ISO 14001, Carbon Neutrality, and the Sustainable Development Goals: A Bibliometric and Systematic Review of Environmental Management Systems

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Abstract

This study aims to systematically review the ISO 14001 research landscape, examining how Environmental Management System (EMS) activities and sub-activities align with carbon neutrality objectives and the United Nations Sustainable Development Goals (SDGs). A two-pronged methodology was employed, combining bibliometric analysis with a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guided systematic literature review. A comprehensive search of the Scopus database identified publications from 2015 to 2025. Bibliometric analysis was conducted to map the intellectual structure of the field, while a qualitative synthesis of 62 relevant articles was performed to extract key themes and practices. The bibliometric results reveal the leading journals, prominent thematic clusters, geographic distribution, and major research topics in ISO 14001 scholarship over the past decade. The systematic review distills the principal ISO 14001-based EMS activities adopted by organizations and demonstrates their alignment with specific SDGs. To elevate these findings analytically, this study introduces the Adaptive Decarbonization Translation Framework (ADTF). This novel model conceptualizes ISO 14001 as a dynamic bridging structure that translates macro-level socio-institutional drivers into micro-level operational decarbonization through an iterative Plan-Do-Check-Act (PDCA) cycle. Several research gaps are identified, and a future research agenda is proposed. This study offers actionable insights for corporate decision-makers and policymakers to enhance the implementation of ISO 14001-based EMSs for decarbonization. The study also provides a robust analytical foundation for future research, demonstrating how standardized environmental management practices can be leveraged in pursuing climate change mitigation and sustainability goals.

Keywords: ISO 14001; Environmental Management Systems; Carbon Neutrality; Sustainable Development Goals; Bibliometric Analysis; Systematic Literature Review

1. Introduction

Global environmental governance has emerged as a pillar of international sustainability efforts, with frameworks such as the United Nations Sustainable Development Goals (SDGs) providing legitimacy for addressing cross-border environmental challenges and fostering global collaboration (Ikram and Boudraa, 2025). In 2015, the UN General Assembly launched 17 SDGs to holistically tackle the planet's social, economic, and environmental issues. Notably, several

SDGs are particularly relevant to organizational environmental management, emphasizing objectives directly tied to corporate sustainability performance (United Nations, 2018; Mosgaard & Kristensen, 2023).

Aligned with the Paris Agreement's ambitions, achieving carbon neutrality has become a critical objective for mitigating climate change (L. Chen et al., 2022). Although absolute zero emissions is unattainable, net-zero status can be reached by offsetting residual emissions through technological innovations and natural carbon sinks. Achieving carbon neutrality, however, requires rigorous measurement and continuous emissions management, which highlights the central role of formal Environmental Management Systems (EMS) in this endeavor (Zhao et al., 2022).

The International Organization for Standardization's (ISO) 14001 standard has been a systematic foundation for implementing EMS around the world for last three decades. First introduced in the mid-1990s as part of the ISO 14000 series, ISO 14001 has been revised multiple times to stay aligned with evolving best practices (Ikram et al., 2019). The standard was developed collaboratively by experts from 88 countries and specifies requirements for establishing an EMS committing organizations to improve environmental performance, reduce their ecological impacts, and ensure regulatory compliance (Margaret et al., 2024； Phan and Baird, 2015). Certification to ISO 14001 involves independent audits by accredited bodies and is supported by a global network of over 160 national standards organizations (Heires, 2008; Ikram et al., 2021). ISO 14001 has become a cornerstone of corporate sustainability management, driving companies to integrate environmental considerations into their operations and decision-making processes (Camilleri, 2022).

Despite ISO 14001's prominence, prior systematic reviews of this standard have been limited in scope. Earlier reviews often focused on specific topics such as organizations' motivations for certification and the perceived benefits or costs of adoption, or they examined certification patterns and performance outcomes in isolation (Ahmed & Mathrani, 2024; Boiral et al., 2018). Related reviews in the sustainability accounting domain applied PRISMA methods, however treated ISO 14001 only as a secondary aspect of broader climate initiatives rather than as the primary subject of analysis (Boiral et al., 2025; Boiral et al., 2025). Consequently, a holistic analysis is lacking that maps the evolution of ISO 14001 in the SDG era, and clarifies how this standard contributes as a mechanism to broader sustainability goals such as the SDGs or environmental, social, and governance (ESG) performance. This study addresses that gap by combining bibliometric mapping with a systematic literature review to provide an integrated perspective on ISO 14001 research over the 2015-2025 period and to identify future research directions.

As the world's most widely adopted environmental management standard, ISO 14001 has prompted organizations to expand their sustainability practices in pursuit of better environmental performance. Firms are increasingly expected not only to deliver financial results, but also to measure and disclose their environmental performance alongside financial outcomes. ISO 14001 provides a practical framework for this purpose, enabling companies to plan, implement, and monitor their sustainability commitments in a structured way (Johnstone and Hallberg, 2020; Tergu et al., 2025). Prior studies suggests that the adoption ISO 14001 is associated with the promotion of proactive environmental practices such as improving energy efficiency, waste reduction, and pollution prevention that enhance overall performance while minimizing environmental impacts (Melnyk et al., 2003; Sroufe, 2003). ISO 14001 is widely regarded as the world's most popular environmental management standard, and its implementation has shifted corporate attention toward continual improvement in environmental management.

Since 2015, there has been a transformative phase in sustainability management characterized by intensive study in environmental management, influenced by global frameworks such as the SDGs (Mishra et al., 2024; Sweileh, 2020; Sianes et al., 2022). Therefore, this paper aims to analyze the evolution of ISO 14001 research over the past decade and its role as a tool for promoting carbon neutrality and sustainable development goals.

This paper aims to fill the identified gaps in the literature by providing a comprehensive, process-oriented analysis of ISO 14001 and its role in facilitating decarbonization while aligning with designated sustainability objectives. The central theoretical contribution of the study lies in explaining the conditions under which ISO 14001 moves beyond formal certification and becomes an effective driver of substantive decarbonization. Rather than assuming that certification automatically yields carbon gains, the review demonstrates that environmental outcomes depend on implementation depth, the embedding of carbon objectives in strategic and operational routines, the use of complementary measurement approaches, and the institutional contexts in which firms operate. In this sense, the primary insight of the study is the identification of a certification-to-decarbonization translation gap between symbolic adoption and substantively embedded implementation. The proposed Adaptive Decarbonization Translation Framework (ADTF) is introduced as a secondary analytical synthesis of this core finding. It does not replace the Plan-Do-Check-Act (PDCA) framework already embedded in ISO 14001; instead, it organizes the review evidence to show how macro-level pressures, internal translation processes, and evaluative feedback condition whether the EMS produces only procedural conformity or meaningful carbon reduction.

To achieve this aim, we employ a dual methodology: a systematic literature review combined with a bibliometric analysis. This approach allows us to consolidate the fragmented literature on ISO 14001 and carbon management, map out the process-level EMS activities and sub-activities through which ISO 14001 fosters sustainability, and examine the alignment of ISO 14001 initiatives with various SDGs over short-, medium-, and long-term horizons.

2. Methodology

2.1 Study Design and Literature Selection

This study follows standard procedures for bibliometric analysis (Öztürk et al., 2024) alongside the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency and rigor in the selection of literature (Shamseer et al., 2015; Page et al., 2022). The study selection process comprised the four main PRISMA stages: identification, screening, eligibility, and inclusion (Liberati et al., 2009; Hiebl, 2023). An R-based workflow was used to implement these stages via automated data cleaning, de-duplication, keyword filtering, and title/abstract screening, resulting in a final dataset of 62 relevant articles.

In the first phase, clear research questions (RQs) were defined a priority to guide the review scope and design. The RQs were formulated based on identified gaps in the ISO 14001 and carbon management literature, the growing emphasis on carbon neutrality and zero-carbon strategies, and the need to link EMS practices with broader sustainability frameworks including the SDGs. The study addressed the following research questions:

RQ1: Which ISO 14001-related carbon management practices have been adopted by organizations and documented in the literature?

RQ2: How is the integration of ISO 14001 with carbon neutrality and zero-carbon strategies implemented, and what are its links to established environmental management frameworks and the SDGs?

RQ3: How is the effectiveness of ISO 14001 implementation in achieving carbon-reduction and sustainability goals evaluated in the existing literature, and what implications does this have for policy, corporate decision-making, and future research?

Using the predefined research questions as a foundational guide, a comprehensive search was conducted in late 2025 to capture relevant literature published between January 2015 and November 2025. The data collection strategy relied exclusively on the Scopus database to construct the foundational literature pool. The selection of Scopus as the singular primary database is rigorously justified by its extensive interdisciplinary coverage and superior geographical representation. Bibliometric evaluations confirm that Scopus indexes approximately 27,000 to 28,000 active peer-reviewed journals, which represents roughly a 25% to 30% greater volume of active journal coverage compared to alternatives such as the Web of Science Core Collection. Furthermore, approximately 99.11% of the journals indexed in Web of Science are also included in Scopus (Singh et al., 2021). Because research pertaining to the ISO 14001 standard spans highly diverse disciplines encompassing environmental sciences, operations management, industrial engineering, corporate governance, and ecological economics the broader disciplinary footprint of Scopus is essential. Furthermore, Scopus demonstrates significantly stronger indexing of non-English literature and research originating from emerging economies such as localized studies in Chinese or Japanese, which is critical for capturing a truly global perspective on the implementation of an international standard like ISO 14001.

To ensure a high degree of precision and recall in the literature retrieval process, a rigorous search string was engineered utilizing advanced Boolean logic combined with specific proximity operators tailored for the Scopus database architecture (MacFarlane et al., 2022). Recognizing that standard Boolean operators can inadvertently capture false positives when querying complex interdisciplinary domains such as finding the word "carbon" and "management" in entirely unrelated sentences within a single abstract the study employed Scopus-specific proximity operators to enforce semantic relevance. Specifically, the operator’s W/2 (within two words) and W/3 (within three words) were integrated into the search syntax. The W/n operator mandates that the connected terms must appear within the specified numerical distance from one another, regardless of their sequential order. For instance, deploying a nested proximity query such as (carbon OR CO2 OR GHG) W/3 (neutrality OR mitigation OR reduction) ensures the retrieval of tightly coupled phrases like "reduction of corporate carbon" or "carbon neutrality," while excluding documents where the terms are disjointed. Furthermore, the search string design strictly adhered to Scopus operator precedence rules, utilizing nested parentheses to dictate the logical order of operations, ensuring that the proximity requirements (W/2, W/3) were processed prior to the broader Boolean linkages. This optimized lexical search strategy significantly refined the initial corpus, effectively eliminating tangential literature and ensuring that the retrieved documents possessed a highly concentrated focus on the intersection of formalized ISO 14001 and carbon neutrality. Specifically, the search required documents to address “ISO 14001” and at least one carbon-related concept such as *carbon*, *CO_2*, *carbon neutrality*, carbon negative, *net-zero*, *environmental sustainability*, *circular economy* in their title, abstract, or keywords, using the AND operator for linkage and OR for synonymous terms. Figure 1 presents the PRISMA flow diagram of the literature identification and screening process, including the search strategy and results. The initial Scopus query yielded a total of 1,167 documents.

It is imperative to acknowledge a methodological boundary condition regarding the construction of this initial search string. By explicitly anchoring the primary search parameter to the specific term "ISO 14001," this study intentionally prioritized literature directly evaluating the certifiable standard itself. However, this high-specificity approach inherently introduces a limitation regarding search sensitivity. A substantial body of relevant academic literature discussing the broader implications of these frameworks utilizes more encompassing terminology, such as the "*ISO 14000 series*," generic "*environmental management systems*" (EMS), or "*management system standards* such as EU Ecolabel, Eco-Management and Audit Scheme (EMAS)." Consequently, by omitting these broader umbrella terms, the present systematic review may not capture the absolute entirety of the decarbonization discourse, inadvertently excluding highly relevant studies published in leading Scopus-indexed journals. The final corpus of 62 highly relevant articles must therefore be interpreted as a focused, highly specific subset of the literature that explicitly names the ISO 14001 standard in conjunction with carbon neutrality, rather than an exhaustive census of all EMS-related climate mitigation scholarship. Future bibliometric expansions in this domain should broaden the search syntax to include generic EMS terminology to capture the macro-level sustainability strategies that transcend the specific nomenclature of the ISO 14001 certification.

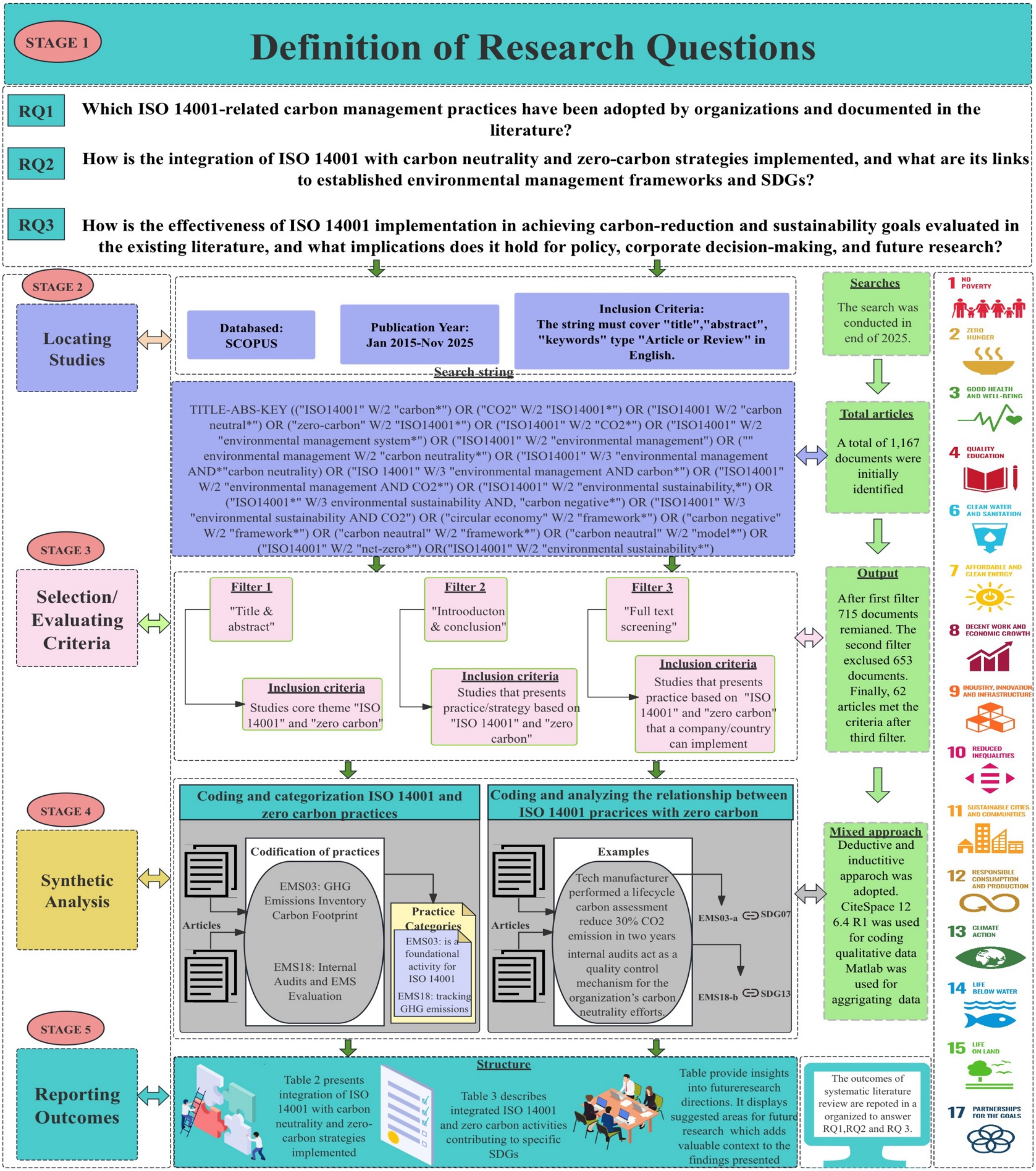
STAGE 1
Definition of Research Questions
RQ1
Which ISO 14001-related carbon management practices have been adopted by organizations and documented in the literature?
RQ2
How is the integration of ISO 14001 with carbon neutrality and zero-carbon strategies implemented, and what are its links to established environmental management frameworks and SDGs?
RQ3
How is the effectiveness of ISO 14001 implementation in achieving carbon-reduction and sustainability goals evaluated in the existing literature, and what implications does it hold for policy, corporate decision-making, and future research?
STAGE 2
Locating Studies
Databased: SCOPUS
Publication Year: Jan 2015-Nov 2025
Inclusion Criteria: The string must cover "title","abstract", "keywords" type "Article or Review" in English.
Searches
The search was conducted in end of 2025.
Search string
TITLE-ABS-KEY (("ISO14001" W/2 "carbon*") OR ("CO2" W/2 "ISO14001*") OR ("ISO14001 W/2 "carbon neutral*") OR ("zero-carbon" W/2 "ISO14001*") OR ("ISO14001" W/2 "CO2*") OR ("ISO14001" W/2 "environmental management system*") OR ("ISO14001" W/2 "environmental management") OR ("" environmental management W/2 "carbon neutrality*") OR ("ISO14001" W/3 "environmental management AND*"carbon neutrality) OR ("ISO 14001" W/3 "environmental management AND carbon*") OR ("ISO14001" W/2 "environmental management AND CO2*") OR ("ISO14001" W/2 "environmental sustainability,*") OR ("ISO14001*" W/3 environmental sustainability AND, "carbon negative*") OR ("ISO14001" W/3 "environmental sustainability AND CO2") OR ("circular economy" W/2 "framework*") OR ("carbon negative" W/2 "framework*") OR ("carbon neutral" W/2 "framework*") OR ("carbon neutral" W/2 "model*") OR ("ISO14001" W/2 "net-zero*") OR("ISO14001" W/2 "environmental sustainability*")
Total articles
A total of 1,167 documents were initially identified
STAGE 3
Selection/ Evaluating Criteria
Filter 1
"Title & abstract"
Inclusion criteria
Studies core theme "ISO 14001" and "zero carbon"
Filter 2
"Introoducton & conclusion"
Inclusion criteria
Studies that presents practice/strategy based on "ISO 14001" and "zero carbon"
Filter 3
"Full text screening"
Inclusion criteria
Studies that presents practice based on "ISO 14001" and "zero carbon" that a company/country can implement
Output
After first filter 715 documents remianed. The second filter exclused 653 documents. Finally, 62 articles met the criteria after third filter.
STAGE 4
Synthetic Analysis
Coding and categorization ISO 14001 and zero carbon practices
Articles
Codification of practices
EMS03: GHG Emissions Inventory Carbon Footprint
EMS18: Internal Audits and EMS Evaluation
Practice Categories
EMS03: is a foundational activity for ISO 14001
EMS18: tracking GHG emissions
Coding and analyzing the relationship between ISO 14001 pracrices with zero carbon
Articles
Examples
Tech manufacturer performed a lifecycle carbon assessment reduce 30% CO2 emission in two years
internal audits act as a quality control mechanism for the organization's carbon neutrality efforts.
EMS03-a SDG07
EMS18-b SDG13
Mixed approach
Deductive and inductitive apparoch was adopted. CiteSpace 12 6.4 R1 was used for coding qualitative data Matlab was used for aggrigating data
STAGE 5
Reporting Outcomes
Structure
Table 2 presents integration of ISO 14001 with carbon neutrality and zero-carbon strategies implemented
Table 3 describes integrated ISO 14001 and zero carbon activities contributing to specific SDGs
Table provide insights into futureresearch directions. It displays suggested areas for future research which adds valuable context to the findings presented
The outcomes of systematic literature review are repoted in a organized to answer RQ1,RQ2 and RQ 3.
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
17 PARTNERSHIPS FOR THE GOALS

Figure 1: PRISMA methodological framework of ISO 14001 and carbon neauratlity (2015-2025).

Moreover, subsequent screening and filtering steps were performed following PRISMA guidelines. In the screening phase, inclusion and exclusion criteria were applied to focus on studies whose core content was directly relevant to ISO 14001 and zero-carbon or carbon management topics. Duplicate records were detected and removed based on DOI and title matches using R scripts to ensure data integrity. Next, a keyword-based filtering was conducted: studies with titles or abstracts containing at least two predetermined keywords linking ISO 14001 with carbon neutrality concepts were retained, reducing the set to 715 articles. In the eligibility phase, the remaining articles underwent full-text assessment to confirm their relevance, ensuring that each study substantially addressed ISO 14001 within the context of an EMS and carbon or climate-related initiatives. After this multi-level filtering process, 62 articles met all criteria and were included in the final review dataset.

In the final phase, these 62 articles were analyzed qualitatively to extract and categorize ISO 14001-related practices relevant to carbon management and zero-carbon objectives (Macura et al., 2019; Ferenhof et al., 2014). A hybrid coding approach was used: deductive coding guided by preset EMS activity categories drawn from the ISO 14001 standard, and inductive coding to capture emergent practices and insights beyond the initial framework. This approach aligns with recent systematic reviews that utilize standards-based frameworks to structure and summarize EMS research (Todaro et al., 2020). The synthesized findings were then organized to address the research questions directly. In particular, the results were structured to illustrate (i) how ISO 14001 implementation practices integrate with carbon neutrality and zero-carbon goals, addressing RQ1 and RQ2, and (ii) how specific ISO 14001-associated practices align with and facilitate progress toward various SDGs, as well as to identify implications and future research needs, addressing RQ3. This structured presentation ensures that the outcomes are clearly aligned with the objectives of the review.

To enhance the transparency of the analytical synthesis, the qualitative review proceeded in three interpretive stages. In the first stage, each article was deductively coded against the EMS activities and sub-activities derived from ISO 14001, which produced the activity architecture. In the second stage, the coded material was re-examined inductively to identify cross-cutting explanatory patterns that were not exhausted by the clause-based structure of the standard. The recurrent patterns were implementation depth, symbolic certification, substantive embedding of carbon objectives, dependence on complementary carbon-accounting tools, contextual moderators such as firm size and regulatory pressure, and heterogeneity in observed carbon outcomes. In the third stage, these first-order patterns were theoretically aggregated into higher-order categories linking antecedent conditions, translation mechanisms, operational enactment, and evaluative outcomes. This final synthesis generated the manuscript's primary contribution, namely the explanation of why ISO 14001 certification does not always translate into substantive decarbonization, and the ADTF was developed subsequently as a supporting integrative representation of that mechanism. Accordingly, the ADTF illustrates as a mixed deductive-inductive synthesis: deductively anchored in the EMS framework of ISO 14001 but inductively shaped by recurrent empirical patterns identified across the reviewed studies.

2.2 Data Analysis Tools

Multiple software tools were utilized to support data analysis and visualization. Bibliographic data from Scopus was managed and preprocessed in R by using RStudio, including tasks such as duplicate removal and preliminary keyword frequency analysis. CiteSpace (version

12.6.4 R1) was employed to visualize bibliometric networks such asco-citation, co-occurrence maps, and to assist in organizing the qualitative coding of ISO 14001 practices and their linkages to zero-carbon objectives. MATLAB was used to aggregate and quantitatively synthesize the coded results, facilitating structured analysis and the generation of charts/graphs from the review findings (Hu et al., 2024). These tools in combination enabled a holistic analysis: the bibliometric component mapped the big picture of ISO 14001 research, while the systematic review provided in-depth insights into content and context.

3. Results

3.1 Bibliometric Analysis Results

3.1.1 Leading Journals in ISO 14001 Research

Table 1 lists the top ten academic journals that published research on ISO 14001 and carbon management topics during 2015-2025, along with their total citation counts. The Journal of Cleaner Production ranks first with 7,475 citations, demonstaring its prominence as a venue for high-impact research at the nexus of environmental management and sustainability. Business Strategy and the Environment is the second most-cited journal in this domain with 3,258 citations, followed by Sustainability (Switzerland), Sustainable Production and Consumption, and Science of the Total Environment. Collectively, these sustainability-oriented journals account for a significant portion of citations in the field, indicating that ISO 14001 and carbon neutrality research is concentrated in a handful of influential outlets. This distribution also highlights the cross-disciplinary nature of the topic, spanning environmental science, corporate sustainability, and management disciplines. The share of top 10 scientific journals by total citations (2015-2025) in the ISO 14001 and zero-carbon research domain is presented in Figure 2.

Table 1: Top 10 most cited journals (2015-2025) in ISO 14001 and zero-carbon research

Rank	Journal	Total Citations
1	Journal of Cleaner Production	7,675 approx.
2	Business Strategy and the Environment	3,258 approx.
3	Sustainability (Switzerland)	2,064 approx
4	Sustainable Production and Consumption	1,490 approx
5	Science of the Total Environment	1,450 approx
6	Journal of Environmental Management	1,432 approx
7	Corporate Social Responsibility and Environmental Management	1,244 approx
8	Journal of Business Ethics	1,236 approx
9	International Journal of Operations and Production Management	910 approx
10	Environmental Science and Pollution Research	706 approx

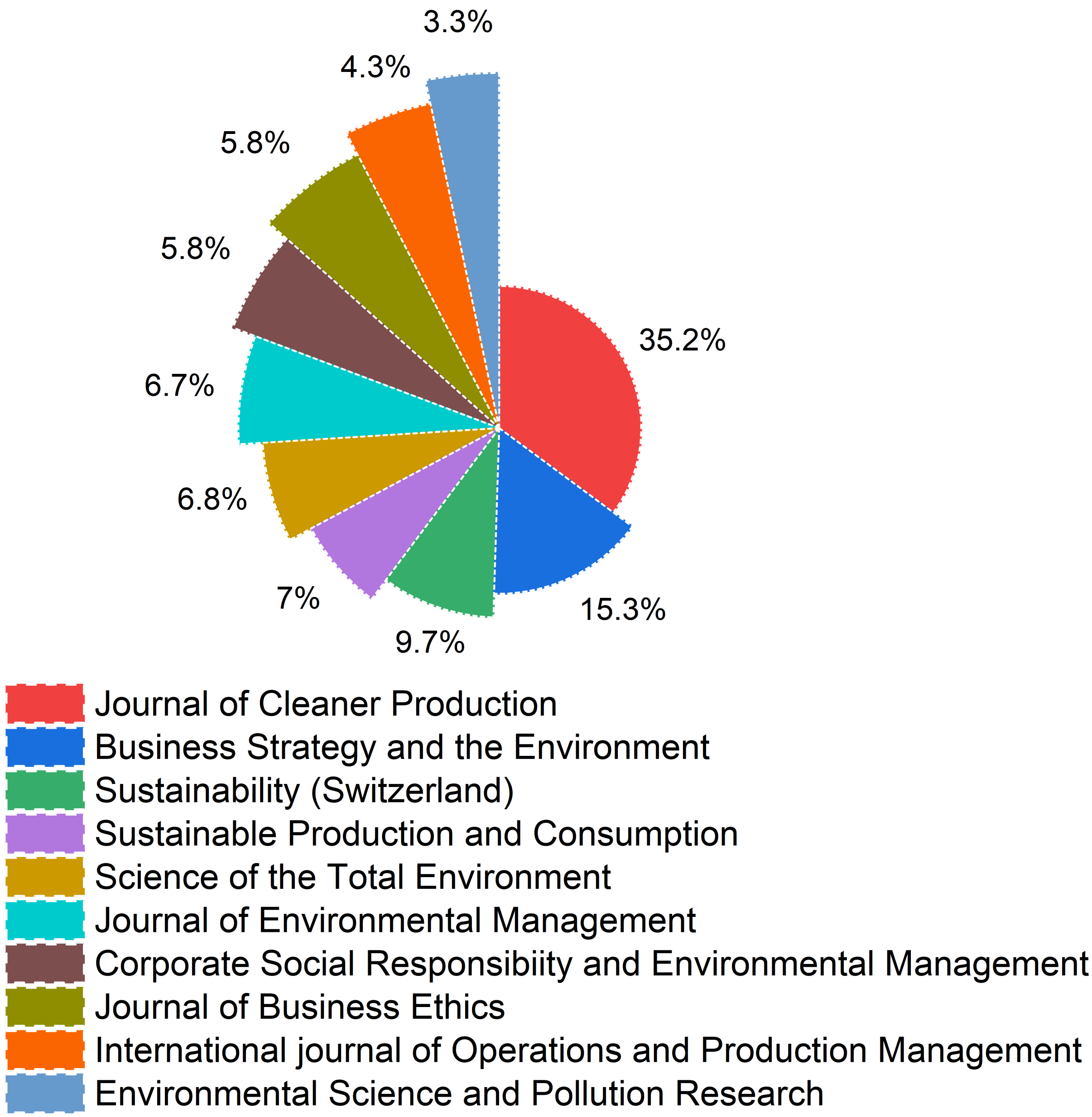

Figure 2: Top scientific journals share by total citations (2015-2025) in the ISO 14001 and zero-carbon research domain

3.1.2 Research Thematic Areas and Clusters

The bibliometric analysis identified several major thematic clusters of research within the ISO 14001 literature. A science mapping of co-citation and keyword networks revealed 11 distinct thematic areas, of which four were especially prominent are presented in Figure 3:

Voluntary Environmental Programs (Cluster #0): This is the largest research theme, indicating that ISO 14001 is often studied in the context of voluntary corporate environmental initiatives. As the central cluster, it characterizes ISO 14001 as a self-regulatory governance tool, with firms proactively adopting EMS standards to signal commitment to environmental improvement beyond legal requirements. This cluster forms the conceptual core that many other research themes build upon.

*Environmental Performance (Cluster #1):*The second major theme emphasizes empirical evaluation of environmental outcomes. A substantial portion of ISO 14001 studies focuses on measuring the standard's impact on organizations' environmental performance such as reductions in pollution, emissions, or resource use. This outcome-oriented cluster affirms that performance improvement is a primary lens through which ISO 14001's effectiveness is assessed in the literature. Environmental performance appears tightly connected to the core cluster, reflecting its importance as both a motivator and result of EMS adoption.

Energy Management (Cluster #2): A third prominent theme extends the discussion to operational energy use and efficiency. Research in this cluster examines how implementing ISO 14001 can drive improvements in energy management, often linking EMS adoption with efforts to reduce greenhouse gas emissions through better energy efficiency or the adoption of renewable energy. This theme represents an operational dimension of ISO 14001's contribution to carbon neutrality, bridging the EMS literature with energy and climate management topics.

Integrated Management Systems (Cluster #3): The fourth major thematic area involves the integration of ISO 14001 with other management systems and standards such as ISO 9001 for quality management, ISO 45001 for occupational health and safety, or broader sustainability management frameworks. Studies in this cluster explore how organizations implement multiple standards simultaneously or unify them under an integrated management system, and how this integration can enhance overall effectiveness. The presence of this cluster suggests a maturation of the field toward a systems-level view, where ISO 14001 is part of a cohesive strategy for sustainability and not an isolated initiative.

Beyond these top clusters, the bibliometric mapping indicated up to 11 thematic areas in total, revealing a diverse and mature research landscape. Specialized topics in smaller clusters include, for example, environmental risk assessment, media attention to ISO 14001, and heterogeneous treatment effects of certification. The existence of these niche themes, alongside the major clusters, suggests that ISO 14001 scholarship has branched out to address both broad governance questions and specific technical or contextual issues.

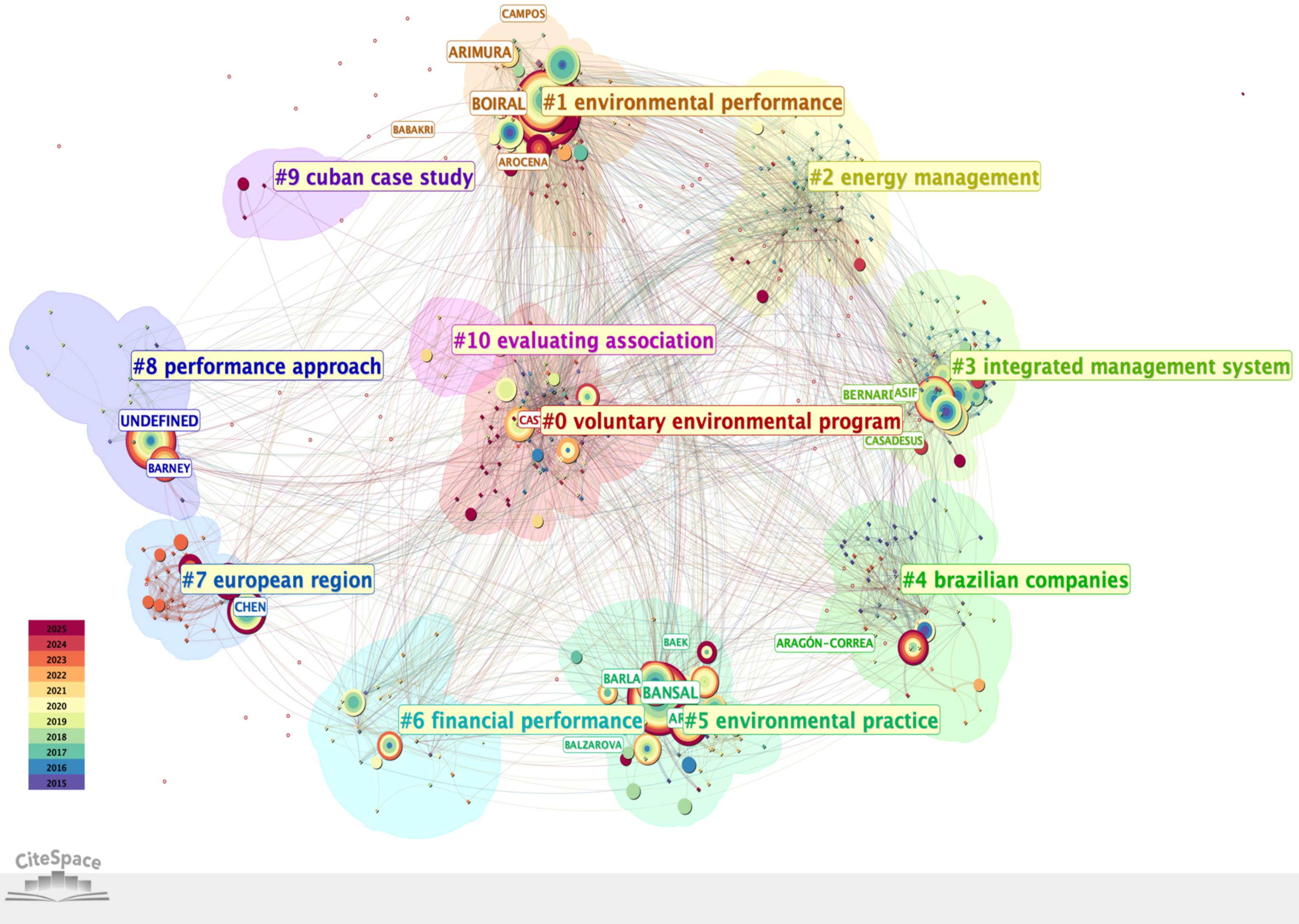

Figure 3: Top 10 research thematic areas in the ISO 14001literature (2015-2025)

3.1.3 Global Research Topics and Knowledge Structure

Figure 4 depicts the mapping of global research topics identified approximately 29 significant research topics or keywords recurring in ISO 14001 publications. The network of co-occurring keywords highlights the field's knowledge structure. Not surprisingly, the most prominent topics align with the thematic clusters described above. "*Environmental performance*" (Topic #0) and "*environmental management systems*" (Topic #1) emerge as the most central nodes in the network, indicating that evaluating the outcomes of ISO 14001 implementation and studying

EMS frameworks themselves are at the heart of contemporary research. Closely linked to these core topics are terms like “integrated management systems”, which corresponds to integrating ISO 14001 with other standards, as noted in Cluster #3 and “*green performance*” which relates to broader sustainability or “*green*” performance outcomes. The prominence of these suggests a growing interest in how ISO 14001 works in concert with other management initiatives and how it contributes to overall sustainability performance beyond compliance. In addition, a variety of more specialized research topics are evident at the periphery of the network, reflecting the field’s expanding scope. The concepts such as “media attention”, “*environmental risk assessment*”, and “*heterogeneous effects*” which refer to how ISO 14001’s impacts may differ across contexts or firms, illustrate that researchers are applying diverse methodologies and perspectives. The presence of these topics, which often involve advanced analytical approaches, indicates increasing methodological sophistication in recent ISO 14001 studies. The topic co-occurrence network demonstrates that the literature has evolved from focusing on the basic adoption and outcomes of ISO 14001 to tackling a wide array of questions, including strategic integration, communication aspects, and lacking performance analyses.

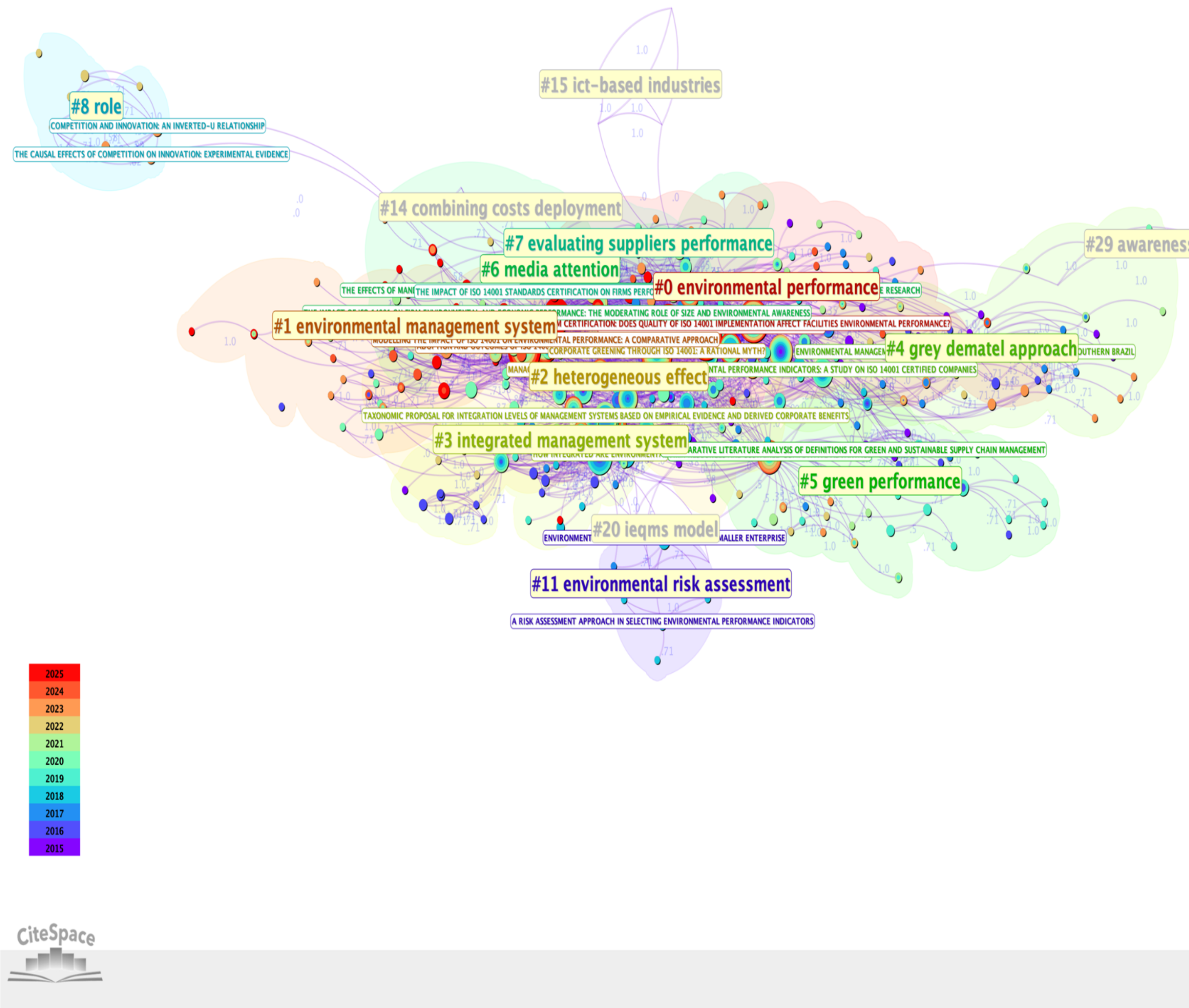

Figure 4: The main global research topics in the ISO 14001 literature

3.1.4 Geographical Distribution of Research

Figure 5 depicts the geographical distribution of ISO 14001 research. It demonstrates that area of study is widespread globally, yet certain countries dominate output and collaboration networks. The bibliometric data reveal a highly internationalized but somewhat uneven landscape. A core group of countries accounts for a large share of publications and citations: notably, Spain, United Kingdom, China, Italy, Brazil, Malaysia, United States, Poland, and Japan emerge as the most prolific contributors to ISO 14001 research in the past decade. These countries often serve as hubs in international co-authorship networks, indicating active collaboration and knowledge exchange among their researchers.

Meanwhile, several emerging or transitional economies appear on the periphery of the collaboration network. However, Morocco, Tunisia, Pakistan, Egypt, Iran, and Croatia show a growing volume of ISO 14001related studies, though their total output remains modest compared to the leading countries. The presence of these countries signals an expanding interest in ISO 14001's applicability in diverse economic and regional contexts, including Africa, the Middle East, and Eastern Europe. The network visualization in Figure 5 also suggests that cross-country linkages are increasing, as evidenced by co-authored publications spanning multiple countries. This trend points to greater international cooperation in examining ISO 14001, which can help in sharing best practices and understanding context-specific challenges. However, the overall structure is still somewhat fragmented, meaning that research communities tend to form clusters around regional or linguistic lines. Bridging these clusters through more global collaborations could further enrich the field.

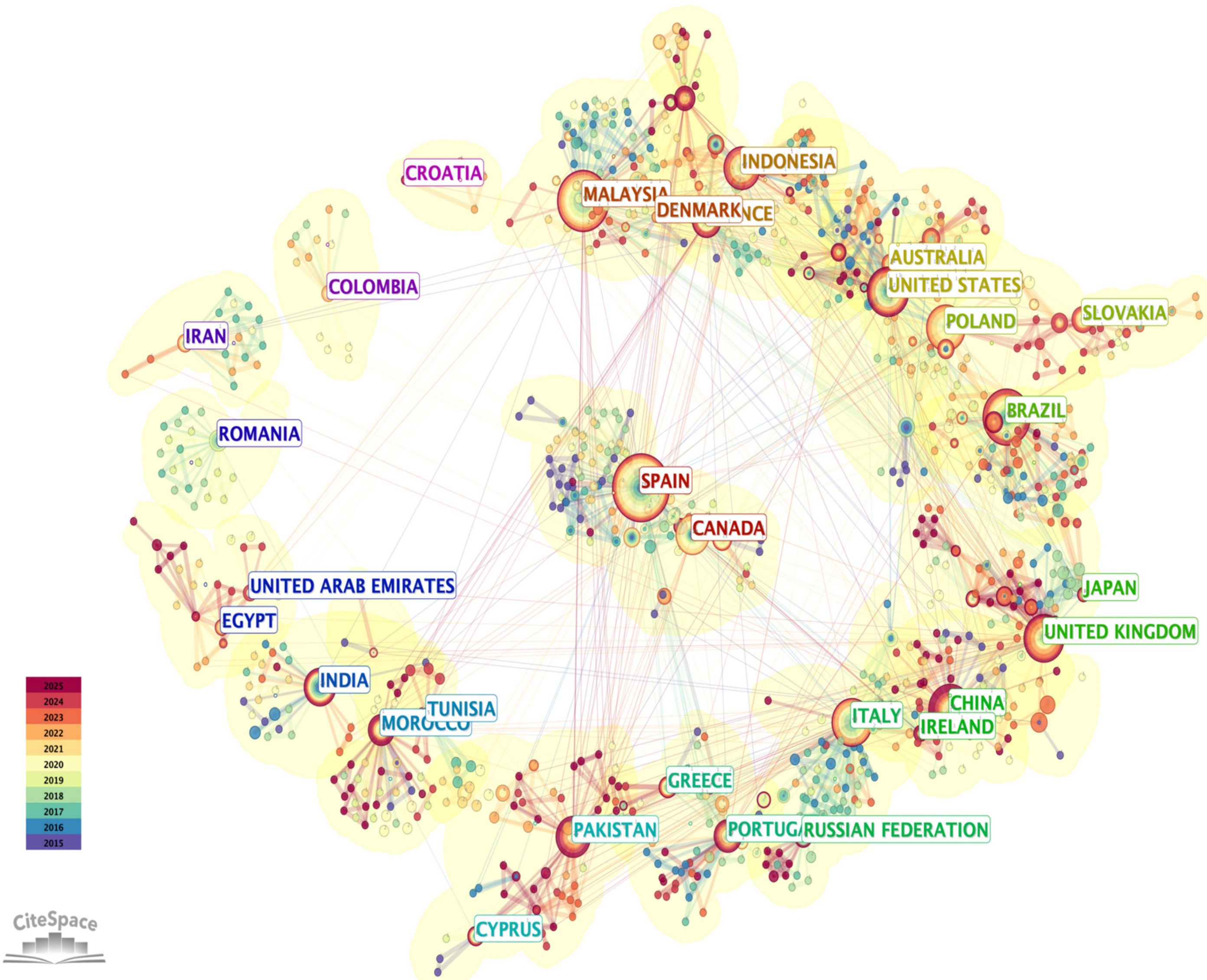

Figure 5: Geographical distribution of ISO 14001 research (2015-2025)

3.1.5 Keyword Co-Occurrence Network

The keyword co-occurrence network presented in Figure 6, which provides another perspective on the intellectual structure of ISO 14001 research by illustrating how frequently key terms appear together in publications. This network illustrates the evolution of ISO 14001 research from fundamental subjects to increasingly complex iintegrated issues. At the center of the network are foundational keywords reflecting the standard and its primary focus: terms such as "*ISO 14001*", "*environmental performance*", "*environmental sustainability*", and "*environmental management system*" form the core, indicating that these concepts are central across many studies. The strong co-occurrence of "ISO 14001" with "*environmental performance*," in particular, highlights the persistent focus on performance outcomes of certification.

Extending from this core, clusters of keywords emerge that link ISO 14001 to more extensive themes. Terms such as "*corporate social responsibility*" and "*stakeholders*" illustrate the connection to social and governance dimensions, suggesting that certain research examines ISO 14001 in relation to corporate responsibility and stakeholder engagement. Moreover keywords such as "*risk assessment*" and "*governance*" suggest an emphasis on management and decision-making processes introduced by EMS adoption.

Notably, several keywords relate directly to climate change and emissions management. "*CO_2 emissions*", "*GHG (greenhouse gas) emissions*", "*energy efficiency*", and "*circular economy*" are all present and closely connected in the network, confirming that many ISO 14001 studies incorporate carbon management and resource efficiency topics. These terms indicate that ISO 14001 is often examined in relation to tangible environmental impact metrics and broader sustainability initiatives. Economic and operational implications of ISO 14001 are also evident: keywords such as "*firm value*", "*economic performance*", "*manufacturing firms*" point to investigations into how EMS adoption affects financial and operational performance.

Furthermore, the keyword network portrays ISO 14001 research as a rich and interdisciplinary field. Early discussions centered simply on the standard itself and basic compliance have given way to comprehensive assessments that connect EMS implementation to environmental outcomes, business value, and global sustainability transitions. The co-occurrence patterns affirm that ISO 14001 is being studied not in isolation, but as part of a web of concepts including climate change mitigation, corporate strategy, and socio-economic considerations.

The patterns observed within the bibliometric and keyword co-occurrence networks extend far beyond a mere descriptive mapping of the literature; they provide crucial analytical insights into the maturation, trajectory, and strategic repositioning of global environmental governance. A critical analysis of the thematic clusters reveals a distinct temporal and conceptual shift in how the academic community and the corporate sector conceptualize standardized management systems. The evolution from foundational keywords associated purely with localized compliance such as "environmental management system," "environmental performance," "pollution control", toward highly strategic, boundary-spanning concepts like "circular economy," "GHG emissions," "corporate social responsibility," and "industry 4.0" which reflects a fundamental paradigm shift.

This thematic trajectory demonstrates that ISO 14001 is no longer viewed solely as an isolated, operational tool for facility-level waste reduction. Instead, the literature increasingly positions the standard as an integrative, macro-level governance mechanism essential for navigating complex global challenges and facilitating structural transformations toward low-carbon economies.

Furthermore, the geographic clustering of research output provides profound insights into the institutional drivers of environmental management. The concentration of high-impact research within specific high-income and rapidly industrializing economies notably the United Kingdom, Spain, Italy, and China analytically mirror the distribution of global regulatory pressures, carbon pricing mechanisms, and institutional capacity. According to institutional theory, organizations adopt voluntary standards in response to coercive, mimetic, and normative pressures. The bibliometric prominence of these nations suggests that robust national climate policies, stringent emissions trading schemes such as the EU ETS, and high societal environmental awareness serve as critical catalysts that elevate ISO 14001 from a voluntary signaling tool to a mandatory baseline for market participation. Conversely, the emerging presence of research from developing economies indicates a gradual diffusion of these institutional pressures through global supply chains, where multinational corporations increasingly mandate ISO 14001 certification from their suppliers in the Global South to manage Scope 3 emissions. Ultimately, these bibliometric trends confirm that as international climate mandates become more rigorous, scholarly investigation intrinsically pivots toward understanding how existing management architectures can be structurally optimized to deliver absolute, rather than relative, systemic sustainability outcomes.

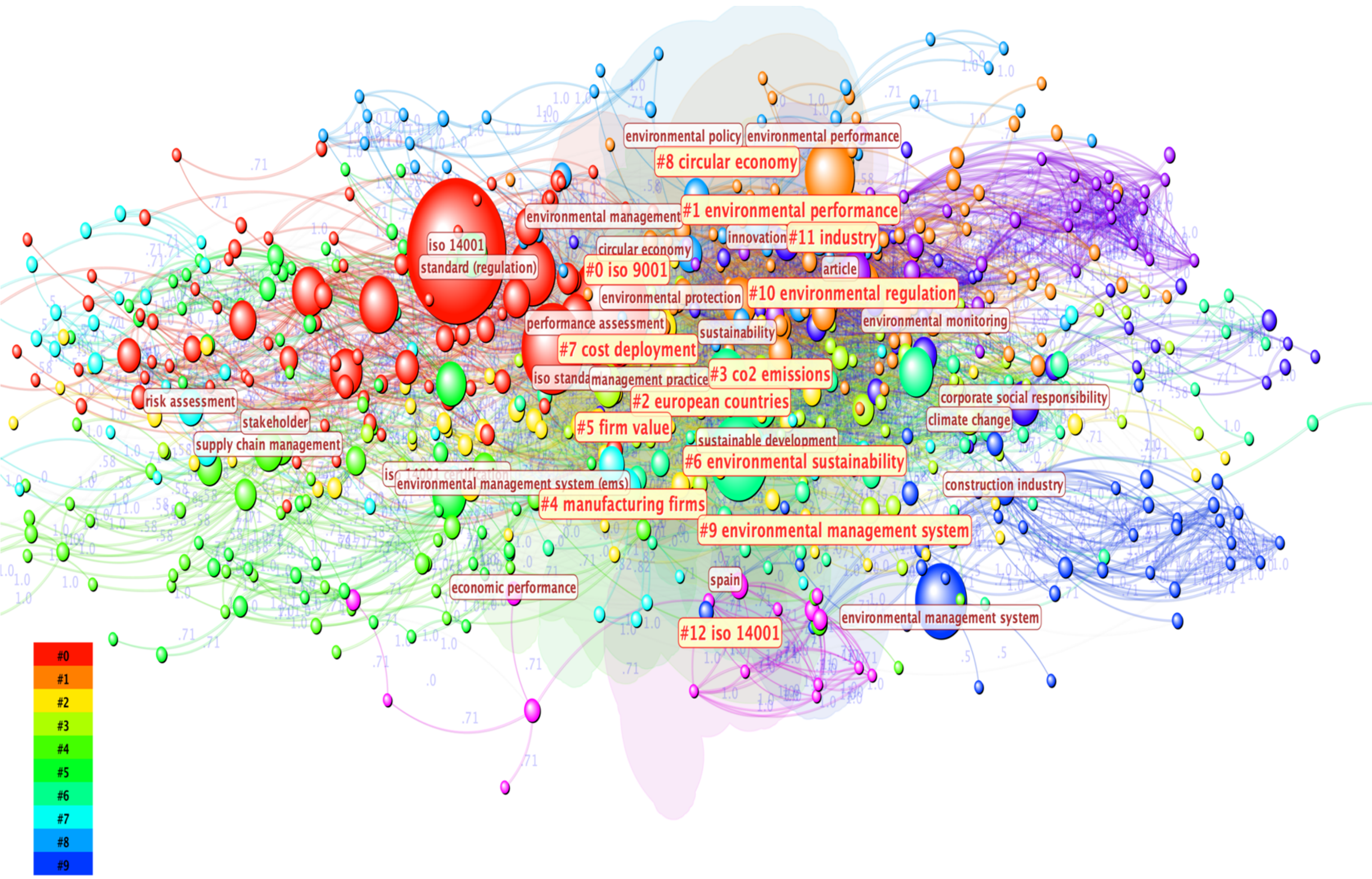

Figure 6: The keyword co-occurrence network of ISO 14001 research

3.2 Systematic Literature Review Results

3.2.1 ISO 14001 Implementation and Alignment with SDGs

To address RQ1 and RQ2, the systematic review examined how ISO 14001-based EMS practices are implemented for carbon management and how these practices align with specific sustainability goals, particularly the SDGs. Table 2 presents a matrix that maps the key ISO 14001 activities and sub-activities identified in the literature to the SDGs they support. The matrix shows a clear pattern over time and in terms of hierarchy in how EMS activities help distinct sustainability goals.

Not all EMS initiatives yield immediate outcomes; some provide short- to medium-term benefits while others are geared towards long-term impact. In the short to medium term, practical EMS activities that are relatively quick to implement tend to drive improvements aligned with operational sustainability goals. Moreover activities such as conducting thorough environmental risk assessments, developing greenhouse gas (GHG) emission inventories, setting carbon reduction targets, continuous monitoring of environmental performance, and performing internal audits all help organizations achieve more immediate progress toward goals like SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production). These EMS practices are linked to tangible decarbonization and efficiency gains in the near term - for instance, by reducing energy consumption or waste generation - thereby contributing to cleaner production processes and better resource management. Although these processes can be time-consuming to establish, once in place they produce measurable improvements in operational sustainability metrics.

Coversely, more transformative, long-term EMS initiatives are required to achieve significant progress towards cbroad climate objectives. This study illustrates activities such as the adoption of renewable energy technologies, implementation of low-carbon process innovations, redesign of logistics for sustainability, and development of circular economy practices are typically categorized as long-term actions. These measures are linked primarily to SDG 13 (Climate Action) - and to some extent to SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities), because they aim for significant decarbonization and systemic change. Table 2 shows that realizing the full benefits of such initiatives often depends on continuous investment, technological advancement, and extensive supply chain or stakeholder collaboration over time. In other words, while ISO 14001 provides the framework to embark on these initiatives, the actual emission reduction outcomes from, say, a new renewable energy project or a circular production model accrue gradually and may only become significant in the long run. Moreover, the ISO 14001& EMS framework ensures that climate action (SDG 13) is embedded across all phases of environmental management from initial policy and planning through operational control and periodic review. The formulation of an environmental policy that expressly incorporates climate commitments, an EMS planning activity that integrates SDG 13 into the organization's strategy. Similarly, incorporating climate-related risk assessment in the context analysis phase, or integrating carbon criteria into operational controls and performance evaluations, means that SDG 13 is continually addressed as the EMS matures. In effect, ISO 14001 acts as an institutional mechanism to ingrain long-term climate considerations into everyday organizational processes and culture (Fonseca & Carvalho, 2019; Mosgaard and Kristensen, 2023; Bravi et al., 2020).

Conversely, SDG 7 and SDG 12 which deal with clean energy and sustainable production/consumption function as more immediate operational gateways for ISO 14001 to deliver decarbonization results (Cestau-Oyhantçabal and Arocena, 2025; Zimon et al., 2022; De Oliveira et al., 2016). The EMS-driven improvements in energy efficiency, waste reduction, and pollution prevention directly support these goals, often yielding measurable outcomes within a short to mid-term horizon such as reduced kilowatt-hour usage, lower waste volumes, decreased emissions intensity. The significance of SDG 7 and SDG 12 in the matrix reflects the fact that firms have direct managerial control in these areas and can implement changes such as upgrading equipment or optimizing processes that facilitates progress toward energy savings or cleaner production metrics.

The systematic review finds that ISO 14001 serves as a meta-management framework that helps translate broad climate and sustainability goals into structured, phased actions within organizations. Table 2 encapsulates this by linking EMS components to SDGs in a hierarchical, temporal fashion: SDG 13 (Climate Action) is addressed throughout all EMS stages (strategic, operational, evaluative), ensuring that climate considerations are institutionalized; SDG 7 and SDG 12 are targeted by concrete operational measures yielding near-term benefits; and other SDGs such as those related to innovation, infrastructure, or partnerships, come into play as the EMS scope expands and deepens over time. This alignment illustrates that while ISO 14001 primarily focuses on environmental management at the organization level, it inherently supports and can be explicitly leveraged to advance global sustainability objective.

To comprehend how localized organizational environmental management practices scale to contribute to global sustainability agendas, it is essential to highlight the precise analytical logic linking specific ISO 14001 clauses to the SDGs. The mapping presented in this study is not merely correlational or anecdotal; it is firmly grounded in the mandatory structural requirements of the standard itself, which systematically and conceptually align with the precise targets defining the SDGs. The ISO 14001 framework operates on the PDCA continuous improvement cycle, which intrinsically mirrors the structural pathways required for sustainable development transitions (Ahmed et al., 2024).

The deep integration between ISO 14001 and SDG 13 (Climate Action) is fundamentally anchored in the strategic planning phases of the environmental management system. Specifically, Clauses 4.1 (Understanding the organization and its context) and 6.1 (Actions to address risks and opportunities) mandate that organizations formally evaluate both the physical risks such as extreme weather impacts on supply chains, and transitional risks such as carbon pricing, shifting consumer preferences associated with climate change (ISO, 2015). By systematically identifying and documenting these vulnerabilities, organizations directly satisfy the requirements of SDG Target 13.1, which focuses on strengthening institutional resilience and adaptive capacity to climate-related hazards. Furthermore, when organizations utilize the ISO 14001 leadership requirements (Clause 5) to formulate public net-zero commitments and integrate climate variables into their core corporate strategies, they are actively operationalizing SDG Target 13.2 (integrating climate measures into policies and planning) at the enterprise level. The standard transforms abstract climate goals into auditable, board-level responsibilities, preventing climate action from remaining marginalized as a peripheral corporate social responsibility (CSR) initiative.

Similarly, the theoretical rationale linking ISO 14001 to SDG 7 (Affordable and Clean Energy) is driven by the standard's requirement to manage significant environmental aspects (Clause 6.1.2) and to establish measurable environmental objectives (Clause 6.2). Because energy consumption is universally identified by industrial and service organizations alike as a primary, highly controllable environmental aspect, organizations utilize the EMS architecture to execute rigorous energy audits, upgrade facility infrastructure, and transition to renewable energy matrices. This structured approach to optimizing energy performance provides the operational accountability required to advance the global transition toward sustainable energy systems. By applying the PDCA cycle to energy inputs, organizations systematically reduce the carbon intensity of their operations, directly supporting the SDG 7 targets of doubling the global rate of improvement in energy efficiency and substantially increasing the share of renewable energy in the global energy mix.

Furthermore, the robust alignment with SDG 12 (Responsible Consumption and Production) is predominantly facilitated by the "lifecycle perspective" introduced in the transformative 2015 revision of ISO 14001 (particularly Clause 8.1, Operational planning and control). Prior to 2015, environmental management often stopped at the factory gate. The revised clause fundamentally shifted this paradigm, compelling organizations to consider and mitigate the environmental impacts of their products and services across the entire value chain from raw material acquisition and design, through manufacturing and distribution, to end-of-life treatment and disposal. By mandating green procurement protocols, substituting hazardous materials, engineering products for extended durability, and redesigning processes to favor circular economy principles, the ISO 14001 directly supports the core tenets of SDG 12 (Oliveira, 2025). This operationalization directly targets SDG indicators aimed at achieving the sustainable management and efficient use of natural resources, as well as substantially reducing overall waste generation through prevention, reduction, recycling, and reuse strategies. Thus, ISO 14001 provides the rigorous, standardized operational mechanism necessary to translate the aspirational macroeconomic targets of the SDGs into tangible, localized corporate realities.

The alignment between ISO 14001 and the 17 UN SDGs systematically maps in Appendix T1, illustrating that its contribution extends far beyond a narrow environmental compliance framework. The evidence demonstrates that ISO 14001 operates as an integrated management framework that simultaneously advances environmental protection, economic efficiency, and social inclusiveness. Across the SDGs, the standard supports resource optimization, pollution reduction, and climate mitigation, while also enabling broader developmental outcomes such as employment generation, improved public health, and equitable access to environmental resources. Importantly, the table 2 highlights how ISO 14001 embeds stakeholder-oriented governance practices, including participatory decision-making and inclusive engagement, thereby linking environmental management with distributive justice considerations. In this context, carbon neutrality emerges not as an isolated technical target, but as part of a wider systemic transformation driven by continuous improvement, lifecycle thinking, and risk-based management. These interconnections position ISO 14001 as a dynamic instrument that contributes to the holistic transition toward sustainable development by integrating environmental, economic, and social dimensions within a unified operational framework.

Table 2: Matrix linking ISO 14001 EMS activities to specific Sustainable Development Goals (SDGs)[1]

Main activities	Sub-activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Environmental Policy and Climate Commitment (EMS1)	Develop environmental vision and mission (EMS1-a)																	
	Commit to public carbon reduction goals (EMS1-b)																	
	Appoint leadership for EMS oversight (EMS1-c)																	
Context Analysis and Climate Risk Assessment (EMS2)	Conduct environmental risk assessments (EMS2-a)																	
	Map climate change scenarios (EMS2-b)																	
	Engage stakeholders on environmental risk (EMS2-c)																	
GHG Emissions Inventory Carbon Footprint (EMS3)	Identification of GHG Emission Sources Across Scopes (EMS3-a)																	
	Collection and Verification of Emission Data (EMS3-b)																	

[1] Strategic Roadmap of how ISO 14001 contributes to SDGs (✓Green block = short-term achievement; ✓blue block = medium-term achievement; ✓red block = long-term achievement).

	Calculation of Organizational Carbon Footprint (EMS3-c)																	
	Preparation and Disclosure of GHG Inventory Reports (EMS3-d)																	
Compliance with Carbon Regulations (EMS4)	Track environmental regulations (EMS4-a)																	
	Update EMS to reflect legal changes (EMS4-b)																	
	Conduct compliance audits (EMS4-c)																	
GHG Reduction Objectives and Targets (EMS5)	Setting Science-Aligned GHG Reduction Targets (EMS5-a)																	
	Embedding Carbon Goals in EMS Programs (EMS5-b)																	
	Reviewing and Updating GHG Objectives Regularly (EMS5-c)																	
Carbon Management Action Plan Implementation (EMS6)	Developing a Carbon Management Action Plan (EMS6-a)																	
	Assigning Roles and Resources for Implementation (EMS6-b)																	
	Integrating Carbon Actions into Operational Processes (EMS6-c)																	
	Monitoring Progress of Carbon Reduction Measures (EMS6-d)																	

Energy Efficiency and Renewable Energy Deployment (EMS7)	Conducting Energy Audits and Baseline Assessments (EMS7-a)																	
	Implementing Energy-Saving Technologies and Practices (EMS7-b)																	
	Integrating Renewable Energy into Operations (EMS7-c)																	
	Tracking and Optimizing Energy Performance Metrics (EMS7-d)																	
Water Conservation (EMS8)	Conducting Water Usage and Leak Detection Assessments (EMS8-a)																	
	Installing Water-Efficient Technologies (EMS8-b)																	
	Implementing Water Recycling and Reuse Systems (EMS8-c)																	
	Optimizing Operational Processes to Reduce Freshwater Demand (EMS8-d)																	
	Monitoring Water Performance (EMS8-e)																	
Sustainable Transportation and Logistics (EMS9)	Optimize transport routes and schedules (EMS9-a)																	
	Adopt electric or low-emission vehicles (EMS9-b)																	
	Track and reduce logistics emissions (EMS9-c)																	
Process Optimization	Redesign processes to minimize resource consumption (EMS10-a)																	

	Adopt cleaner production technologies (EMS10-b)																	
	Reduce emissions through process automation (EMS10-c)																	
Waste Management and Circular Economy (EMS11)	Implement waste segregation and recycling systems (EMS11-a)																	
	Promote material reuse and circular design (EMS11-b)																	
	Audit and reduce landfill disposal rates (EMS11-c)																	
Green Procurement and Supply Chain Engagement (EMS12)	Source materials from certified sustainable suppliers (EMS12-a)																	
	Green suppliers' selection (EMS12-b)																	
	Collaborate with suppliers on carbon reduction goals (EMS12-c)																	
Sustainable Product Design and Life Cycle (EMS13)	Design products for durability, reuse, and recyclability (EMS13-a)																	
	Conduct life cycle assessments to identify impacts (EMS13-b)																	
	Substitute hazardous materials with eco-friendly alternatives (EMS13-c)																	
Carbon Offsetting and	Purchase verified carbon credits for residual emissions (EMS14-a)																	

	Support reforestation or renewable energy offset projects (EMS14-b)																	
	Integrate offsetting strategy into EMS objectives and reporting (EMS14-c)																	
Employee Training and Awareness (EMS15)	Train on ISO 14001 standards (EMS15-a)																	
	Host carbon literacy sessions (EMS15-b)																	
	Include sustainability in onboarding (EMS15-c)																	
Stakeholder Engagement and Communicatio n (EMS16)	Identify and prioritize key environmental stakeholders (EMS16-a)																	
	Conduct regular consultations on EMS goals and impacts (EMS16-b)																	
Monitoring, Measurement and Reporting (EMS17)	Establish indicators for tracking environmental performance (EMS17-a)																	
	Collect and analyze data on key EMS objectives (EMS17-b)																	
	Report results internally and externally for transparency (EMS17-c)																	
Interna l Audits and EMS	Develop and implement an EMS internal audit schedule (EMS18-a)																	

	Evaluate compliance with ISO 14001 requirements (EMS18-b)																	
	Report audit findings and recommend improvements (EMS18-c)																	
Management Review and Strategic Alignment (EMS19)	Review EMS performance against objectives and KPIs (EMS19-a)																	
	Align environmental goals with organizational strategy (EMS19-b)																	
	Approve updates to EMS policies and action plans (EMS19-c)																	
Continual Improvement and Innovation (EMS20)	Identify opportunities for reducing environmental impacts (EMS20-a)																	
	Implement corrective and preventive EMS actions (EMS20-b)																	
	Foster innovation in sustainability practices (EMS20-c)																	
	Track improvement outcomes and update objectives (EMS20-d)																	

3.2.2 ISO 14001 EMS Activities Framework and Decarbonization

To address RQ1 in greater detail, the systematic review synthesized a comprehensive framework of EMS activities and sub-activities through which ISO 14001 can foster decarbonization. Table 3 demostrates these activities across the typical EMS implementation cycle from strategic planning and commitment to operational execution and performance evaluation and highlights how each contributes to carbon management goals. This framework effectively operationalizes the ISO 14001 standard into a set of actionable components aligned with achieving net-zero emissions and related objectives.

The foundation of an ISO 14001 is top management commitment and the foundation of a clear environmental policy. The prior research examined that numerous corporations are now openly integrating carbon neutrality or climate objectives into their environmental strategies as an initial measure. (Ojiako et al., 2025). Moreover, sub-activities in this phase include formulating a vision and mission around sustainability, publicly committing to GHG reduction goals such as science-based targets or net-zero pledges, and appointing dedicated leadership for EMS oversight. By establishing a strong governance mandate and accountability structure for climate action, these early activities set the stage for all subsequent EMS efforts. The literature shows a high emphasis on this phase numerous studies identify leadership engagement and environmental policy as critical drivers of successful ISO 14001-based carbon management. Essentially, “Environmental Policy and Climate Commitment” (EMS1 in Table 3) is the stage where organizations align their strategic direction with carbon neutrality ambitions, ensuring that climate change mitigation is embedded in corporate values and objectives from the outset.

By establishing the overarching commitment, ISO 14001 mandates enterprises to assess their internal and external context (EMS2) and to formulate objectives, targets, and programs

(EMS3). In practice, this involves identifying climate-related risks and opportunities, understanding regulatory and market conditions regarding carbon, and quantifying the organization’s baseline environmental impacts. Key sub-activities include conducting thorough environmental risk assessments that incorporate climate change scenarios such as physical risks from extreme weather, transitional risks from carbon pricing), and establishing a GHG inventory or carbon footprint of the organization. By mapping out emissions sources such as Scopes 1, 2, and relevant Scope 3, and forecasting future climate impacts, companies can set informed carbon reduction objectives under their EMS. Similarly, another sub-activity involves engaging stakeholders by consulting with employees, suppliers, or the community regarding environmental risks and expectations. This process aids in prioritizing actions and strengthening support for forthcoming initiatives. These planning activities correspond to setting measurable targets for emission reductions and developing management programs to achieve them. The review indicates that firms with ISO 14001 frequently integrate carbon targets into their EMS objectives. This integration guarantees that climate action plans are founded on data, including risk, carbon footprint analysis, and are methodically incorporated into the organization's management cycle.

The implementation and operational control of the EMS involve specific actions and measures established to mitigate environmental impacts and meet the objectives outlined during the planning phase. Several EMS activities are utilized to strategically facilitate decarbonization outcomes: (a) Ensuring compliance with both general environmental legislation and specific climate-related regulations and standards, including emissions trading requirements, carbon taxes, and mandatory reporting obligations. ISO 14001 frameworks enable organizations to proactively manage compliance and frequently exceed it, thereby positioning companies to anticipate more stringent future carbon regulations. (b) Operational controls and process improvements involve the implementation of technologies and modifications to processes aimed at reducing waste, enhancing efficiency, and minimizing emissions. This include the adoption of cleaner production techniques, improvements in waste management to reduce methane emissions, and enhancements in water and energy efficiency within processes. Although not solely centered on carbon, these actions facilitate emissions reductions and are prevalent in organizations certified under ISO 14001. (c) Improving energy management is a particularly critical activity identified in the context of energy efficiency and renewable energy deployment. Organizations often engage in initiatives aligned with ISO 14001 to enhance energy efficiency through the adoption of advanced equipment, optimization of heating, cooling, and industrial processes, and the integration of renewable energy sources such as solar panels, wind, and biomass into their operations. These initiatives directly translate to lower CO_2 emissions and are often highlighted as the most effective means for ISO 14001-certified organizations to cut their carbon footprint (Sam & Song, 2022; Johnstone and Hallberg, 2020).

ISO 14001 promotes continuous improvement, leading to incremental decarbonization instead of abrupt reductions. This finding indicates that although improvements driven by EMS can be significant, attaining absolute zero emissions typically necessitates additional innovations or external offsets that extend beyond the capabilities of an EMS alone. The literature indicates that the implementation of ISO 14001 primarily emphasizes internal operations that are directly controllable by the company. Activities associated with supply chain and product life-cycle emissions, including Scope 3 emissions from suppliers or during product use, are infrequently documented in ISO 14001 studies. This is likely because managing external or downstream emissions is more challenging and often outside the standard's immediate scope. Firms have struggled to extend their EMS influence effectively to suppliers or customer behavior, especially given the complexity of tracking Scope 3 emissions (Wagner, 2020; Zimon et al., 2020). Consequently, EMS-driven decarbonization has primarily demonstrated in aspects such as energy consumption, process efficiency, and waste management within organizational confines, while indirect emissions reductions through procurement policies and logistics optimization represent a domain requiring further advancement.

Performance evaluation and continuous improvement of EMS activities involves monitoring outcomes, reviewing performance, and continually improving the system. ISO 14001 requires organizations to periodically evaluate their EMS through internal audits and management reviews, and to seek opportunities for improvement. Our analysis indicates that evaluative and feedback mechanisms are essential for maintaining long-term progress in carbon management.

Furthermore, employee training and involvement and stakeholder engagement are important sub-activities that often determine the success of EMS initiatives. Several studies emphasize that building a culture of sustainability through green training programs, incentives for emissions reduction ideas, cross-functional climate teams, and transparent communication - significantly enhances ISO 14001's impact (Khatib et al., 2023; Balawanth et al., 2025). The human and organizational factors contribute to the EMS being a dynamic system that continuously adapts and enhances rather than a fixed set of procedures. Firms exhibiting high employee engagement in their EMS often report sustained and cumulative enhancements in carbon performance, as employees across all levels play a role in identifying inefficiencies and developing innovative solutions. Engaging external stakeholders, including local communities, NGOs, and industry groups, can yield valuable feedback and foster broader improvements. This engagement reinforces the organization's commitment and may influence its reputation and market expectations.

The systematic review develops an EMS activity framework illustrating the role of ISO 14001 in promoting decarbonization. This process encompasses the establishment of climate-conscious leadership and policies, precise planning and analysis, execution of specific emission reduction initiatives, and ultimately, assessment of progress while strengthening a culture of continuous improvement. This process-oriented perspective clarifies that ISO 14001's role in achieving carbon neutrality is not attributable to a singular, definitive action, but rather through a series of interconnected practices that collectively advance an organization towards reduced carbon emissions. This study identified several limitations, particularly the insufficient emphasis on value-chain emissions and the dependence on indirect performance indicators. These findings suggest potential areas for future research and practice aimed at enhancing the effectiveness of ISO 14001 in addressing climate change.

Table 3: ISO 14001 EMS activities and sub-activities framework aligned with decarbonization objectives

Authors	Main Activity	Sub-Activity	Description
(Cid-Bouzo et al., 2025) (Margaret et al., 2024) (Yan et al., 2025) (Neves et al., 2017a) (Orcos et al., 2018) (Abid et al., 2021a) (Mungai et al., 2020b) (Chiarini and Vagnoni, 2016) (Maletič et al., 2015) (Dos Santos Ferreira and Gerolamo, 2016) (Jabbar et al., 2025) (Ofori et al., 2024) (Riaz et al., 2022) (de Junguitu & Allur, 2019) (Gull et al., 2022) (da Fonseca, 2015) (Kasravi et al., 2022)	Environmental Policy and Climate Commitment (EMS1)	Develop environmental vision and mission (EMS1-a) Commit to public carbon reduction goals (EMS1-b) Appoint leadership for EMS oversight (EMS1-c)	In the ISO 14001 framework, establishing an environmental policy with explicit climate change commitments sets the strategic direction for carbon management. Top management is required to commit to environmental improvement and prevention of pollution, which now often includes pledges toward carbon neutrality or net-zero. For example, PwC Greece integrated its global net-zero 2030 commitment into its ISO 14001 environmental policy, aligning organizational priorities with decarbonization targets. Such a policy provides a clear mandate for emissions-reduction initiatives and ensures that zero-carbon goals are embedded in the company's environmental objectives and culture. By publicly stating carbon-reduction aims in the policy, organizations demonstrate leadership and create accountability, laying the groundwork for all subsequent ISO 14001 activities that drive toward net-zero emissions.
(Bakkass et al., 2025) (Mahzun et al., 2020)	Context Analysis and Climate Risk Assessment (EMS2)	Conduct environmental risk assessments (EMS2-a)	ISO 14001:2015 requires organizations to understand their context and consider how environmental conditions like climate change affect them. This means identifying climate-related risks and

(Lewicka and Lewicka, 2019) (L. M. C. M. da Fonseca, 2015b)		Map climate change scenarios (EMS2-b) Engage stakeholders on environmental risk (EMS2-c)	opportunities as part of strategic planning. By analyzing issues such as regulatory changes (carbon pricing) and physical climate risks such as extreme weather events, companies build resilience and inform their carbon management strategies. For instance, UK retailer ASDA assessed that 95% of its fresh produce range is at risk from climate change, underscoring the need to integrate climate risk into business planning. Proactively addressing these risks and opportunities through the EMS ensures the path to carbon neutrality is robust against future climate impacts, while also allowing organizations to capitalize on opportunities (like renewable energy incentives) that aid decarbonization.
(Ajina et al., 2025) (Tergu et al., 2025) (Ikram et al., 2020) (Chrysikopoulos and Chountalas, 2018) (André and Valenciano-Salazar, 2020)	GHG Emissions Inventory Carbon Footprint (EMS3)	Identification of GHG Emission Sources Across Scopes (EMS3-a) Collection and Verification of Emission Data (EMS3-b) Calculation of Organizational Carbon Footprint (EMS3-c) Preparation and Disclosure of GHG Inventory Reports (EMS3-d)	Measuring the organization's carbon footprint is a foundational activity for ISO 14001 carbon management. Under the planning phase, companies identify significant environmental aspects, often finding greenhouse gas (GHG) emissions as a top priority. A comprehensive GHG inventory (covering Scope 1, 2, and relevant Scope 3 emissions) establishes the baseline and reveals major emission sources. Current standards like ISO 14064 complement ISO 14001 by providing detailed guidance for GHG accounting and verification. Many firms use this data-driven approach to pinpoint reduction opportunities; for example, one tech manufacturer performed a lifecycle carbon assessment under its EMS and then targeted high-emission areas, achieving a 30% total carbon reduction in two years. By quantifying emissions, organizations can set informed targets and track progress toward net-zero or carbon-neutral goals, ensuring that carbon management efforts are grounded in solid data.
(Ajina et al., 2025) (Weerasinghe and Jayasooriya, 2020)	Compliance with Carbon Regulations (EMS4)	Track environmental regulations (EMS4-a)	In implementing ISO 14001, organizations must identify and comply with environmental legal requirements - which increasingly include climate-related regulations. This involves tracking and

(Waxin et al., 2019) (Tergu et al., 2025) (Hassan & Kadhum, 2023) (Ajidarma et al., 2018)		Update EMS to reflect legal changes (EMS4-b) Conduct compliance audits (EMS4-c)	adhering to laws such as emission trading schemes, carbon taxes, or mandated GHG reporting. Ensuring compliance not only avoids penalties but also drives carbon reductions in line with national policies. As part of an EMS, companies establish processes to stay up to date with such regulations and integrate them into operational controls and objectives. For example, many European firms certified to ISO 14001 have incorporated EU Emissions Trading Scheme obligations into their EMS, using it to systematically monitor CO_2 quotas and find reduction opportunities. By treating regulatory carbon constraints as minimum performance criteria, organizations set a foundation on which to build voluntary decarbonization efforts toward net-zero.
(Garrido et al., 2020) (Bravi et al., 2020) (Mayamurugan, 2016) (Behr et al., 2021)	GHG Reduction Objectives and Targets (EMS5)	Setting Science-Aligned GHG Reduction Targets (EMS5-a) Embedding Carbon Goals in EMS Programs (EMS5-b) Reviewing and Updating GHG Objectives Regularly (EMS5-c)	A core element of ISO 14001 is setting environmental objectives and targets - for carbon management, this means formalizing GHG reduction goals. Organizations often establish science-based emissions targets (percentage CO_2 reduction by a certain year) as part of their EMS planning. These goals can range from incremental cuts to ultimate net-zero commitments. Setting clear, measurable targets galvanizes internal efforts and provides benchmarks to track progress. For example, Levi Strauss & Co. set targets to reduce absolute GHG emissions in their facilities by 90% and achieve 100% renewable electricity by 2025 and also committed to net-zero emissions by 2050. By embedding such targets in the EMS, companies ensure accountability and align short-term actions with long-term decarbonization pathways. This practice directly associated with zero-carbon strategies by translating high-level climate ambitions into specific performance metrics and timelines within the ISO 14001 system.

(Garrido et al., 2020) (Bakkass et al., 2025) (Lemkowska and Wiśniewska, 2021) (Behr et al., 2021)	Carbon Management Action Plan Implementation (EMS6)	Developing a Carbon Management Action Plan (EMS6-a) Assigning Roles and Resources for Implementation (EMS6-b) Integrating Carbon Actions into Operational Processes (EMS6-c) Monitoring Progress of Carbon Reduction Measures (EMS6-d)	Once targets are set, ISO 14001 calls for developing plans to achieve them, translating goals into concrete projects and operational controls. Organizations create decarbonization action plans that include initiatives like upgrading equipment, process changes, and other measures to cut emissions in line with objectives. This aligns with ISO 14001's "planning to achieve objectives" requirements and the Do-phase of the PDCA cycle. Key carbon-reduction measures typically address energy use, industrial processes, and logistics. For example, after setting a GHG reduction goal, a manufacturer might implement a multi-faceted carbon action plan: retrofitting HVAC systems, installing energy management software, and optimizing fleet routes. Such plans ensure the company's journey to net-zero is systematically executed with responsibilities, timelines, and resources defined. Integrating the plan into the EMS allows progress to be monitored and adjusted through ISO 14001's continuous improvement process, keeping the organization on track toward its decarbonization goals.
(Weerasinghe and Jayasooriya, 2020) (Gomes et al., 2023) (Laskurain et al., 2017) (Simion Ludușanu et al., 2025)	Energy Efficiency and Renewable Energy Deployment (EMS7)	Conducting Energy Audits and Baseline Assessments (EMS7-a) Implementing Energy-Saving Technologies and Practices (EMS7-b) Integrating Renewable Energy into Operations (EMS7-c)	Improving energy efficiency is one of the most direct ways an ISO 14001 EMS contributes to decarbonization. Organizations identify energy use as a significant aspect and implement programs to conserve energy and reduce fossil fuel consumption. This can include measures such as upgrading to high-efficiency machinery, improving insulation and HVAC systems, optimizing production processes, and promoting energy-saving practices among staff. Industrial case studies show substantial carbon benefits from such initiatives. For instance, one factory streamlined its production line and installed a building management system as part of its EMS, resulting in a 25% reduction in GHG emissions through energy savings and process optimization. These improvements not only cut carbon emissions directly helping move toward net-zero but also

		Tracking and Optimizing Energy Performance Metrics (EMS7-d)	yield cost savings that can be reinvested in further sustainability projects, creating a cycle of continuous improvement. Shifting from fossil-based energy to renewable sources is a pivotal carbon management activity under ISO 14001. Companies integrate renewable energy use into their EMS - for example, installing solar panels on-site, purchasing green electricity, or switching to biomass fuels - to directly lower Scope 2 and sometimes Scope 1 emissions. ISO 14001 provides the framework to set and manage renewable energy objectives, monitor performance, and ensure these initiatives align with other environmental goals.
(Gomes et al., 2023) (Simion Ludușanu et al., 2025)	Water Conservation (EMS8)	Conducting Water Usage and Leak Detection Assessments (EMS8-a) Installing Water-Efficient Technologies (EMS8-b) Implementing Water Recycling and Reuse Systems (EMS8-c) Optimizing Operational Processes to Reduce Freshwater Demand (EMS8-d) Monitoring Water Performance (EMS8-e)	Water conservation is identified as a significant aspect, ISO 14001 guides organizations to establish measurable objectives and integrate water-saving initiatives within their EMS. This process begins with a comprehensive assessment of water usage across operations to pinpoint inefficiencies, leakages, and overconsumption points. In line with ISO 14001's "planning to achieve objectives," organizations then design water management strategies that may include the installation of low-flow fixtures, adoption of closed-loop water recycling systems, or optimization of cooling and cleaning processes. These initiatives directly address the Do-phase of the PDCA cycle by embedding operational controls and best practices that reduce freshwater demand without compromising process performance. For example, a food processing company might introduce automated water monitoring systems, reuse rinse water in non-critical applications, and retrain staff on water-efficient behaviors. ISO 14001 ensures that each water conservation action is systematically executed with clear responsibilities, timelines, and performance indicators. By embedding these plans into the EMS, progress is routinely reviewed, enabling continuous improvement and adaptive management ultimately supporting both sustainability commitments and regulatory compliance.

(Ikram et al., 2022) (Jabbar et al., 2025)	Sustainable Transportation and Logistics (EMS9)	Optimize transport routes and schedules (EMS9-a) Adopt electric or low-emission vehicles (EMS9-b) Track and reduce logistics emissions (EMS9-c)	Transportation and logistics are often major sources of corporate carbon emissions, so ISO 14001 programs frequently include initiatives to make mobility more sustainable. This can involve optimizing distribution routes, improving fleet fuel efficiency, shifting to electric or hybrid vehicles, and encouraging low carbon commuting public transit, carpooling. Deutsche Post DHL a global logistics company developed its own electric delivery vans, street scooters and deployed 5,500 of them in operations, substantially cutting CO_2 emissions from its fleet. Through the EMS, companies set targets for fuel reduction or fleet electrification, implement maintenance and driver training programs, and monitor transport-related emissions. Greening transportation not only lowers direct emissions on the journey to net-zero, but also reduces fuel costs and local air pollution, creating both environmental and economic benefits.
(Johnstone, 2021) (Tergu et al., 2025) (De Oliveira et al., 2016) (Benazzouz and Mihoubi, 2025) (P.-K. Chen et al., 2020)	Process Optimization and Clean Technology (EMS10)	Redesign processes to minimize resource consumption (EMS10-a) Adopt cleaner production technologies (EMS10-b) Reduce emissions through process automation (EMS10-ac	Many firms use ISO 14001 as a platform for cleaner production - redesigning processes and adopting clean technologies to cut emissions. By systematically reviewing operations, companies can identify inefficiencies or high-emission steps in manufacturing, then apply lean and innovative solutions to reduce energy usage and waste. This might involve modifying production techniques, recovering waste heat, switching to lower-carbon fuels in industrial processes, or installing carbon capture on key emission sources. One reported example is a factory that revamped its production line under an EMS initiative and achieved a 25% reduction in GHG emissions. Empirical evidence also shows that ISO 14001-certified firms tend to improve their emissions performance significantly. Such process optimizations directly contribute to decarbonization by lowering the carbon intensity of products and services. They often enhance productivity as well, showing that climate-friendly process innovation can go hand-in-hand with operational excellence on the path to net-zero.

(Bravi et al., 2020) (Bakkass et al., 2025) (Singh et al., 2015) (Simion Ludușanu et al., 2025)	Waste Management and Circular Economy (EMS11)	Implement waste segregation and recycling systems (EMS11-a) Promote material reuse and circular design (EMS11-b) Audit and reduce landfill disposal rates (EMS11-c)	Waste reduction and circular economy practices within an ISO 14001 EMS can also lower carbon emissions, albeit indirectly. Reducing solid waste, increasing recycling, and improving waste treatment all help cut greenhouse gas emissions associated with waste decomposition and the production of new materials. ISO 14001 encourages organizations to manage resources and waste as key environmental aspects, driving initiatives such as recycling programs, composting, and redesigning products or packaging to use less material. These efforts reduce the energy and emissions involved in raw material extraction and waste disposal. As noted by PECB, improving waste management and prevention is an important step to mitigate climate change impacts. For example, companies that achieve zero-waste-to-landfill not only prevent methane emissions from decomposing waste but also shrink their upstream carbon footprint by reusing materials. Embracing circular economy principles through the EMS thus contributes to decarbonization by lessening demand for virgin materials and reducing overall lifecycle emissions.
(Jabbour et al., 2015) (Maletič et al., 2015)	Green Procurement and Supply Chain Engagement (EMS12)	Source materials from certified sustainable suppliers (EMS12-a) Green suppliers' selection (EMS12-b)	ISO 14001:2015 expands the environmental management scope to a life-cycle perspective, prompting organizations to address not only their direct emissions but also those in their supply chain. Green procurement involves selecting suppliers based on environmental performance including carbon criteria, and collaborating with them to reduce upstream and downstream emissions. Under the EMS, companies may require key suppliers to have GHG reduction plans or to report their carbon footprint, and they might favor materials

		Collaborate with suppliers on carbon reduction goals (EMS12-c)	with lower embodied carbon. This approach is vital since supply-chain (Scope 3) emissions often dwarf direct emissions. ISO 14001 provides a framework to integrate these considerations into procurement processes and supplier audits. For instance, many automotive and retail companies now ask suppliers to use renewable energy or adopt science-based targets, leveraging ISO 14001 systems to manage this engagement. By greening the supply chain, organizations can make substantial progress toward their overall net-zero objectives, extending decarbonization efforts beyond their own operations.
(Ajidarma et al., 2018) (Benazzouz & Mihoubi, 2025) (Garrido et al., 2020) (Riaz et al., 2022)	Sustainable Product Design and Life Cycle (EMS13)	Design products for durability, reuse, and recyclability (EMS13-a) Conduct life cycle assessments to identify impacts (EMS13-b) Substitute hazardous materials with eco-friendly alternatives (EMS13-c)	ISO 14001's emphasis on life cycle thinking encourages companies to design products and services with their carbon footprint in mind. This means considering emissions from raw material extraction, through manufacturing and use, to end-of-life disposal - and innovating to reduce those emissions at each stage. Activities in this area include redesigning products to be more energy-efficient or lighter, reducing material and transport emissions, substituting high-carbon materials for lower-carbon alternatives, and extending product durability to reduce replacement frequency. Companies often conduct Life Cycle Assessments (LCA) under their EMS to identify carbon "hotspots" and drive eco-design changes. For example, some electronics firms have reduced product energy consumption and incorporated recycled materials to cut life-cycle CO_2 emissions. ISO 14001 provides the structure to set design-for-environment criteria and objectives, integrate them into R&D processes, and monitor outcomes. Delivering lower-carbon products not only shrinks an organization's own footprint but also helps customers reduce emissions during product use, thus multiplying the decarbonization impact in pursuit of net-zero.
(Johnstone, 2021) (André and Valenciano-Salazar, 2020)	Carbon Offsetting and Compensation (EMS14)	Purchase verified carbon credits for residual emissions (EMS14-a)	While ISO 14001 primarily focuses on reducing direct environmental impacts, many organizations complement their reduction efforts with carbon offsetting to address residual emissions. As part of an EMS, companies can establish procedures

		Support reforestation or renewable energy offset projects (EMS14-b) Integrate offsetting strategy into EMS objectives and reporting (EMS14-c)	for purchasing high-quality carbon offsets or investing in carbon removal projects such as reforestation, renewable energy projects, to counterbalance emissions they cannot eliminate. For example, after maximizing internal reductions, a company might achieve carbon neutrality by offsetting remaining CO_2 through certified forestry projects. ISO 14001 provides the management system rigor to ensure these offset efforts are properly evaluated, verified, and aligned with overall environmental objectives. Integrating offsetting into the EMS helps organizations reach net-zero or carbon-neutral status sooner, while still maintaining focus on continuous internal decarbonization. It creates a structured approach to neutralize emissions ethically and transparently - though importantly, the EMS framework also ensures that offsetting does not substitute for direct emissions reductions, which remain the priority.
(Ociepa-Kubicka et al., 2021) (Jabbar et al., 2025) (Kasravi et al., 2022) (Waxin et al., 2019)	Employee Training and Awareness (EMS15)	Train on ISO 14001 standards (EMS15-a) Host carbon literacy sessions (EMS15-b) Include sustainability in onboarding (EMS15-c)	ISO 14001's success depends on competent and aware employees, so training and awareness programs around carbon management are key activities. Organizations conduct training to educate staff about the environmental policy, carbon reduction goals, and their role in achieving them. This may include workshops on energy-saving practices, guidance for operators on efficient equipment use, or company-wide campaigns to promote a "carbon-conscious" culture. Some companies even implement incentive programs or gamification such as competitions to reduce energy use between departments to engage employees. As an example, one ISO 14001 implementation project launched an awareness campaign that improved employees' environmental behavior and engagement in the company's carbon reduction initiatives. By building a culture of sustainability through education and participation, organizations empower their workforce to contribute ideas and daily actions that cumulatively help achieve carbon-neutral and net-zero targets. In effect, every employee becomes a stakeholder in the decarbonization journey, which can lead to greater innovation and commitment.

(Garrido et al., 2020) (Cid-Bouzo et al., 2025) (Neves et al., 2017b) (Riillo, 2025) (Ojiako et al., 2025) (Orcos et al., 2018)	Stakeholder Engagement and Communication (EMS16)	Identify and prioritize key environmental stakeholders (EMS16-a) Conduct regular consultations on EMS goals and impacts (EMS16-b)	Engaging stakeholders is an important ISO 14001 activity that can amplify an organization's carbon management efforts. Companies communicate with external stakeholders - such as investors, customers, communities, and regulators - about their carbon performance and initiatives, often through sustainability reports or disclosures. This transparency builds trust and can attract environmentally conscious business. According to industry guidance, when companies openly communicate their environmental efforts, it not only earns respect but also aligns stakeholder expectations with the company's sustainability goals. Stakeholder engagement can also involve collaboration: for instance, working with local communities on tree-planting projects or with industry coalitions to develop low-carbon technologies. By sharing progress and challenges, organizations like Unilever and Interface have bolstered their reputation and inspired partners to take action. Such engagement not only supports the company's own net-zero journey but helps drive broader change by influencing and partnering with others in the value chain.
(Weerasinghe and Jayasooriya, 2020) (De Camargo Fiorini et al., 2019)	Monitoring, Measurement and Reporting (EMS17)	Establish indicators for tracking environmental performance (EMS17-a) Collect and analyze data on key EMS objectives (EMS17-b)	Regular monitoring and measurement of environmental performance is fundamental to ISO 14001, and for carbon management this means continually tracking GHG emissions and energy usage. Organizations establish key metrics such as total CO_2 emissions per quarter, carbon intensity per unit of product, and use tools like energy meters and carbon accounting software to collect data. By analyzing this data, companies can evaluate progress against their targets and identify areas needing improvement. ISO 14001 also encourages transparent reporting of results, which

		Report results internally and externally for transparency (EMS17-c)	introduces accountability and drives improvement. DE Grandson Global notes that conducting regular audits to monitor emissions and having a transparent reporting system are crucial to staying on track for net-zero goals. In practice, many firms integrate carbon KPIs into their EMS dashboards and report performance to top management and stakeholders annually. This persistent measurement and reporting regimen ensures that any deviation from the decarbonization path is caught early and corrected, and that successes are documented - maintaining momentum toward the organization's zero-carbon objectives.
(Toha et al., 2020) (Lemkowska et al., 2021) (Jabbar et al. 2025) (Campos et al., 2015)	Internal Audits and EMS Evaluation (EMS18)	Develop and implement an EMS internal audit schedule (EMS18-a) Evaluate compliance with ISO 14001 requirements (EMS18-b) Report audit findings and recommend improvements (EMS18-c)	ISO 14001 requires periodic internal audits of the EMS, which in the carbon management context means verifying that climate-related procedures and controls are effectively implemented. Trained auditors often employees or consultants examine whether GHG data is accurate, energy-saving operational controls are followed, and compliance obligations and objectives related to carbon are being met. This process helps uncover gaps or non-conformities; for example, an audit might reveal that an emissions monitoring log is incomplete or a maintenance routine for efficient equipment was missed, prompting corrective action. According to one guidance, conducting routine EMS reviews and audits is key to identifying improvement opportunities in carbon management. Findings from internal audits feed into management reviews, reinforcing accountability at the highest level. In essence, internal audits act as a quality control mechanism for the organization's carbon neutrality efforts ensuring that what is written in the environmental plans is actually being carried out, and that the EMS continually improves its effectiveness in reducing emissions.
(Xu & Sam, 2025) (Abid et al., 2021b) (Mungai et al., 2020a)	Management Review and Strategic Alignment (EMS19)	Review EMS performance against objectives and KPIs (EMS19-a)	Top management oversight is critical to ensuring the EMS drives carbon neutrality effectively. Under ISO 14001, management review meetings (typically annually) evaluate the EMS performance, including progress on carbon reduction targets, results of audits, changes in context, and adequacy of resources. In these

		Align environmental goals with organizational strategy (EMS19-b) Approve updates to EMS policies and action plans (EMS19-c)	reviews, executives assess whether the environmental policy and objectives (such as net-zero goals) remain suitable and whether deeper strategic changes are needed. This clause provides a "two-way" opportunity - the EMS can inform overall business strategy and vice versa, helping to mainstream climate commitments into high-level decision-making. For example, leadership may decide to increase investment in renewables or set more aggressive GHG targets after reviewing performance data and stakeholder feedback. The IEMA guidance suggests engaging senior leadership through the EMS, even establishing board-level climate accountability or public climate commitments as part of this process. Such high-level engagement ensures that achieving net-zero is not just an operational task but a strategic priority, with resources and corporate direction aligned. Management reviews thus drive continuous alignment of the organization's trajectory with its decarbonization ambitions, enabling course corrections and sustained momentum from the top.
(Weerasinghe and Jayasooriya, 2020) (Johnstone and Hallberg, 2020) (Jabbour et al., 2015)	Continual Improvement and Innovation (EMS20)	Identify opportunities for reducing environmental impacts (EMS20-a) Implement corrective and preventive EMS actions (EMS20-b) Foster innovation in sustainability practices (EMS20-c)	Continuous improvement is the cornerstone of ISO 14001 and underpins long-term decarbonization. Even after initial targets are met, the EMS PDCA cycle drives organizations to seek further improvements and innovative solutions for carbon reduction. This may involve iterative efficiency gains such as squeezing an extra 1-2% energy savings each year as well as breakthrough changes such as adopting new low-carbon technologies or business models. IEMA's climate guidance notes that effective climate action in an EMS can include incremental changes and transformative changes new products, markets, or business models aligned with a net-zero economy. Over time, these efforts compound studies have found that ISO 14001-certified firms achieve significant emissions cuts, averaging around a 34% reduction in GHG emissions relative to pre-

		Track improvement outcomes and update objectives (EMS20-d)	certification levels. Moreover, organizations often ratchet up their ambitions for example, by setting progressively stricter carbon targets or investing in R&D for green innovation - as they mature in their EMS. By continuously raising the bar and fostering a culture of innovation, companies ensure that their path to carbon neutrality isn't a one-time project but a sustained journey. This continual improvement ethos is essential for reaching and maintaining net-zero, as it drives the ongoing evolution and adaptation needed to tackle climate challenges over the long run.

4. Discussion

The findings from this combined bibliometric and systematic review provide several insights that advance the current understanding of ISO 14001's role in promoting carbon neutrality and sustainability. This research contributes to the ISO 14001 body of knowledge in multiple ways. First, the bibliometric analysis offers a holistic and systematic mapping of the intellectual structure of ISO 14001 and carbon management research. By identifying the most influential journals, highly cited articles, key thematic clusters, and active countries from 2015 to 2025, we see how scholarly attention has evolved and where it has concentrated. Notably, the analysis confirms that interest in ISO 14001 has grown and shifted in the past decade, with research increasingly connecting the standard to carbon neutrality and broader sustainability strategies. Within this study we observed that Journal of Cleaner Production and Business Strategy and the Environment are central publication venues, reflecting their focus on interdisciplinary sustainability research and indicating that ISO 14001 topics are often discussed in the context of corporate sustainability and environmental strategy. The surge in publications around 2020 stands out as well this peak suggests a potential turning point, possibly influenced by the heightened global emphasis on climate action and the integration of sustainability into business strategy during that period. The bibliometric trends thus set the stage for interpreting how ISO 14001 research has matured, highlighting that while early studies often treated ISO 14001 in general environmental management terms, more recent studies explicitly frame it as a strategic tool for decarbonization and sustainability integration.

The review identified four main thematic areas in the ISO 14001 literature that describe how the standard is examined in relation to organizational integration and performance outcomes. The first and most prominent theme is environmental performance, which is consistently conceptualized as a multidimensional, measurable outcome of EMS implementation. Numerous studies confirm that ISO 14001 functions as a governance framework enabling firms to monitor and improve various environmental performance indicators ranging from pollution reduction to resource efficiency through a structured continuous improvement process (Papamichael et al., 2023). Within this theme, ISO 14001 is seen not just as a certificate, but as an operational system that helps organizations identify environmental aspects and impacts, set objectives, and take corrective actions to achieve better performance.

Closely linked to environmental performance is the theme of energy management, which emerged as the second major cluster. This theme can be viewed as an integral extension of the environmental performance focus, zooming in on energy use and efficiency as critical factors in both operational cost and GHG emissions. Energy management's prominence in the ISO 14001 literature, Mneimneh et al. (2023) demonstrates that energy-related initiatives are among the most tangible ways companies can improve environmental outcomes and mitigate climate impacts through an EMS. In practical terms, ISO 14001-certified firms often adopt sub-programs akin to or in combination with ISO 50001 as part of their EMS to systematically reduce energy consumption. This integration aligns with the findings from our systematic review that ISO 14001 drives progressive decarbonization efforts in operational domains like energy usage.

The third theme involves Integrated Management Systems (IMS), which reflects managerial practices that combine ISO 14001 with other standardized systems. The literature on IMS indicates that organizations often integrate their EMS with quality (ISO 9001), occupational health and safety (ISO 45001 or similar), and even corporate social responsibility frameworks, developing a IMS (Nunhes et al., 2019). Such integration is intended to streamline processes, reduce redundancies, and align objectives across different management areas. According to prior studies, ISO 14001can be more effective when implemented as part of a holistic management paradigm that also encompasses quality and corporate responsibility goals (Francisco et al., 2024; Domingues et al., 2017). This suggests that a company's decarbonization outcomes under ISO 14001 might be significantly enhanced when climate targets are explicitly integrated into the broader strategic management system, rather than pursued in an isolated environmental department. Moreover, the alignment of ISO 14001 with a company's quality improvement processes or safety training can embed environmental thinking into everyday routines at all organizational levels. Our review's framework implicitly supports this by emphasizing cross-functional engagement and top management leadership, which resonate with the IMS approach.

The fourth theme identified is financial performance, somewhat smaller cluster compared to the others. Research on the financial outcomes of ISO 14001 adoption such as cost savings, profitability impacts shows mixed results and often highlights that outcomes are context-dependent (Benzidia et al., 2025). Prior research indicates that companies exhibiting superior financial performance are prone to invest in and derive advantages from ISO 14001, as they possess the capacity to allocate resources toward sustainability initiatives and may experience improvement in efficiency. ISO 14001 is correlated with enhanced financial performance, potentially facilitated by improved operational efficiency, resulting in cost reductions, and better risk management, which decreases the probability of environmental incidents and associated liabilities. Additionally, it may facilitate improved market access or improve brand reputation, potentially leading to increased sales or customer loyalty. However, these benefits are not universally realized as direct cost savings one systematic review concluded that ISO 14001's financial benefits often come in forms other than immediate cost reduction such as long-term risk mitigation or revenue protection (Heras-Saizarbitoria et al., 2011). This study demonstrates that the financial implications of ISO

14001 are significant yet complex; effective decarbonization initiatives within an Environmental Management System may lead to increased capital expenditures in the short term due to new technologies or process modifications, but can foster innovation and operational resilience that yield long-term benefits.

Beyond the content of the clusters, the bibliometric analysis also indicates a temporal dynamic in the research output. The concentration of ISO 14001 publications around the year 2020, as noted, suggests that this was a peak period for scholarly interest. This tenure aligns with the growing worldwide attention on climate change since the Paris Agreement in 2015 and the policies that followed, as well as the push from the UN's 2030 Agenda for sustainable development. Moreover, it reflects a response to the 2015 revision of the ISO 14001 standard itself, which introduced new elements like a greater focus on leadership, strategic context, and life-cycle thinking. Researchers likely delayed publication to observe the consequences of the amended criteria, ultimately releasing their findings in 2020. The increase in publication volume indicates not only a surge in interest but may also signify a shift in the literature from investigating the benefits of ISO 14001 adoption, a question largely resolved by prior research, to examining how ISO 14001 can be utilized to tackle urgent challenges such as climate neutrality and its integration with other sustainability frameworks.

Based on the insights from the systematic review, this study of RQ1 indicates that ISO 14001 is not a merely a singular; it is a process-oriented management framework that implements a suite of carbon management techniques throughout an organization. Moreover, within study we identified a wide range of EMS-enabled practices, spanning strategic, operational, and evaluative spheres. Early-phase activities such as environmental policy and climate commitment, are heavily emphasized in the literature a finding that aligns with governance-focused studies which argue that without leadership buy-in and clear policy direction, technical EMS measures are likely to be less effective (Camilleri, 2022). The fact that we found a large saturation of research on policy setting, leadership commitment which indicates that many studies recognize these as critical enablers of any successful decarbonization through ISO 14001.

Moving into mid-range operational activities, our findings highlight compliance with carbon regulations and energy management improvements as commonly reported practices under ISO 14001. This pattern implies that organizations often use ISO 14001 as a platform to implement progressive, yet largely incremental, decarbonization measures such as fine-tuning processes to reduce emissions intensity or substituting materials and energy sources for greener alternatives. These initiatives usually result in relative and ongoing reductions in emissions; however, they do not guarantee the complete eradication of emissions, thereby reinforcing the assertion that management systems alone are inadequate for attaining profound decarbonization. Radical changes, such as a complete overhaul of production technology or innovations in business models aimed at achieving zero carbon, are less commonly driven by ISO 14001. Rather, ISO 14001 is more effective in promoting steady progress and incremental innovation.

A significant observation is the insufficient focus on supply chain and life-cycle emissions within the framework of ISO 14001. Companies primarily exert direct control over their internal operations, specifically regarding Scope 1 and 2 emissions; consequently, actions driven by ISO 14001 typically concentrate in these areas. Managing Scope 3 emissions which involve suppliers, product use, and end-of-life is inherently challenging, and our review confirms that it remains an infrequent focus in ISO 14001 studies. Prior research has pointed out difficulties in measuring and influencing these indirect emissions (Wagner, 2020), and our results echo that: firms predominantly leverage ISO 14001 to optimize what they can control energy use, waste, processes and only a minority extend their EMS to engage suppliers or customers on carbon issues. This gap presents an opportunity for future work to find ways to broaden EMS scope or integrate ISO 14001 with supply chain initiatives such as green procurement standards or supplier environmental evaluation to capture more of the value-chain decarbonization potential.

In addition to operational practices, our review highlights the significance of evaluation and feedback activities, the final phase of EMS, for sustained climate performance an area that has been comparatively underexplored in the context of explicit carbon management. These include internal audits, management reviews, and mechanisms for employee and stakeholder involvement. While such practices are well-covered in EMS literature, which appear less frequently in climate-specific contexts, yet researchers stress that they are vital for maintaining momentum and ensuring continuous improvement (Johnstone and Hallberg, 2020).

Our findings indicate that the application of ISO 14001 for carbon management leads to more sustained improvements in carbon performance among firms that invest in internalizing sustainability objectives through training, aligning performance incentives with environmental goals, and growing a culture of sustainability. Technical solutions should be supplemented by organizational development and learning to convert ISO 14001 from a mere compliance activity into a dynamic capability for ongoing emissions improvement. Organizations that have more internal engagement, like employees actively taking part in EMS programs and management being open to environmental performance data, have been shown to make lasting improvements instead of just one-time gains. This supports the idea that decarbonization is an ongoing journey rather than a destination.

In addressing RQ2, our review provides evidence that ISO 14001 serves as a meta-framework that can incorporate carbon neutrality targets and link with other environmental management frameworks and the SDGs. ISO 14001 provides organizations with a systematic framework to translate overarching climate objectives, such as net-zero commitments or SDGs pledges, into practical operational strategies. The ISO 14001 standard prioritizes performance monitoring, risk-based thinking, and continual improvement, indicating that the adoption of carbon neutrality as a strategic objective can be effectively integrated into daily management through ISO 14001(Francisco et al., 2024). This is a crucial distinction as it sets ISO 14001 apart from more prescriptive climate initiatives; ISO 14001 does not mandate specific targets or technologies, but rather offers a framework for organizations to establish their own objectives such as achieving net-zero by a designated year, and methodically pursue them. Our findings demonstrate that ISO 14001 is non-prescriptive yet facilitative: organizations integrate their climate action strategies within the EMS framework, which aids in the execution, monitoring, and modification of those strategies as necessary.

Furthermore, a strong correlation was identified between the implementation of ISO 14001 and SDG 13 (Climate Action). Nearly every aspect of EMS, ranging from policy formulation to operational oversight, aligns with elements of SDG 13 when climate factors are integrated. The literature deminstrtaes the importance of SDG 13, indicating that effective climate action necessitates robust governance capabilities, strong internal accountability, and ongoing improvement attributes that are inherent in a well-executed EMS (Mosgaard and Kristensen, 2023). Thus, ISO 14001 implicitly contributes to SDG 13 by institutionalizing climate concern within the organization's control structure and strategic planning. Instead of treating carbon reduction as a one-time project, ISO 14001 makes it a recurrent agenda item in management cycles.

The integration with SDG 7 (affordable & clean energy) and SDG 12 (responsible consumption & production) is also notable. As discussed in the results, these two SDGs are highly correlated with areas where firms can take direct action and see immediate improvements. The literature we reviewed demonstrates that ISO 14001 adoption often leads to cleaner production practices, better energy management, and waste reduction (Cestau-Oyhantçabal and Arocena, 2025; De Oliveira et al., 2016). These outcomes clearly advance SDG 12 and SDG 7 objectives.

While official documentation from standard-setting bodies often provides a conservative mapping of ISO 14001 primarily to operational goals such as SDG 7, 12, and 13, a rigorous analysis of the contemporary academic literature reveals that a mature EMSs acts as a systemic enabler for a much broader spectrum of the 2030 Agenda. Specifically, the cascading effects of structured environmental governance fundamentally intersect with SDGs 5, 10, 11, 16, and 17.

The theoretical linkage to SDG 5 (Gender Equality) and SDG 10 (Reduced Inequalities) is firmly rooted in the paradigm of environmental justice. The literature establishes that environmental degradation and climate impacts disproportionately burden vulnerable socio-economic demographics and exacerbate gender disparities, particularly regarding access to clean energy and exposure to industrial pollution in the Global South. ISO 14001 addresses these disparities through its requirements for comprehensive stakeholder engagement (Clause 4.2) and the maintenance of a non-discriminatory, inclusive work environment (Clause 7.1.4). By systematically identifying and mitigating the localized environmental impacts of their operations on marginalized communities, certified organizations inherently practice distributive environmental justice (ISO, 2016). Furthermore, leading organizations are increasingly augmenting their EMS with the ISO 53800 guidelines for gender equality, ensuring that environmental training, sustainability leadership, and resource allocations are distributed equitably, thereby institutionalizing SDG 5 within their environmental strategy.

In the context of SDG 11 (Sustainable Cities and Communities), ISO 14001 functions as a localized mechanism for urban ecological resilience. The aggregate reduction in industrial air pollution, responsible effluent management, and optimized waste protocols driven by corporate EMS implementations directly advance Target 11.6, reducing the adverse per capita environmental impact of cities (Ikram et al., 2020). This micro-level operational alignment is synergistically linked to macro-level frameworks like ISO 37101 (Sustainable Development in Communities), where corporate environmental performance underpins broader municipal infrastructure planning and smart city initiatives.

The governance framework and life-cycle requirements of ISO 14001 inherently support SDG 16 (Peace, Justice, and Strong Institutions) and SDG 17 (Partnerships for the Goals). Clause 6.1.3 demands rigorous adherence to compliance obligations, establishing a robust, auditable defense against environmental corruption, illegal resource extraction, and corporate malfeasance. By institutionalizing transparent environmental reporting and submitting to independent third-party audits, ISO 14001 builds institutional accountability, which is a foundational pillar of SDG 16 (ERMCVS. 2025). Simultaneously, the standard's emphasis on a life-cycle perspective compels organizations to transcend their immediate operational boundaries. Tackling Scope 3 value-chain emissions necessitates profound, cross-border collaborations with suppliers, technology providers, and regulatory bodies. This mandate forces certified firms to share clean technologies and harmonize sustainability metrics across the global supply chain, transforming the corporate EMS into a vital node within the international partnership network envisioned by SDG 17 (Horry et al., 2022).

4.1 Transitioning from Certification to Substantive Decarbonization

A central insight emerging from the review is that ISO 14001 certification should not be interpreted as a direct proxy for substantive decarbonization. Across the reviewed studies, certification is associated with a broad range of environmental management practices, yet the magnitude, durability, and carbon specificity of the reported outcomes vary considerably. In many cases, the standard improves managerial discipline, monitoring capacity, and environmental compliance without necessarily producing deep or sustained emissions reduction. The decisive issue, therefore, is not whether an organization is certified, but whether the EMS is implemented with sufficient depth to convert formal requirements into carbon-relevant strategic and operational change (Camell at al.,2025; Oyelakin et al., 2025)

This distinction is best understood through the contrast between symbolic adoption and substantive embedding. Symbolic adoption occurs when certification is pursued primarily for legitimacy, procurement access, or reputational signaling while core investment routines, process technologies, and supply-chain practices remain largely unchanged. Under such conditions, the EMS tends to function as a documentation system that supports procedural conformity and incremental efficiency gains, but not transformative carbon reduction. Substantive embedding, by contrast, is evident when carbon-related objectives are integrated into managerial incentives, capital allocation, procurement criteria, process redesign, product stewardship, and the internal framework of auditing and review. The review therefore suggests that the central theoretical challenge is to explain how organizations move from formal certification to substantively embedded implementation (Tsai, 2026; Altarazi and Haddaden, 2026).

The literature further shows that this movement is contingent upon identifiable boundary conditions. Internally, implementation depth is reinforced by top-management commitment, technical capability, employee training, cross-functional coordination, and the availability of reliable emissions data. Externally, deeper carbon outcomes are more likely where firms face stronger regulatory pressure, greater societal environmental awareness, investor scrutiny, and demanding supply-chain expectations. Conversely, resource constraints, fragmented data environments, and weak institutional pressure tend to confine firms especially SMEs to procedural compliance. These contingencies help explain why carbon outcomes diverge across firms even when the same standard is formally adopted (Ofori et al., 2026; Saleh et al., 2026).

A further boundary condition concerns the object of management itself. ISO 14001 is more readily mobilized for operational domains that firms can directly control, such as energy use, process efficiency, waste, and compliance management, than for value-chain emissions that require influence over suppliers, customers, and product-use phases. This helps explain why the literature reports more consistent improvements in internal environmental management than in absolute, organization-wide carbon reduction (Citterio, 2026). It also clarifies why carbon-accounting hybridization and stronger lifecycle integration become essential when organizations attempt to extend the EMS from internal optimization to broader decarbonization trajectories.

Accordingly, the most consequential contribution of the present review is the identification of a certification-to-decarbonization translation gap and the specification of the mechanisms that narrow or widen that gap. Consequently, the ADTF is presented in the subsection 4.2 as a secondary integrative representation of this fundamental insight. Its purpose is to synthesize the translation mechanism revealed by the review and to clarify how implementation depth and contextual moderators' condition whether ISO 14001 remains largely symbolic or becomes substantively decarbonizing

4.2 The Adaptive Decarbonization Translation Framework (ADTF)

A notable objective of rigorous systematic reviews is to transcend the descriptive categorization of existing literature and generate a higher-order analytical synthesis that clarifies the complex mechanisms linking previously fragmented findings. The central insight of the review is that ISO 14001 becomes decarbonization-relevant only when formal certification is translated into substantively embedded organizational routines. The ADTF makes this translation logic explicit by representing, in a single analytical structure, the conditions under which ISO 14001 remains largely symbolic and the conditions under which it supports meaningful carbon reduction. Its derivation was mixed deductive–inductive. Deductively, the review was anchored in the EMS activities and PDCA logic underlying ISO 14001. Inductively, however, the cross-study comparison repeatedly revealed explanatory patterns that were not reducible to the standard's clauses alone, especially implementation depth, symbolic certification, executive commitment, complementary carbon measurement, sectoral contingencies, regulatory pressure, and outcome heterogeneity. These recurrent first-order patterns were then aggregated into four higher-order dimensions: Institutional Antecedents, Strategic Translation, Operational Integration, and Evaluative Outcomes. The framework therefore emerged neither as a purely abstract conceptual interpretation nor as a simple restatement of ISO 14001 clauses, but as a second-order synthesis of the review findings.

The framework posits that the mere adoption of ISO 14001 operates only as a procedural baseline a necessary but insufficient condition for achieving net-zero emissions. The literature frequently identifies a phenomenon known as "decoupling," wherein organizations secure ISO 14001 certification purely as a symbolic, legitimacy-seeking exercise to appease stakeholders or qualify for procurement contracts, without fundamentally altering their core technological processes.

The added value of the ADTF lies in three analytical extensions. First, it introduces translation quality as a central explanatory issue by distinguishing formal conformance from substantive embedding. Second, it explicitly incorporates the risk of decoupling between certification and operational change. Third, it locates ISO 14001 within the contextual pressures and organizational capabilities that shape whether the cycle generates auditable carbon performance or only procedural compliance. In other words, PDCA describes the internal cadence of an EMS, whereas the ADTF explains the conditions under which that cadence becomes substantively decarbonizing. By organizing the existing literature through this analytical lens, it becomes evident that ISO 14001 functions as a dynamic bridging mechanism that absorbs macro-level climate policies and translates them into micro-level corporate actions. The findings of this review confirm that elements such as emissions reduction, energy efficiency, and resource optimization are already conceptually embedded within the fundamental logic of an environmental management system. Therefore, the critical scholarly contribution of this synthesis lies in recognizing that ISO 14001 provides the rigorous, iterative architecture required to prevent strategic stagnation. While high-level frameworks like the UN SDGs provide the what and the why of corporate sustainability, ISO 14001 provides the how. Through the relentless application of the PDCA cycle, the standard ensures that aspirational net-zero pledges are continuously subjected to operational reality checks, internal audits, and corrective actions, thereby transforming carbon neutrality from a static marketing claim into a continuously evolving operational reality.

Figure 7 depicts the structural components of the proposed ADTF, illustrating how theoretical variables and institutional forces interact within the formal ISO 14001 architecture to drive varying degrees of authentic climate performance.

While the theoretical framework of ISO 14001 logically supports the pursuit of carbon neutrality, a critical evaluation of the empirical literature reveals significant variations in implementation effectiveness across different operational contexts. The literature consistently demonstrates that the impact of ISO 14001 on authentic decarbonization is not uniform; rather, it is highly moderated by a complex interplay of organizational characteristics, sector-specific dynamics, and prevailing macroeconomic and regulatory environments. Understanding these moderating factors and structural barriers is essential for explaining why some certified organizations achieve radical emissions reductions while others stagnate at mere compliance.

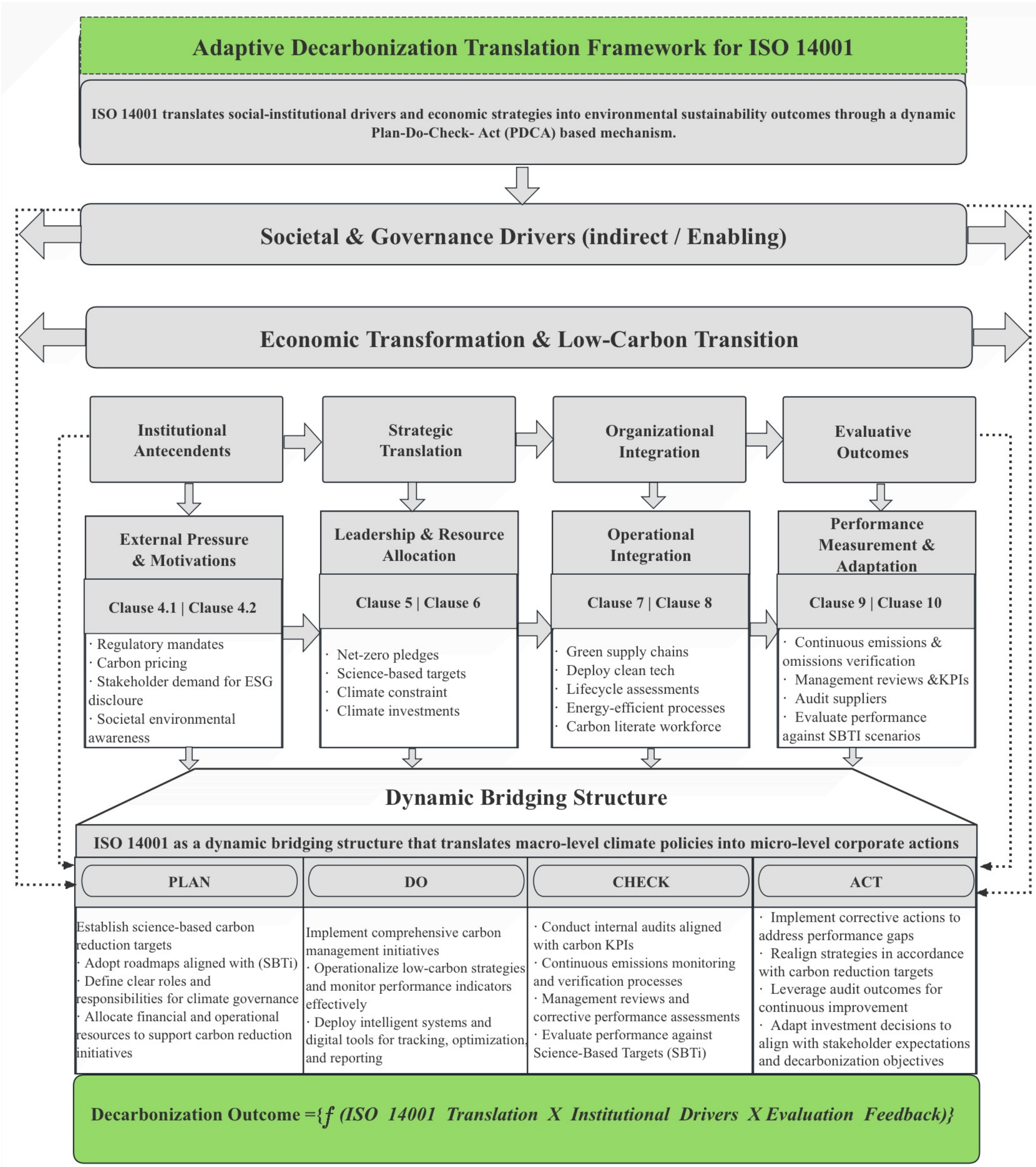

Figure 7: Proposed adaptive decarbonization translation framework (ADTF) for ISO 14001

Firm size and resource availability emerge as primary determinants of implementation depth and subsequent carbon performance. Small and Medium-sized Enterprises (SMEs) consistently encounter severe structural barriers when attempting to leverage ISO 14001 for profound greenhouse gas reductions. The systematic review highlights that SMEs are disproportionately constrained by limited financial capital, a lack of internal technical expertise regarding complex carbon accounting particularly Scope 3 emissions, and the perceived high costs of maintaining certification without guaranteed, immediate financial returns. Furthermore, unlike large multinational corporations, which face intense scrutiny from institutional investors and international regulators, SMEs frequently operate within fragmented supply chains where they experience weak external pressure to push beyond basic regulatory compliance. Consequently, the implementation of ISO 14001 within SMEs often stalls at procedural conformance fulfilling the documentation requirements to satisfy a specific client rather than advancing into transformative, technology-driven decarbonization initiatives.

Conversely, in carbon-intensive sectors such as heavy manufacturing, chemical processing, and energy production, the adoption and effectiveness of ISO 14001 are heavily moderated by external regulatory quality and the Environmental Awareness of Society (EAS). Empirical studies relying on panel data analysis indicate that in jurisdictions characterized by stringent environmental governance, effective regulatory enforcement, and high media visibility regarding climate issues, ISO 14001 adoption yields significantly deeper absolute reductions in carbon emission intensity. In these rigorous institutional contexts, the standard serves as a critical signaling mechanism that mitigates information asymmetry between the firm, regulators, and environmentally conscious stakeholders. Furthermore, internal organizational dynamics play a crucial moderating role. The presence of transformational leadership and a robust green corporate culture act as vital enablers; organizations that actively cultivate employee environmental training, foster cross-functional collaboration, and align executive compensation with sustainability metrics are substantially more successful in overcoming the bureaucratic inertia often associated with formalized management systems. Table 4 highlights the contextual moderators specify the conditions under which each of these dimensions reinforces or weakens substantive carbon performance.

Table 4: Contextual Moderators and Implementation Barriers in ISO 14001 Decarbonization Efforts

Factor Category	**Specific Variable**	**Moderating Effect / Implementation Barrier**	References
Organizational Characteristics	Firm Size & Resource Availability	SMEs face critical capital and expertise shortages, limiting their ability to invest in low-carbon technologies, often resulting in symbolic certification rather than substantive emission reductions.	Johnstone, 2022; Ferrón, 2016)
Organizational Culture	Employee Training & Leadership	High levels of environmental management training (EMT) and transformational leadership significantly enhance the operational effectiveness of the EMS, leading to greater energy savings and proactive carbon reduction strategies.	Chiarini, 2019; Jabbour, 2015)

Sectoral Dynamics	Industry Carbon Intensity	The standard is highly effective at improving technical efficiency and reducing emissions in heavy manufacturing and highly polluting sectors, whereas its impact on service sectors is less pronounced and under-researched.	Song et al., 2026; Sam and Song, 2022; Alsulamy et al., 2022)
Institutional Environment	Environmental Awareness of Society (EAS)	High societal awareness and intense media exposure regarding climate change amplify the positive impact of ISO 14001 on firm profitability and compel deeper, more transparent carbon emission disclosures.	(Arocena et al., 2021; Bugdol et al., 2021)
Regulatory Framework	Government Effectiveness	Stringent environmental regulations, carbon pricing mechanisms, and effective government enforcement heavily moderate the standard's success, transforming ISO 14001 from a voluntary initiative into an essential operational requirement.	(Garrido et al., 2020; Arimura et al., 2016; Hanim Mohamad Zailani et al., 2012)

Supply Chain Complexity	Scope 3 Emissions Management	A pervasive barrier across all firm sizes is the complexity of accurately measuring and reducing value-chain emissions (Scope 3). Organizations struggle to exert influence over fragmented, multi-tier supply networks using the traditional EMS framework.	(Ali et al., 2015; Camell et al., 2025)

Another critical barrier universally identified across the literature is the inherent difficulty of managing and reducing Scope 3 (value chain) emissions through the traditional ISO 14001 framework alone. While the 2015 revision of the standard introduced a lifecycle perspective, organizations continue to struggle with fragmented industry practices, lack of reliable supplier data, and the complexity of exerting influence over globalized upstream suppliers and downstream consumers. The literature strongly suggests that overcoming these complex, boundary-spanning barriers requires organizations to move beyond isolated EMS implementation. Leading organizations increasingly engage in synergistic integrations, such as formally combining ISO 14001 with ISO 50001 (Energy Management Systems) or specific greenhouse gas accounting standards such as GHG Protocol or ISO 14064, to provide the requisite technical rigor and specialized focus necessary for comprehensive carbon neutrality. By evaluating these contextual variations, it becomes clear that ISO 14001 is not a panacea; it is a highly contingent framework whose success in driving decarbonization is inextricably linked to the resources, culture, and institutional pressures surrounding the certified entity.

5. Future Research Directions

Building on RQ3, our study also identified several gaps in the current literature and proposes directions for future research on ISO 14001, carbon neutrality, and sustainability integration. Table 5 presents the identified research gaps and proposed future research directions for ISO 14001 and carbon neutrality

One major gap is the limited use of direct carbon performance metrics in evaluating ISO 14001's effectiveness. Several empirical studies use indirect indicators such as energy consumption, waste generation, or general environmental performance scores as proxies for carbon impact. While these proxies are valuable and often show improvements post-ISO 14001 certification, they do not fully capture actual greenhouse gas emissions trajectories. As a result, the literature has not conclusively determined how much ISO 14001 adoption contributes to tangible GHG emission reductions over time. Future research should incorporate direct emissions data such as tons of CO_2 equivalent, and track them longitudinally for organizations before and after ISO 14001 implementation. Methodologically, this calls for longitudinal or quasi-experimental study designs for instance, difference-in-differences analyses using firms that adopted ISO 14001 versus those that did not, or time-series analyses of a single firm's emissions trend relative to certification timing. Such approaches, possibly combined with matched control groups or instrumental variables to account for self-selection bias, would strengthen causal inferences about ISO 14001's impact on emissions. Additionally, integrating data from carbon accounting frameworks such as ISO 14064 or the GHG Protocol with ISO 14001 studies could help attribute changes in emissions directly to EMS interventions.

A second gap is the sectoral bias in existing research. We observed that a disproportionate number of ISO 14001 studies focus on manufacturing, heavy industry, and other sectors with high visible emissions like petrochemical, automotive, cement. Sectors including services, logistics, agriculture, and construction remain underrepresented, regardless of their increasing significance in emissions contributions. The construction industry and logistics sector are notable contributors to CO_2 emissions; however, the effectiveness of ISO 14001 in these areas is not well established. Future research should investigate ISO 14001 across a broader spectrum of industries, particularly those characterized by diffuse or challenging-to-measure emissions. Comparative research across sectors is essential, particularly in examining whether ISO 14001 produces varying outcomes in carbon reduction between manufacturing and service industries. Additionally, it is important to identify the factors, such as energy intensity, regulatory pressure, and supply chain complexity, that contribute to these differences. The research research may utilize cross-sector surveys or multi-case study methodologies to extract insights regarding sector-specific challenges and effective practices for the implementation of EMS aimed at decarbonization.

Furthermore, another gap pertains to the interaction of ISO 14001 with other standards and initiatives. Organizations rarely rely on a single management standard; they often have multiple certifications and participate in various sustainability programs such as ISO 50001 for energy, ISO 26000 for social responsibility guidance, or industry-specific programs. This study suggests that future research should examine the impacts of IMS on the attainment of net-zero objectives. Does the implementation of ISO 14001 in conjunction with ISO 50001 produce a synergistic effect on emissions reduction that exceeds the cumulative impact of each standard applied independently? What are the best practice models for the integration of carbon accounting standards or science-based targets into an ISO 14001 EMS? Comparative case studies of firms that have effectively integrated multiple frameworks, such as an ISO 14001-certified organization adhering to the science-based targets initiative for greenhouse gas reductions, may yield valuable insights.

Furthermore, research may examine the extent to which integrated audits or unified management reviews encompassing multiple standards facilitate the dismantling of silos and promote innovation in sustainability practices.

The human and organizational dimensions present another area for deeper research. Our review highlights that elements like leadership, corporate culture, employee engagement, and green human resource management (HRM) are frequently mentioned as important but are not deeply examined in quantitative studies. To fill this gap, future research could assess how organizational culture and workforce involvement mediate or moderate the relationship between ISO 14001 implementation and environmental performance. A survey-based study might measure variables such as environmental culture strength or employee environmental training hours and test their relationship with ISO 14001 status in predicting performance outcomes. Qualitative studies could clarify the impact of ISO 14001 on organizational mindsets and the persistence of such changes. Comprehending these soft factors is essential, as two companies may both possess ISO 14001 certification, yet one may realize significant carbon reductions while the other experiences negligible change. The distinction frequently resides in intrinsic motivation, allocation of resources, and organizational culture.

Closely related is the rise of digital technologies and their potential integration into ISO 14001 systems. The concept of a digital EMS embedding IoT sensors, real-time monitoring dashboards, AI-driven analytics for predictive environmental management is an emerging frontier. However, scant research to date addresses the role of digitalization in enhancing ISO 14001 outcomes. Future research could explore pilot implementations where companies use advanced data platforms to track emissions and environmental KPIs within their EMS. Case studies or experimental trials could examine whether digital monitoring such as continuous emission monitoring systems, automated compliance alerts, significantly improves the ability of ISO 14001 systems to identify issues and drive improvements. Another perspective is the potential of blockchain and other secure data-sharing technologies to enhance transparent reporting and foster trust in ISO 14001 performance, such as by connecting a firm's EMS data to supply chain partners or regulators in real time. Investigating the relationships of ISO 14001 and Industry 4.0/5.0 technologies enables scholars to enhance understanding of modernizing EMS for increased effectiveness.

Furthermore, we identified the influence of external context such as national climate policies, market conditions, and stakeholder pressures as an area where more comparative research is needed. ISO 14001 might have differing effectiveness in reducing emissions depending on external factors. Countries where climate policies and carbon pricing are more stringent, firms adopting ISO 14001 may be more motivated to reduce emissions. Conversely, in countries with lenient regulations, certification may serve a more symbolic purpose. A comparative study across multiple countries could analyze outcomes for ISO 14001 certified firms under varying regulatory frameworks or differing levels of investor pressure regarding ESG issues. Cross-national analyses utilizing databases of certified firms and national emission metrics may elucidate the contextual factors that moderate the impact of ISO 14001. This would provide policymakers with insights on how to enhance EMS adoption through complementary measures, such as incentives or stricter standards, to optimize environmental benefits.

As the horizon for the 2030 Agenda approaches, the corporate sustainability landscape is undergoing a profound structural evolution, transitioning from passive environmental compliance reporting to active, systemic impact management. Consequently, future research agendas should expand beyond the isolated study of ISO 14001 to examine its complex integration with a suite of emergent and highly specialized ISO standards designed to close existing systemic gaps, particularly regarding Scope 3 emissions, localized urban resilience, and holistic SDG alignment.

Foremost among these developments is the impending publication of ISO 53001 (Management Systems for the UN SDGs). Expected to achieve Final Draft International Standard (FDIS) status and full publication by mid-2026, ISO 53001 developed in strategic partnership with the United Nations Development Programme (UNDP) will provide the first certifiable, overarching framework for embedding the entirety of the 17 SDGs into corporate governance, strategy, and operations. Future empirical studies should investigate the architectural alignment of these systems: How can organizations utilize ISO 14001 as the specialized environmental engine within the broader, multi-disciplinary chassis of ISO 53001? Examining these synergies and mitigating the risk of audit fatigue between interconnected management systems will be paramount for strategic management scholars.

Furthermore, recent systematic reviews (2024-2025) consistently identify Scope 3 value-chain emissions as the primary driver of corporate carbon footprints, yet they remain the most poorly managed aspect of traditional ISO 14001 implementations due to a lack of direct operational control. To bridge this critical gap, future research should evaluate the synergistic application of ISO 14001 alongside ISO 20400 (Sustainable Procurement). ISO 20400 compels procurement divisions to pivot from initial-cost metrics to Total Cost of Ownership (TCO), integrating environmental externalities and supplier labor practices directly into purchasing decisions. A robust ISO 14001 system remains inherently vulnerable to greenwashing accusations if its procurement arm continues to source from highly pollutive, lowest-bidder suppliers. Academic inquiry should focus on how organizations can deploy ISO 20400 guidelines to exert downstream leverage, enforcing decarbonization compliance across Tier 1 and Tier 2 suppliers.

Similar systemic integrations must be studied regarding ISO 37101, analyzing how corporate EMS implementations can be harmonized with municipal strategies to foster sustainable development in communities.

Finally, the 2025 revisions to the broader ISO framework reflect a necessary pivot toward digital transformation. The integration of advanced technological infrastructure specifically Blockchain Technology (BT) and Internet of Things (IoT) sensor networks offer unprecedented opportunities for real-time, high-fidelity environmental management. Recent literature demonstrates that BT can provide immutable, transparent ledgers for carbon credit verification and supply-chain traceability, effectively neutralizing data opacity during environmental audits. Future research should prioritize pilot studies and empirical evaluations of "Digital EMS" environments, assessing whether the fusion of blockchain architecture and ISO 14001 accelerates the achievement of verifiable net-zero objectives and enhances stakeholder trust in sustainability disclosures.

Table 5 presents various gaps along with proposed research agendas and methodologies. Future research can enhance our comprehension of ISO 14001's significance in the sustainability transition and assist organizations and policymakers in optimizing the standard's effectiveness in attaining net-zero emissions.

Table 5: Identified research gaps and proposed future research directions for ISO 14001 and carbon neutrality

Research Gap	Future Research Agenda	Recommended Methodologies
Integration with emergent SDG Management Systems	Investigate the architectural alignment between ISO 14001 and the forthcoming ISO 53001 standard. Analyze how firms transition from environmental compliance to holistic SDG impact management.	Longitudinal case studies tracking early adopters of ISO 53001. System dynamics modeling to map overlaps between EMS and SDG management structures.
Mitigation of Scope 3 and Value-Chain Emissions	Study the synergistic implementation of ISO 14001 and ISO 20400 (Sustainable Procurement). Evaluate mechanisms for enforcing ESG criteria on Tier 1 and Tier 2 suppliers.	Supply-chain mapping. Surveys of procurement officers. Quantitative analysis of supplier carbon disclosures pre- and post-ISO 20400 adoption.
Technological enablement via Blockchain and IoT	Assess the efficacy of "Digital EMS" platforms. Explore how Blockchain Technology (BT) enhances the transparency and verification of carbon offsets within an ISO 14001 framework.	Pilot implementation studies. Cross-sector analysis of BT adoption in logistics and energy. Stakeholder trust surveys regarding immutable reporting.
Expanded SDG Alignment (SDGs 5, 10, 11, 16)	Examine how ISO 14001 intersects with environmental justice, gender equality (utilizing ISO 53800), and urban resilience (ISO 37101).	Mixed-methods approach combining qualitative interviews on corporate culture with spatial analysis of localized urban environmental impacts.
Causal attribution of ISO 14001 to absolute decarbonization	Isolate the causal effect of ISO 14001 certification on direct GHG emissions trajectories using robust, long-term data sets rather than indirect proxies.	Difference-in-differences analyses. Propensity score matching of certified vs. non-certified firms using standardized ISO 14064-1 GHG inventories.
Research is sparse for certain industries, construction, services that now increasingly hold ISO 14001 certificates.	Investigate industry-specific decarbonization strategies under ISO 14001 construction, transportation. Compare EMS adoption and net-zero practices across sectors to identify barriers.	Industry-level surveys and structured interviews. Comparative case studies highlighting best practices and obstacles in implementing ISO-driven carbon reductions.

Limited research on how ISO 14001 interacts with other standards ISO 50001, EMAS, ECOLABEL to drive decarbonization.	Explore combined effects of integrated management systems on achieving net-zero goals. Study incorporation of carbon accounting standards into EMS.	Comparative case studies. Surveys of certified firms on usage of combined ISO frameworks. Correlation/regression analysis linking multi-standard adoption to emission metrics.
Insufficient focus on human factors, leadership, culture, employee engagement in ISO-driven carbon reductions.	Study the role of corporate culture and Green HRM in motivating ISO 14001's effective use. Assess training, incentives, and internal communication strategies.	Interviews or focus groups with managers and employees. Organizational surveys measuring variables like climate leadership and training programs.
Linkage between ISO 14001 and formal net-zero commitments.	Investigate how ISO-certified firms incorporate net-zero roadmaps into EMS. Develop guidelines for integrating ISO 14001 with external carbon accounting/reporting.	Case studies of corporations with net-zero targets. Surveys of EMS practitioners on use of carbon accounting tools within EMS.

6. Conclusion and Implications

This study offered a comprehensive examination of how ISO 14001 has been researched and applied in the context of carbon neutrality and sustainable development over the last decade. By integrating a bibliometric analysis with a systematic literature review of 62 Scopus-indexed publications from 2015 to 2025, we mapped the evolution of ISO 14001 scholarship and practice in the era of the SDGs. The bibliometric results revealed an expanding yet fragmented research landscape: the ISO 14001 literature is concentrated in leading sustainability journals and is geographically clustered with high contributions from Spain, the UK, China, and other major economies. Thematically, the field has centered on environmental performance, energy management, integrated management systems, and related subjects, indicating a progression of research from broad environmental management to more precise intersections with carbon management and sustainability strategies.

The systematic review established a well-structured framework of EMS activities and sub-activities that organizations have implemented under ISO 14001 to address climate concerns and improve environmental performance. We found that while ISO 14001 provides a foundational governance scaffold for integrating climate objectives into corporate strategy, it does not function as a standalone, versatile toolkit for carbon accounting. Because the standard lacks prescriptive mathematical methodologies or dedicated clauses for calculating carbon savings derived from environmental improvements, its successful application toward net-zero status absolutely requires hybridization. Organizations must seamlessly embed external, rigorous quantitative protocols such as the ISO 14064 series or the WRI/WBCSD GHG Protocol within their ISO 14001 PDCA cycle to translate conceptual climate policies into deeply operational, verifiable emissions reductions. Many firms use ISO 14001 to set policies consistent with carbon neutrality and to implement indirect improvements like energy efficiency, but truly achieving and demonstrating sustained, absolute emissions reductions directly attributable to ISO 14001 remains challenging and, so far, relatively rare in the literature. The effectiveness of ISO 14001 in facilitating decarbonization is typically assessed using indirect metrics, such as process improvements and waste reduction, rather than through direct, long-term emissions tracking. Our review suggests that more outcome-based evaluations examining emissions trajectories pre- and post-certification are needed to fully ascertain ISO 14001's impact on climate mitigation. Despite these limitations, the study offers a more specific contribution than a descriptive mapping of ISO 14001 activities. Its primary theoretical contribution lies in identifying the certification-to-decarbonization translation gap. The review shows that certification does not automatically produce substantive carbon reduction, even though the standard contains managerial routines that are compatible with environmental improvement. Meaningful outcomes depend on implementation depth, the integration of carbon objectives into strategic and operational decisions, the use of complementary measurement practices, and the institutional context surrounding the firm. By foregrounding this mechanism, the study explains why the empirical literature reports heterogeneous carbon outcomes rather than a uniform certification effect.

From a theoretical standpoint, this study bridges the literature on environmental management systems with the emerging discourse on corporate decarbonization and sustainable development. We demonstrated how the ISO 14001 standard traditionally viewed as a basic operational or compliance tool can be reconceptualized as a strategic mechanism that aligns with global sustainability frameworks. By introducing the Adaptive Decarbonization Translation Framework (ADTF), this study synthesizes the existing literature into a cohesive theoretical model. The ADTF clarifies that successful decarbonization is a function of the organization's EMS translation capabilities, external institutional drivers, and rigorous evaluation feedback. For corporate decision-makers, this framework provides a practical roadmap for utilizing the PDCA cycle to bridge high-level climate mandates with day-to-day operational realities. Future researchers can leverage the ADTF to empirically test how varying institutional pressures moderate the effectiveness of specific ISO 14001 clauses in achieving absolute emissions reductions. Moreover, the EMS activities framework and SDG linkage matrix we developed are scholarly contributions that offer a reusable analytical lens. Future researchers can apply these frameworks to systematically evaluate the depth of EMS integration in different contexts, compare the effectiveness of various environmental management approaches, and explicitly link corporate environmental practices to broader sustainability outcomes in a consistent manner. This study clarifies the processes (activities and sub-activities) by which ISO 14001 impacts carbon performance, thereby contributing to management theory regarding the influence of structured management systems on organizational change and environmental innovation.

This study highlights the importance of integrating bibliometric and systematic review methodologies to investigate an expanding and fragmented area of research. The bibliometric analysis provided a quantitative framework that revealed trends, significant works, and collaboration networks, thereby enhancing the qualitative findings from the systematic review. The application of PRISMA guidelines enhanced the transparency and rigor of our literature selection and synthesis process, which is especially advantageous in a field characterized by interdisciplinary research and varying terminologies. Researchers examining related interdisciplinary subjects, including alternative management standards or overarching sustainability challenges, may utilize our dual-method approach to achieve comprehensive understanding. The integration of content analysis with bibliometric data, such as linking thematic clusters to performance outcomes, yields more comprehensive insights than either method independently.

The findings of ths study hold considerable practical implications for practitioners and policymakers. The findings suggest that organizations ought to utilize ISO 14001 not solely as a certification checklist, but as an adaptive framework to integrate climate action into their fundamental business operations. Policymakers and industry leaders can promote the perception of ISO 14001 as a strategic asset for decarbonization among firms. Regulatory bodies and government programs may offer incentives or recognition to companies that utilize their EMS to achieve measurable emissions reductions or to support national SDGs targets. Stakeholders should prioritize the underlying EMS activities that facilitate performance improvements, rather than viewing ISO 14001 merely as a certification. The EMS activities can be utilized by practitioners to evaluate and enhance their environmental programs. Are all pertinent phases such as policy, planning, implementation, review being employed to tackle carbon and sustainability challenges? What are the existing gaps, such as insufficient employee engagement or limited supplier involvement, that could be addressed to improve outcomes?

Additionally, to overcome the persistent technical challenges associated with the global energy transition and the notoriously difficult management of Scope 3 emissions, decision-makers should actively pursue the structural integration of ISO 14001 with highly specialized frameworks. Implementing ISO 14001 in tandem with ISO 50001 (Energy Management) and adhering to the rigorous methodologies of the Science Based Targets initiative (SBTi) creates a synergistic, highly technical approach that bridges the gap between generalized environmental management and targeted, absolute emissions accounting and reduction. To further optimize implementation, organizations must address the technical and administrative burdens identified in the literature, particularly the heavy data intensity required for accurate, auditable carbon monitoring. The integration of advanced digital technologies including Internet of Things (IoT) sensors for continuous emissions monitoring, automated compliance dashboards, and AI-driven lifecycle assessment tools into the traditional EMS framework presents a critical opportunity. Digitalization enhances real-time decision-making, improves the accuracy of GHG inventories, and significantly reduces the bureaucratic overhead that often stifles the continuous improvement cycle.

Policymakers, conversely, should recognize the severe structural barriers inhibiting SME participation in the global decarbonization effort. Rather than imposing uniform regulatory pressures that may inadvertently drive SMEs toward symbolic, superficial certification to maintain market access, government entities and industry consortia should focus on enablement. Policymakers should develop targeted capacity-building programs, localized networking support, subsidized technical consultancy, and specific financial incentives tailored to assist SMEs in overcoming the initial resource constraints associated with substantive EMS implementation and the adoption of low-carbon technologies.

Furthermore, aligning with the SDGs emphasizes the significance of integrating ISO 14001 initiatives with comprehensive sustainability reporting and strategic planning. Companies that are actively pursuing SDG-related initiatives can use ISO 14001 as the internal mechanism to achieve those external goals, ensuring that sustainability commitments are backed by concrete management actions. For policymakers, promoting ISO 14001 adoption in conjunction with national sustainability agendas such as encouraging certified companies to report their contributions to SDG 13, 7, and 12 could amplify the standard's impact on public policy goals.

Our findings also suggest that greater attention to internal management frameworks, digital tools, and life-cycle approaches will further facilitate translating EMS adoption into measurable emissions outcomes. Organizations should consider integrating advanced monitoring IoT sensors, real-time data analytics into their EMS to capture emissions data more accurately and respond quickly to any deviations from targets. Adopting a life-cycle perspective that considers supplier and product impacts beyond the factory gate may enhance the reach of ISO 14001, addressing the substantial emissions that frequently arise upstream or downstream. This may entail collaborations or capacity-building initiatives wherein larger companies support smaller suppliers in enhancing their EMS capabilities, or the formation of industry consortia that disseminate best practices and tools for managing scope 3 emissions.

ISO 14001 has demonstrated its effectiveness as a multifaceted tool within the corporate sustainability framework. This study confirms its significance to the carbon neutrality agenda and emphasizes the significance for innovation and integration to realize its full potential. As global businesses intensify their initiatives to address climate change and the 2030 deadline for numerous SDGs approaches, the significance of ISO 14001 will become increasingly vital. This study provides a systematic framework for organizations to transition from general sustainability goals to ongoing enhancements in environmental performance. The challenge and opportunity ahead involve improving these systems through research, policy support, and practical innovation to achieve the deep decarbonization and sustainability transformations required by our global goals.

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