SDG17-Target17.G can assist firms in knowledge sharing, technology transfer, and collaborative problem-solving initiatives to address sustainability challenges while promoting SDG8-Targets 8.[2, 5, 6, 8]. This entails placing reliable mechanisms for measuring and reporting, defining goals for reducing emissions, and implementing plans to monitor advancement over time.

5.5 Limitations of the study

One primary limitation of this study is that it only examined articles, predominantly those published in the Scopus database. Second, owing to the ongoing updates of the Scopus database and GS, it is possible that some relevant articles were not included in our analysis (Di Vaio *et al.*, 2023b). Nonetheless, this limitation was minimised by incorporating materials accessible up to 30 June 2024. Moreover, the Scopus indexing procedure has flaws. There may still be mistakes or discrepancies, even though the database states that it matches referenced articles with references using cutting-edge technologies. This is because the algorithms used in the database to identify and link documents are erroneous. The database also contains patents and webpages, which may make indexing much more difficult (Valenzuela-Fernandez *et al.*, 2019).

6. Conclusion

The literature underscores the complexity of achieving SDG8, necessitating a nuanced understanding of the interplay between economic growth, decent work, and sustainable development. Furthermore, institutions and other stakeholders are increasingly urging firms to adopt policies that focus on development and are aligned with SDG8 and its targets. However, the ability of firms to respond to these pressures can diverge depending on their resources in the form of IC and their ability to foster partnerships (i.e. relational capital). IC, which comprises knowledge, skills, and innovation, is crucial for firms to develop and implement strategies that lead to decarbonization and contribute to SDG8-Targets 8.[2, 5, 6, 8] ensuring the balance between profit, environmental, and social goals. In addition, the concept of neutrality, which is central to decarbonization efforts, relies on accurate carbon footprinting and accounting techniques to track emissions and implement reduction strategies (Di Vaio *et al.*, 2024b). Therefore, an integrated information approach that gathers data on the IC components involved in decarbonization enables the measurement, evaluation, and reporting of corporate climate change mitigation efforts. This ensures diversification and innovation in productivity, decent work, training, and safe working conditions. Such an approach can be viewed as IC that supports decarbonization.

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Appendix

The supplementary material for this article can be found online.

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