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REVIEW ARTICLE

Mapping the Implementation of the United Nations Sustainable Development Goals

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Received: 6 October 2024 | **Revised:** 28 May 2025 | **Accepted:** 9 June 2025

Keywords: constraints | implementation | mapping | sustainable development | UN SDGs

ABSTRACT

The implementation of the United Nations' Sustainable Development Goals (SDGs) is a process, which has been mobilizing the international community—and resources—in an unprecedented way. However, even though this worldwide movement is expected to mobilize stakeholders from across all society, it remains unclear how this process is yielding the expected results. In an attempt to address this knowledge gap, this study examines the literature on the implementation of the SDGs and performs a mapping of the extent to which they are being implemented. This study combines a bibliometric analysis using the major scientific databases, with a critical appraisal of the experiences and progresses documented in the "Encyclopedia of the UN SDGs". The results show that whereas significant progress has been seen in implementing some SDGs, other goals remain underprioritized or under-resourced. Also, some goals such as SDG13 (Climate action), SDG 3 (Health and Well Being), and SDG 16 (Peace, Justice, and Strong Institutions) are more prominently present in the literature, when compared with the others. Based on the findings, the paper outlines some of the research needs, which should be met, so as to address the implementation problems the mapping has identified.

1 | Introduction: The UN Sustainable Development Goals and Their Implications

The United Nations General Assembly agreed in the creation of a new agenda, entitled "Transforming Our World: The 2030 Agenda for Sustainable Development," which was endorsed by the 193 Member States of the United Nations, and includes 17 Sustainable Development Goals (SDGs).

Overall, the main aims of the Agenda 2030 are to act as an enable towards reducing poverty, creating better livelihoods, protecting the planet, and ensuring peace and prosperity amongst its inhabitants (Ali et al. 2018). The implementation of the goals has been skewed across different countries due to financial circumstances and differences in the access to resources among the different nations (Cernev and Fenner 2020). Other challenges that impact the SDGs refer to the lack of policies and capacities that

This paper is part of the "100 papers to accelerate the implementation of the UN Sustainable Development Goals" initiative.

could support coherent and integrated planning and implementation (Allen et al. 2018), particularly to evaluate and monitor progress, and allows potential synergies to be expanded.

In order to achieve the SDGs, global action is essential, and many barriers—which include but are not limited to financial issues—need to be overcome. However, it has been noted globally that the implementation of certain SDGs may come at the expense of others, thus slowing the overall progress toward implementing sustainable development. More specifically, this has been described as trade-offs and acts as a limitation to the achievement of the goals (Cernev and Fenner 2020). Nevertheless, Fonseca et al. (2020) conclude in their research that the transition toward achieving the Sustainable Development Goals presents many opportunities for mutual reinforcement rather than inhibition.

The United Nations has consistently published reports evaluating global progress toward sustainable development. The 9th edition of the Sustainable Development Report (SDR), released by the UN Sustainable Development Solutions Network (SDSN), reveals that none of the 17 Sustainable Development Goals (SDGs) are currently on track to be fully achieved by 2030. Furthermore, the report estimates that only 16% of the SDG targets are showing measurable progress (Sachs et al. 2024). The lack of progress is universal and has undoubtedly been hindered by the impacts of the climate crisis, the war in Ukraine, a weak global economy, and the lingering effects of the COVID-19 pandemic (UN DESA 2023).

The COVID-19 pandemic has reversed some of the progress made towards the 2030 Agenda (United Nations 2020) and exposed significant vulnerabilities in achieving its full implementation (UN DESA 2020; Leal Filho et al. 2020). However, the SDGs have remained timely and highly relevant as a framework for local COVID-19 recovery strategies, with cities and regions taking active steps to promote them. OECD (2022) highlighted that many cities and regions have leveraged the SDGs to shape their COVID-19 pandemic recovery strategies, even though critical gaps have remained in areas such as multi-level governance, financing and institutional capacity.

The latest United Nations reports emphasize urgent priorities for achieving the SDGs. The UN Report 2023 identifies five key areas for transformative action: recommitment to accelerated efforts, integrated policies for inclusion and sustainability, strengthening governance and institutions, resource mobilization for vulnerable countries, and enhancing the multilateral system (UN DESA 2023). Meanwhile, the UN Report 2024 highlights climate change, peace and security, and inequalities both within and between countries as critical areas requiring accelerated action over the next six decades (UN DESA 2024). Additionally, UNESCO's report Migration, Displacement and Education underscores the key role of education in addressing the challenges of migration and displacement, especially associated with conflicts, calling for stronger international support to ensure inclusive, equitable, and quality education for all in the context of global mobility (UNESCO 2019).

Moreover, it has been reiterated that proper governance is key to achieving the SDGs (Biermann et al. 2017). It has been observed that countries with different economic status have different governance systems in place, and these, in turn, influence the achievement of the SDGs. In the cases of Japan and Indonesia, for instance, it was found that each lacked different structures for the SDGs implementation (Morita et al. 2020). Japan has a relatively good overall set-up, but faces challenges in the monitoring and evaluation of the SDGs implementation process, whereas Indonesia faces some challenges related to the overall vision, objectives, and implementation. Therefore, both countries have achieved different levels of sustainability. This trend illustrates the relevance of collaborative action of governments, as a tool to address the deficits among different countries and in building a proper structure for the SDG implementation process (Morita et al. 2020).

In other instances, the importance of the private sector of countries is stressed. It is widely acknowledged that the private sector is important for accelerating the implementation of the SDGs. This is partly due to the fact that this sector is responsible for much use of resources and environmental degradation, and many industrial activities still lack exploration and recycling balance measures, often leading to adverse effects on human and ecological health (Ali et al. 2017; Andalib Ardakani and Soltanmohammadi 2019). Therefore, sustainability practices in the industry, as advocated by Goal 9 (Industry, innovation and infrastructure) may address these problems and—inter alia—may increase the rate at which SDGs are achieved. However, the role of the private sector is often downplayed due to the overall lack of interest in ecologically efficient development, a trend which leads to a shortage of investments, a lack of prioritization, and improper evaluation and monitoring of ecologically and economically efficient measures (Rashed and Shah 2020).

Furthermore, education has been highlighted as a key to the achievement of sustainable development. The contribution of higher education institutions in implementing the SDGs—especially on campus and among university communities—has been demonstrated on various occasions and derives from their ability to promote education for sustainable development (ESD) and sustainable development programmes (Zhou et al. 2020). ESD involves not only integrating critical topics like climate change and sustainable consumption into educational content, but also promoting a shift towards interactive, learner-centered, and transformative teaching approaches that encourage collaboration and participatory problem solving (UNESCO 2015, 2017).

Concrete actions are required in terms of funding streams for research, more integration of the SDGs into teaching, and greater reliance on the technical expertise of universities to not only support the implementation of the goals but also accelerate the outcomes (Leal Filho 2020). Furthermore, lifelong learning is vital in spreading sustainability knowledge in informal settings, which can also contribute greatly to the accomplishment of the SDGs (Karani and Preece 2020). To fully realize the potential of education in supporting the 2030 Agenda, strong international policy frameworks and coordinated global efforts are essential to scale up ESD and SDG implementation, ensure adequate resources, and align educational strategies with the broader sustainability agenda (UNESCO 2014).

Synergies between the SDGs and other policies need to be made. An example is the Paris Climate Agreement, which shares

FIGURE 1 | Positive and negative aspects of the implementation of the SDGs. *Source:* Prepared by the authors.

certain objectives with the SDGs (e.g., the need for climate action), which can be used to accelerate progress. More recently, the role of science in SDGs attainment is becoming more widely acknowledged, especially the need for more research to be carried out, with the SDGs in mind (Sachs et al. 2019).

The role of research is complex and manifold. On one hand, it can have theoretical and practical contributions to all areas of knowledge and consequently touch on different SDGs—health advancements, technological support for improved production, opportunities for reducing environmental impacts and carbon emissions of different processes, among others. In these cases, however, further collaboration is needed between academia and other social-economic sectors (Eweje et al. 2020; van Zanten and van Tulder 2021). On the other hand, it can enhance the capacity of all these different sectors to properly measure and monitor progress towards the implementation of the SDGs, as constantly innovative methodologies and processes are developed (Avtar et al. 2019; Giles-Corti et al. 2020).

As the last years have been marked by several efforts to support the implementation of the SDGs and the next 5 years will be crucial for accelerating progress, this paper aims to report on an updated assessment of the literature on the implementation of the SDGs and provide a picture of current trends and needs to overcome the observed challenges.

Figure 1 summarizes the positive and negative aspects of the process of implementing the SDGs discussed in this section. Exploring the former and overcoming the latter must be the core effort in the next years of the 2030 Agenda. Called as the Decade of Action, the last 10 years to deliver the SDGs are to be marked by better communication and more opportunities and synergies between goals, in addition to alignments among all sectors and transformative social, economic and environmental solutions (Sachs and Sachs 2021; United Nations 2020).

2 | Methods

This study was conducted by combining two main strands: a *bibliometric analysis* and an *implementation analysis*. In terms of the first approach, it should be noted that an upward trend in the number of academic articles published annually has been observed in the past decades. This makes it challenging to keep updated with the structure and trends related to research fields as using traditional review methods is time and resource intensive (Sharifi 2021). To deal with this issue, several software tools have been developed that facilitate obtaining an overview of a field and detecting major thematic focus areas based on text mining approaches. VOSviewer is one such tool that we have used in this study to detect and map major focus areas related to the implementation of SDGs (van Eck and Waltman 2010). The objects of analysis in VOSviewer are academic articles archived in the Web of Science (WoS), a prominent database for indexing peer-reviewed academic articles.

To retrieve relevant publications, we designed a broad-based search string that includes combinations of terms related to SDGs and implementation (using the search terms: TS = (("SDG*" OR "sustainable development goal*") NEAR/4 ("implement*" OR "action*" OR "best practice*" OR "success stor*" OR "operationali*" OR "achiev*" OR "monitor*" OR "adoption" OR "deploy*" OR "application*" OR "attain*")) and Indexes = SCI-EXPANDED, SSCI, A&HCI, ESCI). The initial search returned 3276 articles. These were screened to exclude irrelevant records, and at the end 2242 articles were selected for analysis using VOSviewer. The software provides different types of bibliometric analysis, such as co-citation analysis, bibliographic coupling, and term co-occurrence analysis. As our aim was to understand major thematic areas, we used the term co-occurrence analysis in this study. This analysis reveals terms that co-occur frequently in titles, abstracts, or keywords of academic literature. To have a more comprehensive focus, we did the analysis using abstracts. To improve accuracy, before doing the final analysis, a thesaurus file was developed to avoid considering synonyms separately (e.g., SDGs and 'sustainable development goals'). For better presentation, we set the minimum co-occurrence frequency to 17. The output of term co-occurrence analysis is a graph of nodes and links, where node size is proportional to the occurrence frequency and link width is proportional to the strength of links between two terms. Terms that are closely linked to each other form clusters that indicate thematic focus areas.

TABLE 1 | Characteristics of the encyclopedia of the UN Sustainable Development Goals.

	Publication year	Number of chapters	Number of accesses by September 2024		Publication year	Number of chapters	Number of accesses by September 2024
SDG 1	2021	395	15,000	**SDG 10**	2021	254	13,000
SDG2	2020	181	11,000	**SDG11**	2020	272	24,000
SDG3	2020	234	28,000	**SDG12**	2020	243	32,000
SDG4	2020	352	31,000	**SDG13**	2020	159	21,000
SDG 5	2021	276	20,000	**SDG 14**	2022	260	10,000
SDG 6	2022	250	6990	**SDG15**	2021	263	15,000
SDG7	2021	289	12,000	**SDG16**	2021	306	12,000
SDG8	2021	304	14,000	**SDG17**	2021	307	11,000
SDG9	2021	341	18,000	**Total**			293,990

Interpreting these clusters requires familiarity with the field. For this purpose, we have referred to selected studies that provide justification and evidence for the way terms are linked.

We complemented this through an implementation analysis of the volumes of the Encyclopedia of the UN Sustainable Development Goals. The focus here was to understand how scientific research is contributing to the implementation of the SDGs. The publication is composed by 17 volumes, one for each goal, with an average of 275 chapters per volume. The Encyclopedia has over 4600 chapters and was published between 2020 and 2022 (Table 1). By September 2024, the chapters achieved over 290,000 accesses. Involving more than 1500 authors and contributors, the Encyclopedia is the largest editorial project on sustainable development ever undertaken.

By means of a content analysis, each chapter available in the living reference work was systematically screened to identify references to the targets of the respective SDG volume in which the chapter was published. These references were classified into two categories: (1) mentions of progress in the implementation of the target and (2) mentions of gaps in the implementation of the target. The analysis was then conducted quantitatively, calculating the percentage of mentions to each target in relation to the total number of chapters that included references to SDG targets.

To ensure consistency in classification, a predefined coding framework was applied, with clear criteria for distinguishing between progress and gaps. Mentions of progress were coded when chapters provided evidence of advancements, successful initiatives, or improvements in achieving the SDG target. Conversely, mentions of gaps were identified when chapters highlighted barriers, challenges, or unmet needs hindering progress toward the target. The analysis was conducted manually by the authors of this study, all sustainability researchers trained in qualitative analyses. This methodological approach allowed for a structured assessment of the extent to which different SDG targets were addressed in the reference work.

3 | Results and Discussion

This section presents the findings from the study, starting with the bibliometric analysis and then with the implementation analysis.

3.1 | Bibliometric Analyses

The output of the term co-occurrence analysis is shown in Figure 2. The figure provides some interesting insights about the major focus of research on the implementation of SDGs. In the figure, terms that have co-occurred frequently in the literature form clusters that are shown in unique colors. It is also possible to identify sub-clusters under each cluster. This clustering approach makes it easier to interpret the term co-occurrence map. However, it should be noted that there are also connections between and across different clusters. Terms such as climate change (and related terms such as CO_2), management, health, policy, impact, and institutions have co-occurred more frequently with other terms. This may indicate that more attention has been paid to the implementation of SDG 13 on climate action, SDG 3 on health, and SDG 16 on peace, justice, and strong institutions. Water resources (SDG 6), food security and agriculture (SDG 2), energy (SDG 7), mortality (SDG 3), poverty (SDG 1), cities (SDG 11), land and biodiversity (SDG 15), education (SDG 4), innovation (SDG 9), consumption (SDG 12), economic impact and circular economy (SDG 8), gender and women (SDG 5), and equity (SDG 10) are other frequently used terms (in descending order of frequency).

Four major clusters can be identified in Figure 2. Two core terms (i.e., SDGs and sustainability) are positioned at the intersection of the four clusters, indicating that implementing the SDGs requires taking action across different sectors. Two clusters (in yellow and blue) are dominated by terms related to climate change. This, again, confirms the major focus on SDG 13 in the research on SDGs implementation (Salvia et al. 2019). The yellow cluster is mainly focused on climate change adaptation and

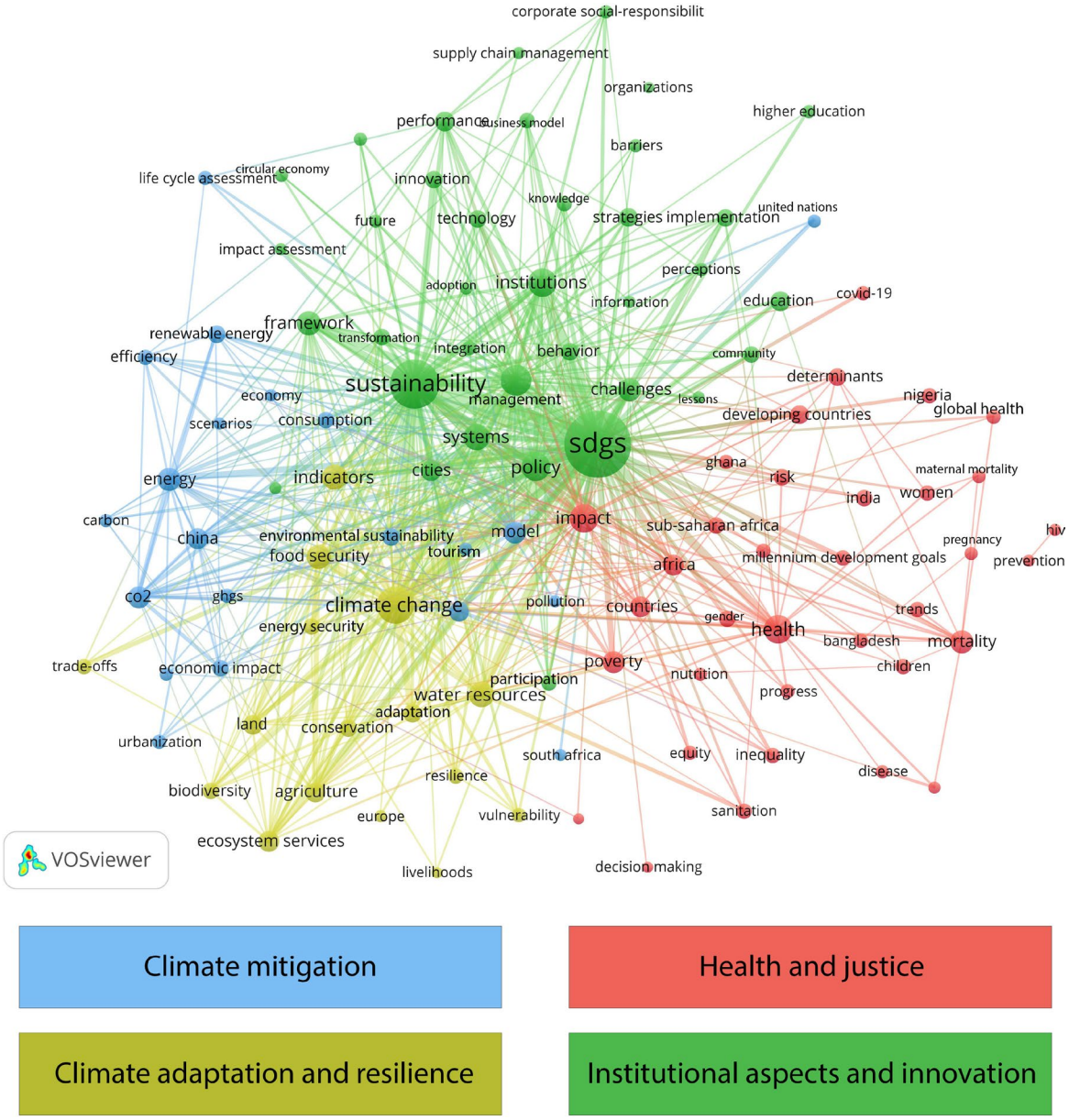

FIGURE 2 | The output of term co-occurrence analysis. In this figure, each node represents a term that has co-occurred frequently with other terms. Node size is proportional to the co-occurrence frequency, and link thickness is proportional to the strength of connection between terms.

resilience. Water resources, food security, and energy security are three key terms in this cluster. This indicates increasing concerns over the impacts of climate change on the availability and accessibility of these resources.

Climate change is exacerbating food, energy, and water insecurities, especially in the developing world. However, research in these regions often focuses on local or regional implementation rather than taking a more systematic approach that could enable the replication of solutions or the dissemination of lessons learned and experiences to similar regions (Babel et al. 2020; Verbist et al. 2020; Henry 2019). As a consequence, although implementation-focused research exists regarding the trade-offs and synergies between SDGs, the water-food-energy nexus is an area that still requires further development (Cansino-Loeza and Ponce-Ortega 2020; Leung Pah Hang et al. 2016; Marttunen et al. 2019). Water insecurity is also linked to the capacity of regions to implement a blue economy, particularly factors such as national stability, corruption, and infrastructure. These challenges can be improved by integrating historical natural and social science data, as well as through collaborative planning approaches involving researchers and stakeholders (Cisneros-Montemayor et al. 2021). Similarly, the food system has been a critical area for transformation to tackle food security in respect to climate change needing financial, technological, and policy interventions (Campbell et al. 2023).

In addition, terms such as ecosystem services, agriculture, land, and biodiversity also form a sub-cluster in this adaptation-focused cluster. Their significance for climate adaptation and livelihood security is emphasized by the fact that research on implementation of SDGs has shifted more focus on SDG 14 life below water and SDG 15 life on land, both of which targeting biodiversity conservation and restoration and

ecosystem services. Weber and Weber (2020) demonstrated the link between these environmental-focused goals to ecological modernization theory discussing the link between environment and development, suggesting that means of implementation for both are aligned, while other studies presented cases for revisiting the idea of the value of ecological systems of a country (e.g., Cumming et al. 2017; Wurz et al. 2022). Strassburg et al. (2020) showed that the use of a multicriteria optimization approach in ecosystem restoration might avoid up to 60% of expected extinctions and restrain 30% of the total CO_2 increase in the atmosphere, while Keith et al. (2023) proposes a function-based typology approach with a hierarchical structure to progress on developing conservation targets and sustainability goals. Pan et al. (2023) show that the ecosystem services and green infrastructures in the residential, transport and industrial sectors could reduce urban carbon emissions by up to 25% in European cities, highlighting the contribution of consistent nature-based solutions to achieve carbon neutrality.

The blue cluster is closely linked to the yellow one but with more focus on climate mitigation-related issues. As expected, the term energy has a central position and is closely linked to terms such as CO_2, China, renewable energy, efficiency, and economic impact. This is strongly associated with the need for decarbonization through energy efficiency improvements and the transition to renewable energy. Emerging nations like China have a significant role on the path to a global de-carbonization, and sector-based studies are prominent (Li et al. 2017; Stephenson et al. 2021; Zhao et al. 2021). Closely linked is the interaction of mitigation-based energy issues to urbanization and the relevant economic development. In their 2020 study, Manesheri et al. analyzed data for selected Australian cities for the period of 1986–2011 and suggested that climate change strategies and policies need to consider urbanization, along with greenhouse gases, to cope with future climate change scenarios.

Similarly, Huo et al. (2021) tried to assess the acceleration of urbanization and its potential challenges for China's decarbonization efforts with scenario simulation arguing that effective strategies in the building sector can be achieved with careful planning. A further link can be observed between the research on biodiversity-urbanization-energy as the interlink between the terms as well as the tradeoffs and synergies between their associated goals are an upcoming area implementation-based research although currently these studies are towards the adaptation to climate change effects derived by urbanization (Huang et al. 2021). Keith et al. (2023) call for a new urban narrative for sustainable development centered on place-based approach, capable to better integrating the biodiversity, health and well-being and climate change agendas, and create larger communal space in which researchers, urban practitioners, policymakers and local government representatives undertake symbiotic approaches (Leal Filho et al. 2022).

Moving on from impacts on biodiversity or the ecological systems in general, the health aspect of the SDGs has become increasingly important in cities (Crane et al. 2021) but also the recent global epidemic (Talukder et al. 2021; Joshi et al. 2021; OECD 2022) based on the complex system of nature–human linkages and interdependencies. An amplified number of studies on assessment as well as implementation is observed. Fenner and Cernev (2021) discussed the success of specifically SDGs 1, 3, 14, and 15 and offered that unless there is a re-focus on SDGs, the target-based outcomes may be severely hindered.

As implied by the contents of the green cluster on institutional aspects and innovation, all these interdependencies are yet to be transformed from a conceptual basis to implementation, and the implementation research needs to be supported by the ownership of their local, national, or global institutions. Institutions are the driving forces to disseminate the implementation-based research by encouraging the research on trade-offs and synergies between the SDGs. In the green cluster, the term institution has a central position. Again, this highlights the significance of institutional capacity for the achievement of SDGs. This cluster indicates that institutions have a crucial stand by aiding the implementation-based research in all aspects, from innovation to knowledge, strategic implementation, education, technology, and corporate social responsibility. Here, SDGs 16 and 17 come into play, specifically underlining the difference between developed and developing countries. Nemat and Pain (2021)'s argument on the lack of reference or coverage to the so-called illicit economy poses a high threat to the overall global progress. This is coupled with many other studies in vulnerable regions with similar problems (Calvo et al. 2019), fully diverging from the implementation research coverage with a different take of challenges for developed countries (Janowski 2016).

Finally, the red cluster is dominated by terms related to SDGs 1, 3, 4, 5, and 10. These are issues related to health and justice. The terms of this cluster are mainly discussed in contexts such as Sub-Saharan Africa, Nigeria, Ghana, India, Bangladesh. As expected, with the global COVID-19 pandemic—which peaked in 2020–2022—an accumulation of research is in health, followed by poverty and inequality-focused research. Nonetheless, particular attention should be given to the recovery of the capacity of conservation practices in the protected areas of these regions, well characterized in terms of illegal wildlife trade, poor governance, and persistent funding shortages, and currently experiencing an alarming cropland expansion, especially the Afrotropical region (Meng et al. 2023). The lack of the term governance or its synonyms in this cluster, indicates that implementation research avoids or lacks the association with governments of the developing countries to these inequality-based problems of the developing countries. Here, once again, the emphasis is on SDG 17, "partnerships for the goals" as at the core of SDGs, the understanding is that not one government, NGO or even country can achieve these global goals and progress requires collaboration especially that of governments with the aid of private sector and civil society to push all decision makers towards a firm approach towards these global goals (Schaltegger et al. 2018; Vazquez-Brust et al. 2020).

In order to complement this analysis, Table 2 presents the leading authors publishing on matters related to sustainable development (2015–2024), based on Leal Filho et al. (2024). The list reflects a diverse range of institutions and geographic regions, and reflects the interdisciplinary nature of sustainability research, as the authors' works span environmental management, education, energy systems, circular economy, and institutional governance. Their publication records indicate their role in influencing discussions

TABLE 2 | Leading authors publishing on matters related to sustainable development.

Author	Institution	Publications
Leal Filho, W.	Hamburg University of Applied Sciences/ Manchester Metropolitan	158
Ren, J.	The Hong Kong Polytechnic University	92
Adebayo, T.S.	Cyprus International University	64
Schaltegger, S.	Leuphana Universität Lüneburg	57
Anholon, R.	State University of Campinas	52
Azapagic, A.	The University of Manchester	50
Streimikiene, D.	Lithuanian Energy Institute	48
Svensson, G.	Kristiania University	46
Duić, N.	University of Zagreb	46
Klemeš, J.J.	Brno University of Technology	45

on sustainability and providing empirical and theoretical findings to support SDG-related policies and practices.

3.2 | Implementation Analyses

The second source of data collection was focused on the content analysis of the Encyclopedia's chapters and the identification of progress and gaps addressed by the authors related to each goal/target. Table 3 presents an overview of the results, showing the percentage of the content that approaches gaps and progress for each target, where the references are categorized based on the level of progress and gaps observed for each target. The analysis shows perceptions of how the targets are being addressed in terms of their implementation progress and identifying areas where gaps exist. Targets with strong progress indicate successful actions, while targets with significant gaps signal areas that require additional attention and resources. The strongest references to implementation progress (> 50%) are noted for specific targets in SDGs 9, 14, 15, and 17 (i.e., 9.1, 9.4, 14.A, 15.1, 15.5, 15.9, 17.16, and 17.17) and the targets with the fewest references to implementation gaps (0%) are within SDGs 1, 3, 4, 9, 11, 12, 14, and 15 (1A, 3.5/3A/3D, 4.6-4C, 9.2/9.4, and 11.4-5/11.4-5/11B-C/12.1-2/12 .4-C/14A/15.3-4/15.6/15.8).

SDGs 9 and 14 have therefore the strongest indicators of progress. In SDG 9, key progresses were related to developing and upgrading infrastructure. These topics were especially referred to as playing a key role in evidence-based policymaking and smart and green technologies (Türkeli and Kemp 2021). Unlike the other goals in this section, SDG 14 prominently features a "means of implementation" target as its primary focus for implementation progress. This target refers to the implementation of international sea law. Studies highlight the significant contributions of the blue economy and sustainable ocean management to national policies and practices (Nursey-Bray and Marsh 2022). They emphasize the necessity for more data and research on the effects of local changes in the global context. The Antarctic Treaty is cited as a strategic model for fostering international cooperation (Xavier and Convey 2022), while co-governance and participatory management are recognized as crucial elements in effective ocean stewardship (Martinho 2022).

SDGs 15 and 17 also demonstrate strong progress. For SDG 15, which focuses on life on land, progress is notably observed in target 15.1, concerning the conservation and restoration of terrestrial and freshwater ecosystems. This includes an increase in protected areas and efforts to reverse ecosystem degradation. For instance, Nkonya and Kato (2020), among the chapters selected for indicating progress towards this target, report on effective policies that support both economic and institutional environment to offer legal protection and economic incentives for landowners and operators. Adeniyi (2021) covers the Red List Indices of Threatened Species—the indicator of the changing state of global biodiversity, and calls for action in addressing the Red List and species extinction in order to help achieve 5.1, amongst other targets. Similarly, target 15.5, which addresses the urgent action needed to reduce biodiversity loss, shows progress, particularly in policies aimed at preventing species extinction. Traylor-Holzer et al. (2019) and Funk (2020) are examples of chapters that reported on potential progress around prevention of extinction, covering ex-situ management and the process of mapping ecoregions and their role in planning conservation actions, respectively. In SDG 17, which centers on partnerships for the goals, both target 17.16 (enhancing the global partnership for sustainable development) and target 17.17 (encouraging effective partnerships across sectors and stakeholders) show strong progress. These targets have benefitted from increased international cooperation and multi-stakeholders partnerships aimed at addressing cross-cutting issues of all goals, and chapters coverage of these issues range from analyzing key systemic issues for implementation (Diemer et al. 2020) to the role of specific actors, such as the private business sector and its finance and trade contributions (Amato 2020).

An example of good practice for implementing Sustainable Development Goal 13, which focuses on climate action, is the Climate Smart Agriculture (CSA) approach. This practice aims to increase agricultural productivity while enhancing resilience to climate change and reducing greenhouse gas emissions. By integrating crops and livestock, farmers can optimize resource use (like water and nutrients), improve soil health, and increase biodiversity. This approach also allows for better pest management and can enhance resilience to climate shocks. Another approach is training and supporting farmers in sustainable practices and technologies. This can include providing access to climate information, best practices, and advanced agricultural techniques, enhancing their

TABLE 3 | Analysis of implementation by SDG and target.

SDG 1	1.1	1.2	1.3	1.4	1.5	1.A	1.B						
Progress	22%	39%	26%	35%	30%	26%	17%						
Gaps	13%	9%	4%	9%	4%	0%	4%						
SDG 2	2.1	2.2	2.3	2.4	2.5	2.A	2.B	2.C					
Progress	33%	14%	24%	19%	14%	0%	0%	14%					
Gaps	38%	14%	33%	19%	10%	5%	10%	24%					
SDG 3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.A	3.B	3.C	3.D
Progress	11%	5%	5%	26%	0%	11%	5%	11%	21%	0%	16%	16%	0%
Gaps	16%	5%	11%	16%	0%	11%	5%	11%	21%	0%	21%	16%	0%
SDG 4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.a	4.b	4.c			
Progress	15%	3%	9%	15%	9%	18%	45%	6%	0%	0%			
Gaps	6%	9%	3%	3%	6%	0%	0%	0%	0%	0%			
SDG 5	5.1	5.2	5.3	5.4	5.5	5.6	5.A	5.B	5.C				
Progress	15%	22%	19%	19%	15%	19%	19%	22%	15%				
Gaps	37%	52%	37%	22%	33%	26%	30%	30%	30%				
SDG 6	6.1	6.2	6.3	6.4	6.5	6.6	6.A	6.B					
Progress	17%	22%	17%	20%	24%	15%	9%	13%					
Gaps	17%	22%	11%	13%	17%	11%	9%	7%					
SDG 7	7.1	7.2	7.3	7.a	7.b								
Progress	50%	45%	45%	41%	23%								
Gaps	14%	9%	9%	9%	5%								
SDG 8	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.1	8.A	8.B	
Progress	18%	21%	21%	18%	32%	21%	25%	25%	21%	7%	7%	7%	
Gaps	29%	29%	29%	29%	39%	32%	32%	32%	29%	11%	7%	11%	
SDG 9	9.1	9.2	9.3	9.4	9.5	9.a	9.b	9.c					
Progress	59%	29%	24%	53%	35%	18%	12%	24%					
Gaps	6%	0%	6%	0%	12%	12%	6%	12%					

(Continues)

TABLE 3 | (Continued)

SDG 10	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.a	10.b	10.c									
Progress	19%	31%	25%	13%	19%	19%	25%	6%	13%	19%									
Gaps	13%	6%	6%	6%	6%	6%	13%	6%	6%	6%									
SDG 11	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.a	11.b	11.c									
Progress	50%	40%	35%	30%	15%	25%	25%	20%	15%	20%									
Gaps	15%	10%	5%	0%	0%	5%	5%	5%	0%	0%									
SDG 12	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.a	12.b	12.c								
Progress	21%	43%	29%	36%	14%	43%	21%	14%	7%	7%	14%								
Gaps	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%								
SDG 13	13.1	13.2	13.3	13.3A	13.3B														
Progress	34%	27%	48%	14%	16%														
Gaps	27%	5%	23%	7%	7%														
SDG 14	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.A	14.B	14.C									
Progress	19%	32%	3%	5%	27%	3%	14%	56%	7%	19%									
Gaps	15%	14%	5%	3%	12%	2%	3%	0%	3%	8%									
SDG 15	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	15A	15.B	15.C							
Progress	72%	7%	0%	0%	69%	3%	3%	0%	59%	21%	7%	3%							
Gaps	28%	7%	0%	0%	24%	0%	3%	0%	17%	7%	3%	3%							
SDG 16	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	16.1	16.a	16.b							
Progress	27%	20%	34%	12%	15%	34%	41%	12%	7%	24%	17%	20%							
Gaps	12%	7%	15%	7%	17%	10%	5%	2%	2%	7%	5%	5%							
SDG 17	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	17.1	17.11	17.12	17.13	17.14	17.15	17.16	17.17	17.18	17.19
Progress	30%	26%	37%	26%	26%	30%	26%	22%	33%	19%	22%	22%	26%	37%	30%	63%	56%	33%	30%
Gaps	30%	30%	33%	26%	30%	30%	26%	22%	33%	26%	30%	26%	26%	33%	30%	59%	56%	37%	30%

Note: the percentage refers to the ratio between the numbers of mentions to each target in relation to the total number of chapters that had mentioned any SDG targets in each volume. For example, in the volume of SDG 1, target 1.1 was referred to as opportunities of progress or gaps in five and three chapters, respectively, in a total of 23 chapters that had mentioned any SDG 1 target.

ability to adapt to climate change impacts while improving productivity.

Also, an example of good practice for implementing Sustainable Development Goal 15, which focuses on life on land and aims to protect, restore, and promote sustainable use of terrestrial ecosystems, is the Forest Stewardship Council (FSC) Certification. This initiative promotes responsible forest management worldwide.

The FSC certification ensures that forests are managed in a way that preserves biological diversity, supports the livelihoods of local communities, and maintains the ecological functions of forest ecosystems. Certifying organizations must meet management standards that balance social, economic, and environmental needs.

The FSC standard encourages reforestation and afforestation efforts, contributing to carbon sequestration and restoring degraded landscapes, which are vital for combating climate change and maintaining ecosystem services.

In contrast, the targets with the fewest references to implementation progress (0%) are SDGs 2, 3, 4 and 15 (2.A-B, 3.5, 3A, 3D, 4B-C, 15.3-4, 15.8), and in terms of implementation gaps in implementation, the strongest references to implementation gaps (> 35%) for targets within SDG 2, 5, 7, and 17 (2.1, 5.1-5.3, 8.5, and 17.16-17). SDG 2 therefore has the strongest indicators of implementation gap or a lack of progress. Here, evidence indicates that the eradication of hunger depends on significant investment and the transformation of food commodity markets, which are intricately linked to markets and systems driven by economics (rather than broader considerations) (Avtar et al. 2019). Here, Almulhim & Cobbinah (2022, p359) highlight that local and national implementation can also be "skewed towards socio-economic development with limited focus on environmental issues" which in turn has multiple, consequential effects on eradicating hunger. Recent evidence also highlights that it is not just these infrastructural challenges which challenge the reduction of hunger, but the spatial aspects of addressing hunger in urban or rural areas and the subsequent effects in other interlinked economies and communities (Baffoe et al. 2021).

For SDG 5, which aims for gender equality, the strongest implementation gaps are seen in targets 5.1–5.3, which focus on ending all forms of discrimination, eliminating violence against women, and eliminating harmful practices like child marriage. Gender-based violence and harmful cultural practices remain significant challenges in many regions, particularly in areas where legal frameworks and enforcement mechanisms are weak. Some of the topics covered by the chapters that reported on gaps include patriarchal views and sexual harassment (Swemmer 2019a), femicide and the lack of accountability of states that fail to prosecute perpetrators of violence against women (Swemmer 2019b), and transport/mobility safety and how this topic interlinks with economic advancements, social progress, and equal access and participation (Sharma-Brymer and Sharma 2020). Progress in these areas has been slow, requiring stronger commitments from governments and communities to address deeply rooted socio-cultural issues.

For SDG 8, focused on decent work and economic growth, gaps are evident in target 8.5, which seeks to achieve full and productive employment and decent work for all. The challenges in this area stem from labor market inequalities, particularly in terms of gender pay gaps and the informal economy, which disproportionately affect women and marginalized groups (Chowdhury et al. 2020). Efforts to achieve full and productive employment under SDG 8 are further complicated by corporate reluctance, transparency concerns, and the potential undermining of local governance in regions with weak administrative frameworks, all of which limit progress toward providing equitable and inclusive job opportunities (Suwala and Albers 2020).

In SDG 17, in addition to the highlight in terms of progress, targets 17.16 and 17.17 have also received attention in terms of gaps for implementation. This is due to the fact that, despite the growing recognition of the importance of global partnerships, many partnerships lack meaningful collaboration, transparency, and accountability (Zaman 2020). Furthermore, data gaps persist, indicating insufficient capacity to monitor and report on progress towards the SDGs and impeding further efforts to track and evaluate initiatives effectively. Science, technology, and innovation play a critical role in this context and in addressing persistent global challenges linked not only with SDG 17 but also with all goals (Senise et al. 2020).

SDG 10, which focuses on reducing inequalities, and SDG 14, aimed at conserving marine life and oceans, face significant under-implementation due to a variety of interconnected challenges. For SDG 10, persistent income disparities, systemic discrimination, and inadequate social protection systems contribute to growing inequalities within and between countries. Many nations struggle with political instability and governance issues that hinder the implementation of equitable policies. Additionally, social and economic shocks, such as those caused by the COVID-19 pandemic and regular economic recessions, exacerbate existing inequalities, making it difficult for marginalized groups to access essential services and opportunities.

Similarly, SDG 14 is under-implemented largely due to overfishing, pollution, and habitat destruction, which threaten marine ecosystems. Achieving this goal is complicated by inadequate governance of maritime resources and insufficient international cooperation, particularly in regions where marine ecosystems cross national boundaries. Moreover, competing interests between economic development and conservation often lead to policy decisions that prioritize short-term gains over long-term sustainability. Without comprehensive strategies that address these interrelated challenges, progress toward SDG 10 and SDG 14—as well as in respect of the other SDGs—remains significantly hindered. Effective governance, increased funding, and global partnerships are some of the measures deemed essential to enhance implementation and achieve these critical goals bearing in mind the rapidly approaching 2030 deadline.

Table 4 provides information on specific challenges faced by Sub-Saharan Africa, Southeast Asia, and Latin America in SDG implementation.

Table 5, which is by no means comprehensive, highlights how various technologies can specifically contribute to achieving the

TABLE 4 | Challenges faced by specific regions and their implications for SDG implementation.

Region	Specific challenges	Implications for SDG implementation
Sub-Saharan Africa	• Limited access to quality education	Hinders progress on SDG 4 (Quality Education) and reduces human capital development.
	• High poverty rates and income inequality	Challenges achieving SDG 1 (No Poverty) and SDG 10 (Reduced Inequalities).
	• Inadequate healthcare systems	Impacts SDG 3 (Good Health and Well-being) through high disease burden and low access to services.
	• Vulnerability to climate change	Threatens achievement of SDG 13 (Climate Action) and affects food security (SDG 2).
Southeast Asia	• Rapid urbanization without infrastructure planning	Complicates efforts toward SDG 11 (Sustainable Cities and Communities).
	• Environmental degradation	Affects biodiversity and ecosystem services, challenging SDG 15 (Life on Land).
	• Political instability and governance issues	Impairs policy coherence required for SDG implementation across multiple goals.
	• High incidence of natural disasters	Obstructs progress in SDG 13 (Climate Action) and SDG 11 (Sustainable Cities and Communities).
Latin America	• Social inequality and exclusion	Hinders progress on SDG 10 (Reduced Inequalities) and contributes to social unrest.
	• Corruption and weak governance	Impairs effective resource allocation and accountability for SDG implementation.
	• High rates of violence and crime	Challenges SDG 16 (Peace, Justice, and Strong Institutions) and affects community stability.
	• Environmental issues from deforestation	Impacts SDG 15 (Life on Land) and exacerbates climate change (SDG 13).

SDGs, showcasing their potential for driving sustainable development across multiple sectors.

Although technological advancements can support the 2030 Agenda, Sachs et al. (2024) emphasizes that urgent global oversight is needed to address potential threats and ensure effective regulation. Establishing and supporting global and regional centers of excellence is essential to empower all regions in research, development, production, and oversight of technologies aligned with sustainable development. Additionally, open science, including free access to scientific and technical publications, is crucial for fostering equitable access to advanced knowledge, particularly for scientists in poorer countries and regions.

In comparing the results analyses of this paper with the latest SDG Index and Dashboards (Sachs et al. 2024) a clear contrast emerges regarding the overall progress and challenges faced in achieving the Sustainable Development Goals (SDGs).

The results of scientific research highlight notable progress in certain goals, such as SDGs 9, 14, 15, and 17, while emphasizing critical gaps in SDGs 2, 5, and 8 that require urgent attention and resources. It underscores the importance of targeted interventions, international cooperation, and data collection to address these gaps and improve implementation. On the other hand, Sachs et al. (2024) present a more concerning view of global SDG progress, particularly since 2020, with several goals, including SDGs 2, 11, 14, 15, and SDG 16, falling behind. It also highlights specific areas, such as obesity rates, press freedom, and sustainable nitrogen management, where progress has reversed or stagnated. Despite these setbacks, some areas like SDG 9 show slightly more positive trends, although the progress is still slow and uneven. Both analyses agree on the need for urgent action, international collaboration, and better data to track and accelerate SDG implementation, especially in the face of challenges like the COVID-19 pandemic.

4 | Conclusions

This paper reports on a study which has attempted to map the implementation of the UN SDGs. The first conclusion which can be made is that the mapping exercise has revealed significant progress in certain areas, while other goals remain underprioritized or under-resourced. For instance, the bibliometric analysis showed that SDG13 on climate action, SDG 3 on health, and SDG 16 on peace, justice, and strong institutions are more prominently present in the literature when compared with the others. In addition, two clusters (in yellow and blue) are dominated by terms related to climate change, confirming the major focus on SDG 13 in the research on SDGs implementation.

Here, it needs to be pointed out that there are clear geographical disparities in SDG implementation, with developed

TABLE 5 | Technologies and their contributions to the SDGs.

Technology	SDG contribution	Description of impact
Precision Agriculture	SDG 2 (Zero Hunger)	Enhances crop yield and resource efficiency through data analytics, ensuring food security and sustainable farming practices.
Biotechnology	SDG 3 (Good Health and Well-being)	Accelerates drug discovery and vaccine development, improving health outcomes and tackling diseases.
Artificial Intelligence (AI)	SDG 4 (Quality Education)	Personalises learning experiences, optimises resource allocation, and provides scalable educational opportunities.
Clean Water Technologies	SDG 6 (Clean Water and Sanitation)	Implements efficient water purification and distribution systems, ensuring access to safe drinking water and hygiene.
Renewable Energy (Solar, Wind)	SDG 7 (Affordable and Clean Energy)	Provides sustainable energy solutions, reduces reliance on fossil fuels, and lowers greenhouse gas emissions.
Mobile Banking Platforms	SDG 8 (Decent Work and Economic Growth)	Facilitates financial inclusion, enabling access to banking services for underserved populations, enhancing economic opportunities.
Telecommunication Technologies	SDG 9 (Industry, Innovation, and Infrastructure)	Expands access to education, health services, and information, bridging the digital divide and fostering economic growth.
Waste-to-Energy Technologies	SDG 11 (Sustainable Cities and Communities)	Converts waste into energy, reducing landfill usage, and promoting sustainable waste management practices.
Smart Grid Technology	SDG 13 (Climate Action)	Enhances energy efficiency and management, facilitates the integration of renewable energy sources, and reduces emissions.

countries generally progressing more rapidly than developing countries. Still, in connection with the bibliometric analysis, it is seen that research on the implementation of SDGs has shifted more focus on SDG 14, life below water, and SDG 15, life on land.

In respect of the implementation analysis, based on the Encyclopedia of the UN SDGs, it is seen that the implementation of the SDGs and targets is rather unequal. Part of the reason for this may be that the involvement of various sectors (government, private sector, civil society) varies widely. While some goals, like climate action (SDG 13) and quality education (SDG 4), have garnered broad-based support, others, such as life below water (SDG 14), struggle with limited engagement. Moreover, the lack of consistent, high-quality data remains a major challenge in accurately tracking progress. The effectiveness of SDG implementation is hindered by gaps in data, particularly in low-income countries.

Many of the difficulties in implementation are common to all SDGs, from the chronic lack of finances to poor governance and lack of reliable indicators. Therefore, it is important to seek solutions that not only address specific problems associated with one given SDG but also those which may help to support others. For instance, an international fund to support the implementation of the SDGs may prove more efficient than ad hoc allocations to a single SDG such as SDG13, which aims to combat climate change but does not fully address the issue of ecosystem depletion, as seen in SDG15.

The unequal emphasis seen in the implementation analysis also showed that the interconnected nature of the SDGs requires integrated approaches rather than isolated interventions. Goals that recognize and address the synergies and trade-offs between them are more likely to succeed. For instance, achieving the SDGs by 2030 will require stronger global partnerships, especially in financing, technology transfer, and capacity building. Therefore, the targets seen in SDG17 depart from a sound basis. They also suggest that developed countries need to play a more active role in supporting developing nations through these partnerships. The success of the SDGs will depend on localized implementation strategies that consider the specific social, economic, and environmental contexts of each region. In this context, local governments and communities should be empowered to drive the agenda.

Constraints in financial and human resources continue to be a major barrier to achieving the SDGs, particularly in low-income

countries. Addressing these constraints will require both international support and innovative financing mechanisms. Whereas the political will and weak governance structures in some regions have slowed down SDG progress, strengthening institutions and promoting good governance are seen as important for sustained progress. Overall, to effectively track progress and make data-driven decisions, there is a need for improved monitoring and reporting mechanisms. This includes investing in statistical capacities at national and sub-national levels.

Concrete actions to address the various problems can be:

a. To establish comprehensive data collection systems that encompass quantitative and qualitative indicators relevant to the SDGs. This includes integrating data from various sources such as government agencies, NGOs, private sectors, and community-based organizations to create a holistic view of progress.

b. To leverage modern technologies such as big data analytics, artificial intelligence, and mobile applications to enhance data gathering, analysis, and reporting. These technologies can facilitate real-time monitoring and provide timely insights into SDG progress as demonstrated by Fonseca et al. (2024) and Benjira et al. (2025), by enabling more accurate predictions, automating routine tasks, and improving decision-making through data-driven recommendations.

c. To develop standardized indicators aligned with the UN SDG framework to ensure consistency and comparability across regions and countries. Well-defined metrics will enable more accurate tracking of progress and identification of challenges.

This paper has some limitations. The first one is that the paper relies on data from various sources, some of which may have inconsistencies, gaps, or outdated information. This can affect the accuracy of the mapping and the conclusions drawn. In addition, in some regions, particularly in low-income countries, data on SDG implementation is either unavailable or of poor quality. This limitation may result in an incomplete or skewed representation of progress. Moreover, the study primarily depends on secondary data sources, which may not always capture the nuances of local contexts or the latest developments in SDG implementation. Since the study much relies on secondary data from various sources, discrepancies in the credibility or reliability of these sources can affect the overall findings. In addition, different organizations may use varying metrics to assess contributions to the SDGs, making it challenging to compare results across studies and sectors. A lack of standardized indicators is also known to hinder the evaluation of progress. Finally, in some regions, data collection may be insufficient, particularly in developing countries, which can restrict comprehensive analysis and result in gaps in understanding.

Despite these limitations, this paper provides a welcome addition to the literature, especially since the mapping exercise has identified a set of implementation gaps that need to be addressed.

As to the future, research is needed on the SDGs that are currently under-researched or lack sufficient implementation strategies, such as SDG 14 (Life Below Water) and SDG 16 (Peace, Justice, and Strong Institutions). In addition, there is a need for more longitudinal studies to track the long-term impacts of SDG-related interventions, especially in different geographical contexts. Moreover, further work is needed on how to encourage multi-stakeholder collaboration, including academia, private sector, governments, and civil society, to leverage diverse expertise and resources. Furthermore, studies are needed on how the potential of technology and innovation should be fully harnessed to address SDG challenges, particularly in data collection, monitoring, and implementation strategies. The private sector can play an important role in implementing the SDGs by leveraging resources, innovation, and expertise to drive sustainable development. Businesses can contribute through investment in sustainable technologies, practices, and products that align with the SDGs, particularly in areas such as clean energy, responsible consumption, and poverty alleviation. In addition, the private sector can promote sustainability within its supply chains by adopting ethical sourcing, reducing waste, and implementing environmentally friendly practices, which directly support Goals such as Climate Action (SDG 13) and Life on Land (SDG 15).

The implementation of the UN SDGs represents one of the most ambitious global agendas ever undertaken. While significant progress has been made, there is still much to be done. The success of this agenda depends on sustained commitment, innovative approaches, and the willingness of all stakeholders to collaborate and share responsibility. As we rapidly approach the 2030 deadline, it is very important that efforts are intensified, and that the lessons learned from this mapping exercise are used to inform and improve ongoing and future initiatives.

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