



Sustainable futures: Aligning climate actions and socio-economic justice through the just energy transition

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ABSTRACT

The transition towards a just and equitable energy system is a crucial pathway to reconciling climate action with socio-economic justice, as outlined by the Sustainable Development Goals (SDGs) and the Paris Climate Agreement. This systematic review examines the evolving scope of the Just Energy Transition, which has expanded from labor concerns to broader socio-economic and environmental dimensions. It presents a compelling case for safeguarding marginalized and vulnerable communities as economies shift to low-carbon models. The review investigates the synergies and trade-offs between SDG implementation and climate action, emphasizing the need to balance economic growth, energy access, food security, and infrastructure development with climate change adaptation and mitigation efforts. Achieving a just energy transition requires prioritizing renewable energy investments, sustainable infrastructure, and policies that promote equity. Decentralized energy systems have effectively reduced energy poverty and alleviated regional disparities. However, the review also identifies potential trade-offs, such as economic disruption and increased inequality, if the transition is not managed inclusively. These challenges require an integrated policy framework that promotes cross-sectoral collaboration, drives clean energy innovation, accelerates the mobilization of private capital, and implements targeted subsidies. Such a comprehensive approach is indispensable for securing sustainable futures that meet climate action and socio-economic justice mandates. Comprehensive stakeholder engagement and capacity-building initiatives are critical to executing a just transition that aligns economic policy with environmental stewardship.

1. Introduction

The dual agendas of the Sustainable Development Goals (SDGs) and climate change mitigation efforts have emerged as critical in global policy and scholarly discourse on socioeconomic and environmental sustainability [1,2]. The energy sector, in particular, plays a pivotal role in aligning these agendas, especially through the Just Energy Transition (JET), which seeks to bridge the aspirations of the United Nation's 2030

Agenda and the Paris Agreement [3]. The clean energy transition seeks to address the pressing challenges of energy access and security, economic growth, affordable access, and environmental sustainability. An incremental approach focused on low-carbon development offers a realistic and practical pathway to stimulating decarbonization while addressing climate change challenges [4].

Transitioning away from fossil fuels towards a clean energy future is not devoid of complexities. Thus, successfully achieving a just energy

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transition for everyone requires minimizing the negative impacts (trade-offs). Notwithstanding, it is essential to acknowledge that attaining clean energy is not entirely free from environmental challenges. For instance, solar batteries, a key component of renewable energy systems, may cause serious environmental harm due to the heavy metals used in their production and disposal. The transitioning process is essential not only for fairness but also for ensuring alignment with the 2030 Agenda for Sustainable Development Goals (i.e., ensuring everyone benefits) and the Paris Agreement. An example of benefits (synergies) would be the contribution of JET to SDG 7, which calls for providing access to reliable, clean energy for all. Renewables also empower even remote communities with decentralized off-grid solutions [5]. Furthermore, the increased use of renewables directly reduces reliance on fossil fuels and aligns with SDG 13 by reducing greenhouse gas (GHG) emissions, a key driver of climate change [6,7].

However, discussions on the Just Energy Transition (JET) and its links to climate justice reveal notable imbalances, with some facets of justice receiving far more attention than others. Historically, much of the focus has been on labor market impacts, energy transitions in high-income countries, and carbon pricing policies, while broader socio-economic and regional disparities have received comparatively less attention [8,9]. For instance, studies frequently examine the effects of decarbonization on industrial workers in Europe and North America, whereas issues such as energy poverty, land dispossession, and the vulnerabilities of informal economies in the Global South remain underexplored [10]. This imbalance can be attributed to several inter-related factors. First, the geographical concentration of research institutions and funding in developed nations often shapes the research agenda. Hence, a stronger scholarly focus on issues relevant to high-income economies than challenges specific to low-income countries [11]. Second, prioritizing economic efficiency over social equity in dominant theoretical frameworks influences how justice is conceptualized, often sidelining more profound structural inequalities related to historical injustices, colonial legacies, and systemic marginalization. Third, political and institutional interests play a role, as research funding and policy discussions frequently align with government and corporate priorities. Normally, emphasizing market-driven solutions like carbon pricing while downplaying grassroots and community-led approaches to energy justice [12]. Additionally, the methodological challenges associated with studying justice-related outcomes—such as the lack of reliable data on informal economies, gendered impacts, and indigenous rights—further reinforce these asymmetries [13]. These factors collectively contribute to an uneven knowledge base, necessitating a more inclusive and interdisciplinary approach to ensure climate justice research reflects the diverse realities of affected communities worldwide.

Country-specific approaches provide valuable frameworks for understanding how Just Energy Transition (JET) strategies can be tailored to regional socio-economic contexts. Examples such as Germany's partnership-driven energy transitions, highlighted by the Moroccan-German Energy Partnership (PAREMA), and India's initiatives in decentralized renewables [14], offer practical and adaptable models for aligning JET with diverse regional realities. These models help frame country-specific approaches to JET while addressing unique challenges and opportunities. Furthermore, a recent study by Ouassou et al. [15] provides a complementary perspective by examining carbon transparency within global supply chains. The study also emphasizes the role of institutional and innovative capacities, the increasing complexity of contemporary supply chains, and their impact on carbon transparency efforts, particularly in developing countries like Brazil and Malaysia. The findings underscore how heightened global awareness of climate change, sustainable development goals, and transitions to green economies drive innovation, particularly in technological contributions to sustainable development. This aligns with the growing emphasis on transparency and accountability as essential dimensions of a just energy transition, linking global economic systems to equitable and sustainable

practices.

Community Renewable Energy (CRE) or Renewable Energy Communities (RECs) emerge as a viable option for offering localized solutions to energy access while fostering community empowerment and equity. Furthermore, CRE initiatives bridge the gap between energy transitions and social justice by enabling marginalized communities to gain control over energy resources—thereby directly addressing SDG 10 (Reduced Inequalities) and SDG 1 (No Poverty). Similarly, Ahmed et al. [16] highlight how decentralized renewable systems can play a transformative role in enhancing energy access and empowering communities, especially in underrepresented regions. Likewise, Tamasiga et al. [17] underscores the impact of renewable energy microgrids in alleviating energy poverty and enhancing socio-economic outcomes in underserved communities. On the other hand, Nashi and Ouakil [18] show how renewable energy development mitigates adverse effects of energy price volatility. Tamasiga et al. [17] also emphasize the environmental benefits of microgrids, such as reduced greenhouse gas emissions, while addressing challenges like high initial capital costs, operational complexities, and regulatory barriers. Both studies demonstrate that community-driven initiatives, complemented by supportive policy frameworks and innovative financing solutions, are vital for ensuring equitable and sustainable clean energy transitions. Additionally, Coban [19] explores the design and optimization of off-grid hybrid renewable energy systems, showcasing their potential to provide efficient, cost-effective, and environmentally sustainable energy solutions in remote areas with inadequate infrastructure. The study reveals how hybrid systems can outperform traditional power solutions, contributing to long-term energy access and enhanced community resilience.

While research has explored interactions between Sustainable Development Goals (SDGs) and climate actions (see, for example [7,20,21]), there is a lack of studies specifically focusing on how these connect with the JET. This apparent gap is significant as a just energy transition is crucial in achieving SDGs (UN 2030 Agenda) and climate goals stipulated in the Paris Agreement. Therefore, the scientific aim of the current work is to explore the synergies and trade-offs between Sustainable Development Goals (SDGs) and climate actions at both country and global levels, with a particular focus on a Just Energy Transition (JET). The subject of the research was to obtain a comprehensive understanding of these interactions by systematically reviewing existing studies across multiple disciplines. This study extends the existing sustainability and climate policy research by employing a systematic review approach, consolidating diverse methodological findings, including literature reviews, empirical analyses, and bibliometric studies. This approach provides a holistic assessment of the complex dynamics between SDGs and climate actions under the Paris Agreement, ensuring a more integrated perspective on the challenges and opportunities of a just energy transition.

This paper brings a new look to the existing literature in the following areas: (i) the asymmetries in the representation of climate justice within the Just Energy Transition (JET) discourse, (ii) the synergies and trade-offs between Sustainable Development Goals (SDGs) and climate mitigation efforts, (iii) the role of technology in ensuring a just transition, mainly through decentralized renewable energy systems and innovations in carbon transparency, and (iv) the need for a more inclusive research agenda that integrates diverse regional perspectives and interdisciplinary methodologies for a comprehensive understanding of justice in energy transitions.

To ensure clarity and consistency throughout this study, the definition of synergies and trade-offs presented in the Intergovernmental Panel on Climate Change (IPCC)'s 2018 Special Report on Global Warming of 1.5 °C (IPCC, 2018) is adopted. As outlined in that report, synergies and trade-offs refer to the positive and negative effects of various mitigation strategies on achieving the Sustainable Development Goals (SDGs). The systematic review adopted here will focus on mitigation strategies associated with a just energy transition. Specifically, the study examines how a just energy transition, defined as a shift

towards clean energy sources that prioritizes social equity and economic development, can reinforce progress toward the SDGs (synergy) or create unintended negative consequences (trade-off). This allows an exploration of how different approaches to transitioning away from fossil fuels can create positive outcomes for achieving various SDGs and climate actions while identifying potential drawbacks that may require targeted solutions.

To address the identified gap and aim of the study, the following research questions guided this study:

- 1) How has the literature on climate change actions, synergies, and trade-offs between climate actions and SDGs evolved (e.g., publication trends, etc)?
- 2) What are the co-benefits and synergies between SDGs and climate change actions, and how do these interactions contribute to broader sustainable development objectives?
- 3) What are the potential challenges and trade-offs associated with actions aimed at mitigating or adapting to climate change that may hinder progress towards specific SDGs, and how can these be effectively addressed?
- 4) How do Just Energy Transition strategies address the impacts of climate change actions on vulnerable populations (e.g., job displacement in fossil fuel industries) in the context of achieving specific SDGs related to socio-economic justice (e.g., SDG 1: No Poverty, SDG 10: Reduced Inequalities)?

In summary, this study uses a systematic review to synthesize existing research findings and uncover knowledge gaps regarding the challenges of transitioning to a clean energy future. The analysis of methodologies, results, and key insights from the literature develops a comprehensive understanding of the synergies and trade-offs involved in achieving a just energy transition through the socio-economic lens.

2. Methodology

2.1. Research design

The PRISMA protocol was followed to conduct this systematic review [22,23]. The systematic review involved bibliographic and content analyses of literature focused on trade-offs, synergies and conflicts between sustainable development goals and climate change actions. The literature search for this study was drawn from the Web of Science and Scopus databases because of their expansive coverage of scholarly publications [24–26]. In addition, the format of the exported articles from Web of Science and Scopus permits bibliographic analysis using Biliometrix Software. The PRISMA process in Fig. 1 outlines the systematic approach used to identify, screen, and include studies in the review, ensuring transparency and reproducibility.

2.1.1. Step 1: Identification

Initially, 434 records were identified from two major academic databases: 183 from the Web of Science (WoS) and 251 from Scopus. This step ensures a comprehensive search across high-impact sources. Before the screening, 109 duplicate records were identified and removed, reducing the dataset to 325 unique records. This step prevents bias caused by redundant studies and ensures each record is counted only once.

2.1.2. Step 2: Screening

The remaining 325 records were screened for relevance and compliance with the study's inclusion criteria. During this phase, 2 records were excluded because they were not written in English. This step ensures that only studies accessible to the research team are considered.

After the screening, 323 records were considered relevant, and their full texts were sought for further assessment. However, 17 records could

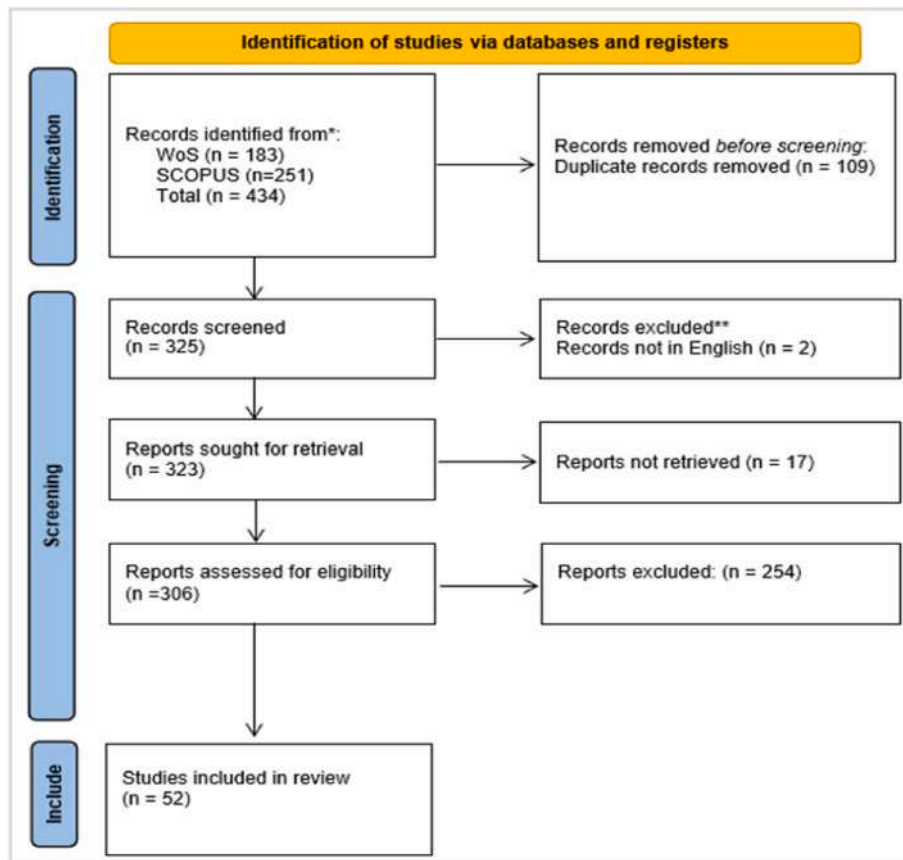


Fig. 1. PRISMA flow chart.

not be retrieved, likely due to paywalls, restricted access, or missing documents.

An in-depth assessment was conducted on the 306 retrieved reports to evaluate their relevance to the study. Following this review, 254 reports were excluded because they did not meet specific inclusion criteria, such as lacking a direct focus on the research topic or failing to provide necessary data.

2.1.3. Step 3: Inclusion in review

After the rigorous selection process, 52 studies were included in the final systematic review. These studies form the foundation of the research, providing valuable insights into the interactions between climate change actions and Sustainable Development Goals (SDGs). This process ensures a high-quality, unbiased, and comprehensive literature selection, reinforcing the reliability of the study's findings.

2.2. Data collection

In the initial phase of document selection, a query with specific keywords was generated and applied to the Web of Science (WoS) and Scopus on December 20, 2023, as detailed in Table 1. This resulted in the retrieval of a total of 183 from the WoS and 251 from Scopus. In the second stage, the Scopus and Web of Science records were merged in RStudio, and an additional step was taken to exclude 109 duplicate records and 2 records that were not written in English, reducing the combined count of Scopus and WoS to 323 records. Only 17 records were retrieved due to a paywall, which resulted in 306 records being assessed for eligibility. After screening the full texts for relevance, only 52 records were included in this systematic review.

The systematic review protocol included terms related to different interactions that may occur between sustainable development goals and climate change adaptation and mitigation measures. It also included the terms "trade-offs," "co-benefits," and "synergies."

2.3. Search query

The logical statement analysis ensures that the search captures relevant studies using a comprehensive set of keywords. These keywords cover climate change mitigation, adaptation, resilience, SDGs, and interactions (e.g., trade-offs, synergies, co-benefits). The breadth of terms ensures that the search is not overly restrictive, allowing the collection of studies from diverse perspectives within the climate and sustainability research fields. The inclusion of terms related to various interactions, such as "trade-offs," "synergies," and "co-benefits," ensures that the systematic review examines the dynamic relationships between

SDGs and climate change measures. Using logical operators such as "OR" and "AND" allows for broad but precise searches, capturing studies that address different facets of the research question. The formula's specificity with terms related to climate change and SDGs helps reduce irrelevant records and ensures that only pertinent documents are retrieved.

2.4. Data retrieval from Scopus and Web of Science

Scopus and Web of Science were selected for their comprehensive databases, which are widely recognized for their rigorous indexing of academic literature across various fields, including climate change and sustainable development. These platforms provide access to high-impact, peer-reviewed articles that are vital for ensuring a robust systematic literature review. These databases ensure access to a large pool of reputable academic publications. Retrieving documents from two major platforms increases the likelihood of capturing comprehensive and diverse studies, thereby enhancing the scope and validity of the review.

2.5. Screening and exclusion criteria

The exclusion criteria were clear and included the removal of non-English documents and those that did not contain the specified keywords. This ensures that only studies that meet the language and relevance standards are included. Adherence to strict inclusion and exclusion criteria guarantees that only relevant documents are considered. Ensuring the documents are in English is necessary for consistency and ease of analysis, mainly when conducting a systematic review in a specific language. Specific keywords ensure that only studies that directly address the intersection of climate change, SDGs, and interactions are included.

2.6. Final document assessment

In the second phase, duplicate records were removed (Fig. 1), ensuring that unique studies were retained for further assessment. This step eliminates the potential for overrepresenting any single study, which could bias the systematic review's conclusions.

After merging records and excluding duplicates, a final set of 306 documents was assessed for eligibility. After screening the full texts for relevance, only 52 records were included. By thoroughly screening the full texts of the remaining records, the review ensures that only studies that meet the exact scope and relevance criteria are included in the final analysis. This rigorous vetting process enhances the reliability and focus of the review's findings.

This format ensures that each aspect of the data collection process is explained in detail while highlighting its role in ensuring the high quality of the systematic review's output.

Table 1
Inclusion and Exclusion criteria for documents in the study.

Logical Statement Analysis	Search formula
Scopus	(TITLE-ABS-KEY (("climat* change" OR "global warming") AND ("mitigation") AND ("adaptation" OR "resilience") AND ("SDG" OR "Sustainable Development" OR "sustainable development goal") AND ("tradeoff*" OR "trade-off*" OR "conflict" OR "synergy" OR "synergies" OR "co-benefit*" OR "cobenefits*" OR "interaction*" OR "inter-relationship*" OR "interrelationship*"))))
Web of Science	TS= (("climat* change" OR "global warming") AND ("mitigation") AND ("adaptation" OR "resilience") AND ("SDG" OR "Sustainable Development" OR "sustainable development goal") AND ("tradeoff*" OR "trade-off*" OR "conflict" OR "synergy" OR "synergies" OR "co-benefit*" OR "cobenefits*" OR "interaction*" OR "inter-relationship*" OR "interrelationship*"))
Inclusion	1 Document written in English. 2 Document containing the keywords
Exclusion	1 Documents not written in English. 2 Documents not containing the keywords

3. Results and analysis

In this section, the study findings are organized into three main parts. Firstly, a summary of descriptives from the included studies is provided. The second part covers annual scientific production, the most relevant sources, and contributions from various countries. This is followed by an overview of the included studies, which includes details such as titles, study methodology, location and key findings. Finally, the systematic review questions were addressed through a content analysis based on text mining and keyword co-occurrence analysis exploring cluster topics.

3.1. Descriptives

Table 2 presents a summary of the descriptive statistics of the documents included in this systematic review. The 52 included documents

Table 2

Summary of descriptive statistics of included studies in the systematic review.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2002:2023
Sources (Journals, Books, etc)	38
Documents	52
Annual Growth Rate %	8,91
Document Average Age	7,32
Average citations per doc	66,4
References	2631
DOCUMENT CONTENTS	
Keywords Plus (ID)	200
Author's Keywords (DE)	165
AUTHORS	
Authors	202
Authors of single-authored docs	8
AUTHORS COLLABORATION	
Single-authored docs	9
Co-Authors per Doc	4,3
International co-authorships %	30
DOCUMENT TYPES	
Article	35
article conference paper	1
article; proceedings paper	1
book chapter	9
Review	6

are from 2002 to 2023. The document steps are articles (35), conference papers (1), proceedings paper (1), book chapters (9) and reviews (6).

3.2. Publication trends

As shown in Fig. 2, the number of publications gradually rises from 2000 to 2023, with volatile fluctuations in citation counts across the years. Initially, there is only one publication in 2000, but by 2021, the number of publications peaks at 46. Likewise, total citations increased substantially over the years, reaching a peak in 2017 with 1856 citations.

From 2015 to 2017, there is a surge in both the number of publications and citations, aligning with the inception of the Paris Agreement for Climate Change in 2015. This period marks a crucial turning point, indicating a heightened recognition and interest in Sustainable Development Goals (SDGs) and climate change. This upward trend suggests the heightened importance of addressing sustainability and climate change issues. However, the remarkable decrease in citations after 2017 could be explained by several factors. First, the peak in 2017 likely reflects the cumulative citations of influential works published following

global agreements like the Paris Agreement, which later stabilized as these works reached saturation in scholarly referencing. Second, shifts in academic and funding priorities may have led researchers to explore newer or niche areas within climate action and SDGs.

3.3. Most relevant sources

Table 3 summarizes the sources of documents, their citations, and the number of documents. "Earth's Future" is the most cited source (684 citations) with only one document included, suggesting it's a highly impactful journal but only one specific article was used. Other frequently cited sources include "Ecology and Society" (663 citations) and "Climate Policy" (592 citations), both with only one document used. This pattern continues throughout the table, indicating the research likely relied on various sources.

3.4. Top 10 most influential countries by citations

Table 4 highlights the distribution of research contributions in the analyzed publications based on country affiliation. Germany is the most productive country, with the highest total citations (1817) and a substantial average citation count per article (454.25). This indicates a significant contribution from German researchers, with their work being highly cited. Germany has entered into just energy transition partnerships with South Africa and Senegal, making the country more relevant to the discourse of SDGs and Climate change actions.

The United States follows second place with considerably fewer citations (327) and a lower average (54.50). Countries like the Netherlands (3rd) and Kenya (5th) have a higher average citation count per article than the US, suggesting their research might be more impactful despite lower overall output.

3.5. International collaboration network with the most relevant countries

The international collaboration network and scientific production presented in Fig. 3 (left and right panels, respectively) reveal complementary insights into the global research landscape related to energy transitions. The left panel emphasizes the structure of research collaborations and geographical distribution, while the right panel highlights disparities in research output across nations. Together, these panels underscore the systemic imbalances in global energy research, shaped by resource availability, institutional capacity, and collaboration dynamics.

In the collaboration network (left panel), Western nations, notably the USA, Germany, and the United Kingdom, act as central nodes, initiating and maintaining diverse partnerships with countries

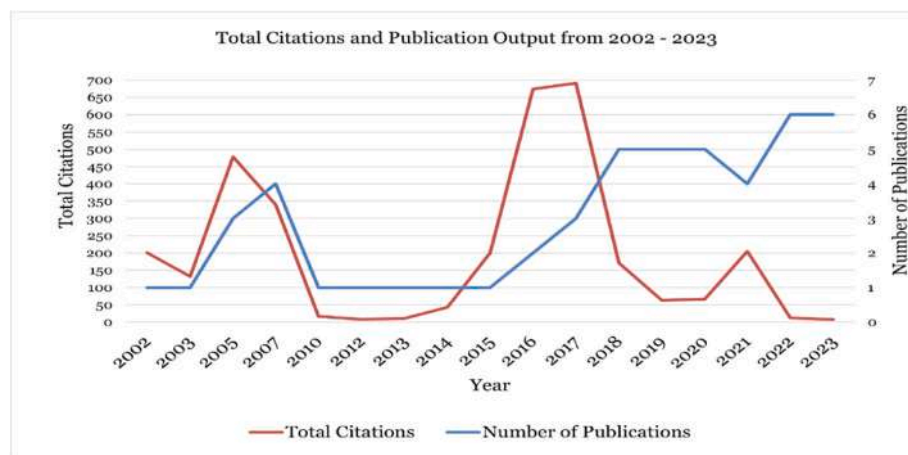


Fig. 2. Publication trends from 2000 to 2023 on the domain.

Table 3
List of sources, citations and number documents.

Journal	Citations	Number of Documents
Earth's Future	684	1
Ecology And Society	663	1
Climate Policy	592	6
Environmental Science & Policy	323	2
Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects	200	1
Environmental Science And Policy	190	1
Science of The Total Environment	129	1
Mitigation and Adaptation Strategies for Global Change	111	3
Journal of Environmental Management	96	3
Current Opinion in Environmental Sustainability	74	1
Climatic Change	71	1
Journal of Cleaner Production	37	1
Climate And Development	17	2
Sustainability	25	3
Global Environmental Change-Human and Policy Dimensions	15	1
Contributions to Economics	15	1
Sustainability Science	12	1
Local Economy	11	1
Forests	11	1
International Journal of Disaster Risk Reduction	10	1
International Journal of Agricultural Sustainability	6	1
Current Science Unasylva	6	1
An Introduction to Circular Economy	5	1
Climate Change: The Social and Scientific Construct	4	1
Springer Climate	3	1
Journal of Energy in Southern Africa	3	1
International Journal of Climate Change Strategies and Management	3	1
World Review of Science, Technology and Sustainable Development	2	1
Progress In Disaster Science	1	1
Environmental Research Letters	1	1
Morocco: Environmental, Social and Economic Issues of the 21st Century	0	1
Innovation Systems, Economic Development and Public Policy: Sustainable Options from Emerging Economies	0	1
Global Climate Change and Environmental Refugees: Nature, Framework and Legality	0	1
Frontiers In Sustainable Food Systems	0	1
Energy Strategy Reviews	0	1
Cabi Agriculture & Bioscience	0	1
African Handbook of Climate Change Adaptation	0	1

Table 4
Most productive countries by total citations.

Country	Total Citations	Average Article Citations	Rank
Germany	1817	454.25	1
USA	327	54.50	2
Netherlands	309	103.00	3
Japan	167	41.75	4
Kenya	117	58.50	5
United Kingdom	99	19.80	6
Switzerland	81	40.50	7
Ghana	57	28.50	8
Thailand	34	34.00	9
Canada	26	13.00	10

worldwide. These nations engage heavily with Africa (e.g., Kenya, Zimbabwe, Malawi), Asia (e.g., India, Bangladesh), and Europe (e.g., the Netherlands, Austria), reflecting their leadership in climate-related research. However, the pattern reveals an over-reliance on North-South collaborations, as intra-regional collaborations within the Global South are relatively rare. Instances such as Bangladesh-Brazil or Zimbabwe-Malawi partnerships stand out as exceptions, demonstrating the limited scope of South-South collaborations. This underlines

structural barriers, such as limited research funding and institutional frameworks in developing regions, which constrain their capacity for autonomous partnerships.

The scientific production data (right panel) complements this by showing how the volume of research output correlates with these collaboration dynamics. The USA dominates with 22 contributions, followed by the UK (16) and India (14). European nations, including Germany (11) and the Netherlands (8), also feature prominently, showcasing their consistent engagement in energy and sustainability research. Asian countries like India, Japan (10), and China (6) are active contributors, although China's relatively low representation contrasts with its global leadership in renewable energy technologies. African countries, such as Ghana (8), Kenya (7), and South Africa (6), show increasing representation, particularly through collaborative efforts reflected in the left panel. Yet, other African and Latin American nations contribute minimally, with countries like Nigeria, Senegal, and Brazil producing only one document each.

This juxtaposition of collaboration and production highlights a self-reinforcing cycle: countries with advanced academic infrastructure and funding dominate scientific output and influence the collaborative agenda. Western nations leverage their institutional resources while developing nations remain dependent on North-South partnerships. The lack of intra-regional collaboration in the Global South further exacerbates disparities, limiting the diversification of research perspectives.

Addressing these inequities requires a dual approach. First, promoting South-South collaborations is crucial to fostering regional innovation and reducing dependence on Western partnerships. Second, increasing funding and capacity-building programs in underrepresented regions can empower local researchers and institutions to engage in and lead global research networks. Additionally, integrating regional journals into global indexing systems can enhance the visibility and impact of research from developing nations, ultimately creating a more equitable and inclusive global research landscape.

3.6. Corresponding author's countries

Fig. 4 highlights the distribution of articles by country, showing significant geographical disparities in the research landscape. Western nations dominate the publication output, with the USA leading at 15.4 % of the total articles, followed by Germany and the United Kingdom, each contributing 9.6 %. These countries benefit from well-established academic institutions, robust funding mechanisms, and access to globally indexed journals, allowing them to lead energy and sustainability research. In contrast, despite their critical involvement in energy transitions, developing nations are underrepresented. Notable contributors from Africa, such as Ghana, Kenya, and Malawi, demonstrate meaningful participation. Still, their research relies heavily on international collaborations, as indicated by their 100 % Multiple Country Publication (MCP) percentages. This reliance reflects limited domestic resources and institutional capacity for independent research.

Asian countries such as China and India, often highlighted for their significant contributions to renewable energy transitions, are represented by a relatively modest number of articles, with only two and three publications, respectively.

Geographical biases can be attributed to disparities in funding, access to advanced research infrastructure, and the visibility of regional journals in global indexing platforms like Scopus and Web of Science. Addressing these biases requires targeted interventions, including capacity building through training and funding programs for researchers in underrepresented regions and fostering international collaborations to integrate diverse perspectives that are contextually relevant.

3.7. Summary of studies included in the systematic review

Table 6 presents the 52 studies that met the inclusion criteria and successfully passed the screening process, which involved evaluating

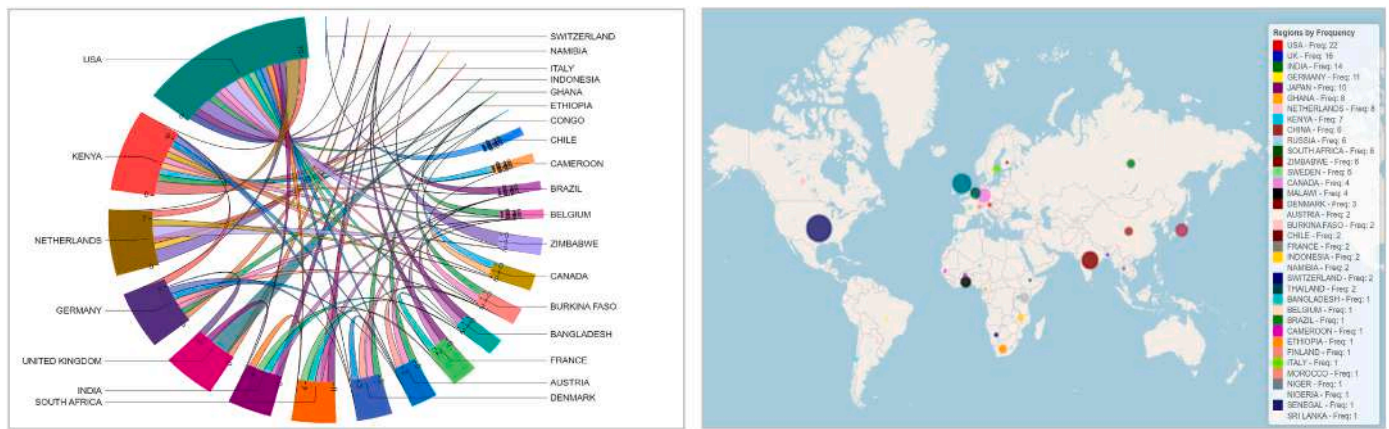


Fig. 3. Left panel international collaboration network, right panel countries scientific production.

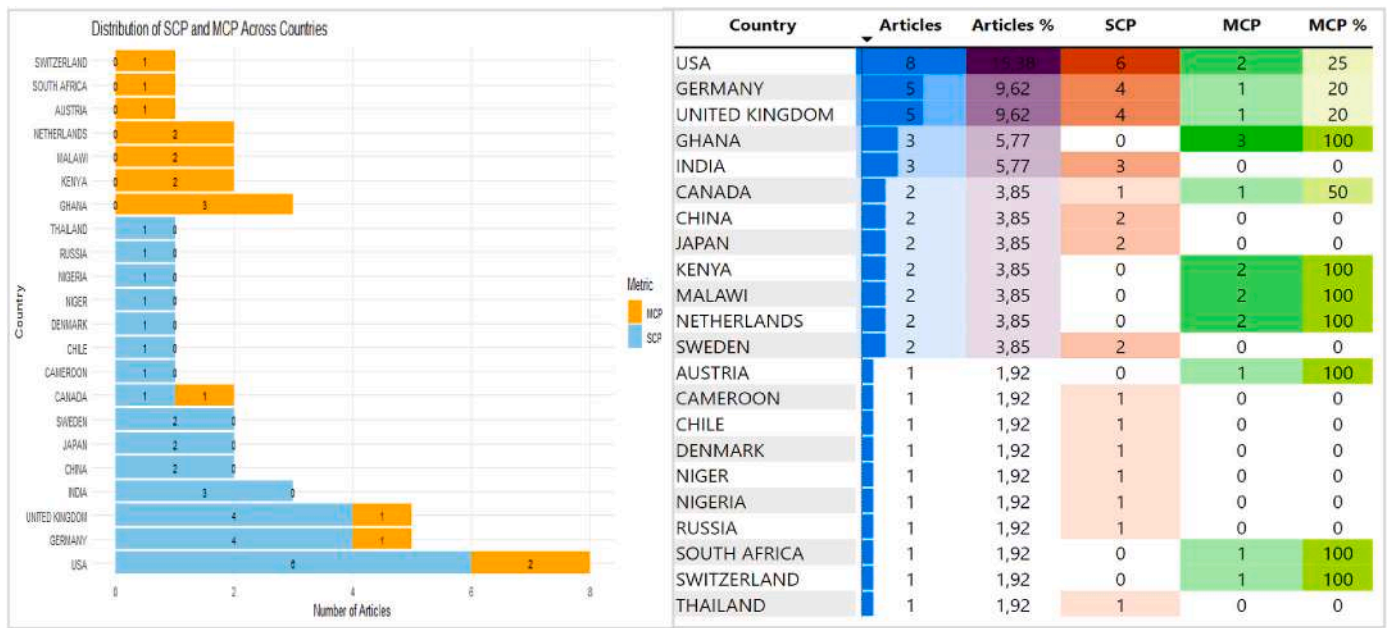


Fig. 4. Corresponding author's countries based on number of documents
Notes: SCP; Single Country Publications, and MCP; Multiple Country Publications.

their titles, abstracts, and full texts. Africa is the continent with the most representation (30 %), followed by Asia (22 %) and Europe (16 %). This suggests recognizing developing countries' vulnerability to climate change impacts. This could be due to factors like reliance on rain-fed agriculture, limited resources for adaptation measures, and existing social and economic inequalities. However, more research from North and South America (6 % total) would provide a more global perspective.

About (24 %) used mixed methods, indicating a growing trend towards combining qualitative and quantitative data. The relatively lower use of quantitative methods (16 %) suggests a need for further studies that measure and analyze the effectiveness of these strategies through concrete data. However, the dominance of qualitative methods (60 %) suggests a focus on understanding concepts, experiences, and perceptions related to these strategies. A deeper analysis of these findings is presented in the discussion section of this research study. Studies like Duguma et al. [21] suggest that middle-income countries can leverage development and climate action synergies. On the other hand, other studies like Shrestha & Dhakal [30] highlight potential trade-offs. Several studies emphasize the importance of collaboration between actors, leadership, and integrated approaches. For example, Antwi-Agyei

et al. [36] call for cross-sectoral integration, while Nyiwul [37] highlights institutional barriers hindering such in Africa. Banwell et al. [71] highlight the need for stronger government collaboration in Chile. Kalafatis [42] highlights strong leadership as a factor for success, while Nyiwul [37] emphasizes the need for capacity building in Africa.

The studies summarized in Table 5 propose several key thematic nomenclatures to classify the topics discussed across 52 studies on climate change and sustainable development. These categories include synergies and trade-offs in Sustainable Development Goals (SDGs), which are essential to understanding climate action's interconnected nature. For instance, Pradhan et al. [27] demonstrate how SDG 1 aligns with most goals, while SDG 12 often shows trade-offs, emphasizing the complexity of achieving these goals simultaneously. Mitigation and adaptation strategies are critical components of effective climate policy. Tol [29] underscores the need for integrated policymaking, highlighting that fragmented approaches to mitigation and adaptation can impede the efficiency and effectiveness of policy outcomes. Similarly, Ruban et al. [31] highlight the critical need to integrate renewable energy transitions into mitigation and adaptation strategies, reinforcing the argument that coordinated approaches are essential for advancing

Table 5

Thematic classification of climate change and sustainable development studies.

Nomenclature	Study
Synergies and Trade-offs in SDGs	Pradhan et al. [27], Luttikhuis and Wiebe [2], Duguma et al. [21], Swart & Raes [28]
Mitigation and Adaptation Strategies	Tol [29], Shrestha & Dhakal [30], Ruban et al. [31], Srivastava et al. [32], Sharifi [33], Chia et al. [34], Denton et al. [35]
Institutional and Policy Frameworks	Antwi-Agyei et al. [36], Nyiwul [37], Ngum et al. [38], Hoffmaister & Román [39], Wilbanks & Sathaye [40], Chuku [41], Kalafatis [42]
Decentralized Renewable Energy Systems	Venema & Rehman [43], Selvakkumaran & Silveira [44]
Climate-Smart Agriculture (CSA)	Antwi [45], Homann-Kee Tui et al. [46], Antwi-Agyei et al. [47]
Just Energy Transition	Hägele et al. [3], Mfon [48], Hoff et al. [49]
Nature-Based Solutions and Ecosystem Restoration	Kabisch et al. [50], Favretto et al. [51], Woolf et al. [52]
Barriers to Climate Action	Amesho et al. [53], Orie [54], Kahime et al. [55]
Integration of Development and Climate Goals	Janetos et al. [56], Swart et al. [57], van Noordwijk et al. [58]
Social Impacts of Climate Action	Anukwonke et al. [59], Harry & Morad [60], Kumar & Bindu [61], Tschakert & Olsson [62]

effective climate policies.

Institutional and policy frameworks remain a significant barrier to effective climate action, as identified by Antwi-Agyei et al. [36], who highlight gaps in implementing Nationally Determined Contributions (NDCs) in Ghana. Decentralized renewable energy systems, such as those proposed by Venema and Rehman [43], offer solutions to climate change by addressing rural development challenges. Climate-smart agriculture (CSA) highlights the trade-offs between increased productivity and environmental sustainability, as explored by Antwi [45] and Homann-Kee Tui et al. [46]. Just energy transitions, nature-based solutions, and ecosystem restoration also play a critical role in climate resilience, with studies advocating for equitable and integrated approaches. Lastly, barriers to climate action include financial, technical, and institutional challenges, as noted by Amesho et al. [53] and Orie [54], while the integration of development and climate goals remains crucial for holistic progress, as emphasized by Janetos et al. [56]. Social impacts of climate action must address inequalities and enhance community resilience, particularly for marginalized groups, as shown in the work of Anukwonke et al. [59] and Kahime et al. [55].

4. Discussion

This section discusses the synergies and tradeoffs between SDGs and climate actions through the lens of the just energy transition.

4.1. Synergies between SDGs and climate actions

Table 7 presents the synergies between SDGs and climate action, demonstrating how addressing climate change can propel progress across various sustainable development objectives. A pivotal element in this dynamic is the transition to sustainable and renewable energy sources, a fundamental pillar of the Just Energy Transition. This transition aids in carbon emission reduction, a key aspect of SDG 13 (Climate Action), but also promotes advancements in SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities) by curbing air pollution and enhancing energy accessibility [74].

Shrestha and Dhakal [30] underscore the significance of integrated approaches that consider mitigation and adaptation measures in the fight against climate change. These approaches play a crucial role in realizing SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land), as well as SDG 11 (Sustainable Cities and Communities), SDG 7 (Affordable and Clean Energy), and SDG 6 (Clean Water and Sanitation). Nyiwul [37] highlighted renewable energy as a leading climate mitigation approach in African countries to target emission

Table 6

Summary of relevant studies considered in systematic review.

No	Study	Methodology	Country	Interpretation of the content
1	[21]	Mixed methods	Multiple countries	The study examines how a country's income level and vulnerability to external factors affect its potential to achieve this synergy. The results show that middle-income and small island countries have good synergy scores while developed countries have lower scores.
2	[3]	Qualitative	Germany and South Africa	The study finds challenges in balancing environmental benefits with job losses (SDG 8 & 10) and resource management (Water-Energy-Food-Land nexus, SDGs 2, 6, 7, 15). The research concludes by highlighting key considerations for designing such transitions, including inclusive decision-making, impact assessments, and strong coordination across various actors and levels of government
3	[27]	Qualitative	227 Countries	SDG 1 shows synergies with most goals, while SDG 12 commonly exhibits trade-offs. Leveraging synergies and addressing trade-offs are crucial for achieving SDGs.
4	[29]	Qualitative	n.a	Adaptation and mitigation are often analyzed separately despite their interdependence. This hampers the understanding of trade-offs between them. Facilitative adaptation, akin to mitigation, requires long-term policies and competes for resources, underscoring the need for integrated analysis and decision-making
5	[36]	Qualitative	Ghana	It finds significant alignment between Nationally Determined Contributions (NDCs) and SDGs but highlighting challenges in cross-sectoral integration and implementation capacity.
6	[30]	Qualitative	Nepal	The research investigated potential benefits and drawbacks of pursuing combined mitigation and adaptation strategies for climate change, using the Analytical Hierarchical Process.
7	[53]	Quantitative	Namibia	The study identifies challenges, including

(continued on next page)

Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
8	[32]	Mixed	Mixed	uncertainties in predicting climate change effects and determining adaptation options and costs. Integration offers diverse benefits, yet further research is needed to understand sector vulnerability and identify cost-effective adaptation measures. Results highlight irreversible impacts of continued GHG emissions, necessitating substantial reductions and adaptation-mitigation co-benefits to combat climate change effectively.
9	[2]	Qualitative	Several European nations, including Norway, Belgium, the Netherlands, and Spain.	The study developed a new method to analyze these interactions and find positive social impacts (SDG synergies) but also environmental drawbacks (trade-offs) due to material use. This study connects analyzing SDG interactions to responsible innovation, suggesting it helps assess a technology's overall sustainability and inclusivity.
10	[63]	Mixed	Tapei	It identifies influences and effects, finding no synergy in responses to climate change mitigation and adaptation. Standalone policies result in trade-offs, underscoring the need for coordinated policymaking and systemic assessments
11	[46]	Mixed	Zimbabwe	The study shows the potential trade-offs associated with adopting climate-smart interventions on incomes, food security, and greenhouse gas emissions.
12	[64]	Mixed	Chile	It highlights the substantial resource consumption and waste generation by agriculture, heavy industry, and forestry, impacting water, energy, and food security.
13	[54]	Qualitative	Nigeria	The study reveals that, Nigeria lacks climate change laws, hindering effective adaptation efforts. Integrating adaptation into poverty reduction strategies is crucial for addressing climate change impacts and achieving SDGs.
14	[31]	Mixed	Mixed	The study highlights that shifting from fossil fuels to cleaner, renewable energy is essential for

Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
15	[48]	Qualitative	Nigeria	achieving sustainable development and addressing the challenges posed by climate change, The study highlighted SDG 1,2,9 by demonstrating how climate change disrupts livelihoods, threatens food security, and fuels conflict between farmers and pastoralists. The proposed use of technology for conflict resolution aligns with SDG 9, emphasizing innovation and infrastructure for peacebuilding
16	[59]	Qualitative	n.a	Developing countries and marginalized groups, particularly women, face disproportionate effects, exacerbating inequality. Integrating mitigation and adaptation strategies is essential for addressing these challenges and achieving environmental sustainability while prioritizing equity and well-being.
17	[57]	Qualitative	n.a	Stabilizing greenhouse gas concentrations hinges on broader socio-economic development paths, urging climate policy integration within larger policy frameworks.
18	[37]	Qualitative	Africa	The analysis suggests that Africa's ability to benefit from sustainable development synergies in climate strategies is limited by institutional barriers hindering funding, capacity building, and technological innovation
19	[65]	Qualitative	n.a	By categorizing green infrastructure (GI) solutions on a 'green grey' scale, the review reveals key combinations of benefits and provides strategies to maximize positive outcomes while managing trade-offs. These insights are crucial for decision-makers seeking sustainable development solutions that address the challenges posed by climate change.
20	[33]	Qualitative	n.a	it reveals that studies focus on sectors like energy and land use, revealing risks from both mitigation (increased exposure) and adaptation (higher emissions). Integrated assessment frameworks are crucial to managing these conflicts

(continued on next page)

Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
21	[45]	Mixed	Ghana	CSA implementation involves trade-offs and synergies that vary across agro-ecological zones. This study prioritizes CSA practices by examining farmer uptake, drivers, and benefits/drawbacks (e.g., irrigation boosts productivity but increases GHGs). Results highlight differences between zones and the need to consider trade-offs for effective CSA action plans in dryland farming
22	[66]	Mixed	India	Results revealed challenges faced by smallholders, including changes in rainfall patterns, reduced farm sizes, and lack of resources. It identified three key approaches to adaptive capacity related to the Sustainable Development Goals
23	[44]	Qualitative	Ethiopia, Kenya and Democratic Republic of Congo (DRC)	natural hazard mitigation, social vulnerability and social-ecological resilience. Results reveal varying electricity access targets and Intended Nationally Determined Contributions (INDC) among countries. Ethiopia aims for nearly 100 % renewable energy, Kenya will reach only 54 % renewables by 2030, and DRC has a high renewable percentage but low per capita consumption despite becoming a power exporter
24	[52]	Mixed	Ethiopia	Social safety net programs, particularly those incorporating public works for land and ecosystem restoration, can mitigate climate change while addressing poverty. Lessons from Ethiopia suggest these programs can inform global development strategies with climate benefits.
25	[63]	Qualitative	n.a	It proposes principles for synergy, emphasizing ecosystem health, community resilience, monitoring carbon and adaptation benefits, and explicit planning for adaptation outcomes, advocating for incentivizing adaptation goals within forest carbon initiatives
26	[67]	Quantitative	Spain	This highlights the limitations of single sustainability indicators.

Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
27	[56]	Qualitative	n.a	Correlations exist between factors like tourism, education, and economic development; causality needs further investigation. Better-rated areas have higher income and employment rates, while low unemployment doesn't necessarily correlate with high sustainability. Proposes a framework that optimizes efforts towards supporting development, poverty alleviation, and climate change mitigation and adaptation goals.
28	[46]	Mixed	Zimbabwe	It highlights market-oriented interventions and social protection mechanisms to support sustainable intensification and improve incomes and food security while considering the implications for greenhouse gas emissions.
29	[43]	Qualitative	Global South and North	This study positions decentralized renewable energy (DRE) as a strategy for mitigating and adapting to climate change. It highlights how DRE access in rural areas can reduce deforestation, poverty, and vulnerability to climate impacts while also lowering greenhouse gas emissions.
30	[68]	Qualitative	India	In the case of agriculture, the analysis suggests that the Green Revolution era's focus on technology development and high-yielding varieties drove the initial innovation system.
31	[58]	Qualitative	n.a	This study highlights the need for integrated land management across agriculture and forestry to achieve the SDGs. It argues for viewing these sectors as a continuum rather than separate entities. The study suggests overcoming bottlenecks such as limited resources, time constraints, and fragmented institutional structures to achieve synergy.
32	[47]	Mixed	Ghana	Identified synergies include enhanced productivity through mixed cropping and intercropping with legumes, improving soil fertility and crop yields.

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Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
33	[28]	Qualitative	n.a	Trade-offs were observed, with economic viability emerging as a significant concern due to capital-intensive practices like irrigation and improved crop varieties. While synergies exist in specific sectors like land-use management, the global potential for fully integrated approaches seems limited due to differing scales and economic factors.
34	[69]	Qualitative	n.a	Results show that many measures provide co-benefits and synergies, particularly in sectors such as green infrastructure, buildings, and transportation.
35	[70]	Qualitative	India	Recommend a multi-pronged approach: assess village vulnerabilities, promote sustainable practices, and eliminate harmful policies. Location-specific weather stations, early warning systems, and Indigenous crops are crucial for adaptation.
36	[41]	Qualitative	Africa	By considering environmental, social, economic, and institutional factors, Africa can create policies that address both development needs and climate change. Challenges like weak institutions and fragmented sectors need to be addressed.
37	[40]	Qualitative	n.a	Climate policy negotiations should prioritize sustainable development goals and acknowledge that the most effective mitigation and adaptation mix depends on the severity of climate change. Limited mitigation can make adaptation very challenging.
38	[71]	Mixed Methods	Chile	The study suggests that stronger collaboration between national, regional, and local governments and a focus on community priorities can improve climate resilience efforts.
39	[55]	Qualitative	Morocco	The study highlights the negative consequences on water resources, health, food security, and migration. Despite a national sustainable development strategy, Morocco remains particularly vulnerable,

Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
40	[51]	Mixed methods	South Africa	especially in terms of health. Current approaches to land use and restoration projects limit their ability to achieve benefits for climate adaptation, mitigation, and development (triple wins).
41	[50]	Qualitative	Seven European countries	The study argued that nature-based solutions (NbS) should ensure social equity and not displace residents or worsen inequality. Affordable housing strategies should be integrated with NbS projects to ensure everyone benefits from increased green space.
42	[35]	Qualitative	n.a	The study defines climate-resilient pathways that combine mitigation (reducing climate change) and adaptation (coping with impacts) to achieve sustainable development. These pathways require ongoing adjustments and consider social, economic, and environmental factors.
43	[34]	Qualitative	n.a	This paper examines better integrating adaptation (coping with climate change) into forest carbon reduction projects. Current guidelines for these projects focus on maintaining forest health and community needs but don't explicitly consider adaptation.
44	[42]	Mixed	USA	Cities with strong leadership, environmental departments, and educated populations were likelier to pursue climate-compatible development.
45	[72]	Qualitative	n.a	Local environmental policies can benefit the climate, but deeper mitigation might require switching to expensive fuels, creating trade-offs.
46	[60]	Qualitative	n.a	The study highlights the need to consider the social and economic aspects and asserts that traditional approaches focused only on technology or economics won't work. It highlights that climate change, sustainable development, and poverty are interconnected.
47	[38]	Qualitative	Cameroon	The biggest challenge to integrated climate action

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Table 6 (continued)

No	Study	Methodology	Country	Interpretation of the content
48	[62]	Qualitative	n.a	is a lack of funding, followed by poor coordination, communication, and public participation. The study proposes a framework that focuses on building society's ability to adapt to climate change while reducing inequality.
49	[39]	Qualitative	Mozambique	Existing programs, such as National Adaptation Programmes of Action, can be used to identify areas where development and adaptation goals overlap.
50	[73]	Qualitative	n.a	Climate change policy goes beyond just energy use now. It includes reducing emissions, capturing carbon, and preparing for climate impacts. This requires many sectors to work together, but these sectors have other priorities, especially in developing countries.
51	[61]	Qualitative	India	A Resilience Master Plan can help cities improve their ability to withstand disasters while also achieving sustainable development goals.
52	[49]	Qualitative	Ghana and Burkina Faso	The shift from fossil fuels aligns with climate goals and offers social, economic, and environmental benefits but requires diversifying beyond hydropower.

reduction through increased consumption of renewable energy sources.

In addition, McElwee et al. [80] discuss how nature-based solutions can address the interconnected challenges of climate change in lower-income countries, potentially contributing to the achievement of SDGs such as SDG 15 (Life on Land), SDG 13 (Climate Action), and SDG 10 (Reduced Inequalities). In this study, although some trade-offs with local communities were identified in the short term, these trade-offs were reported to be minimizable through more effective government policies [48].elucidates the intricate relationship between climate change and sustainable development goals (SDGs) in the context of conflicts in West Africa, particularly Nigeria. Examining how climate change impacts livelihoods and food security and triggers conflicts between farmers and pastoralists underscores the interconnectedness between climate actions and SDGs, such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 13 (Climate Action). Additionally, the recommendation to utilize technology for conflict resolution aligns with SDG 9 (Industry, Innovation, and Infrastructure).

A further illustration of the connections between SDGs and Climate Actions is discussed by Kupika et al. (2018). The study illustrates how past wildlife policies in Zimbabwe aligned with the green economy agenda's goals, despite not specifically targeting climate change. Still, even though recent wildlife policies in Zimbabwe now emphasize a green economy agenda, there remains a need to integrate green economy principles into biodiversity-related policies better. Orchard et al. [66] identified three key approaches to adaptive capacity related to the

Sustainable Development Goals (SDGs), namely: natural hazard mitigation (SDG 13), social vulnerability (SDG 1, 2, and 5), and social-ecological resilience (SDG 15). Their study highlighted the importance of collective action in addressing these SDGs and emphasized the need for tailored, context-specific solutions for sustainable development.

Given the diverse effects of climate change on SDGs, it is important to implement policies that address climate impacts and adaptation strategies from a multi-scale perspective to enhance climate resilience. This involves promoting integrated ecosystem management that considers the interconnectedness between industry, agriculture, trade, and health (Ibrahim & Samy, 2022). For instance, a successful national initiative in Ethiopia that aimed to restore land and promote sustainable land management not only helped reduce poverty (SDG 1) but also unexpectedly led to lower greenhouse gas emissions and increased landscape carbon stocks, contributing to climate change mitigation [52]. From this perspective, a project on agroforestry can be found sequestering carbon, thus supporting SDG 13, promoting food security (SDG 2), and safeguarding biodiversity (SDG 15). To maximize synergies for a just energy transition, policymakers should use integrated planning approaches that holistically map interactions and pinpoint win-win situations.

4.2. Trade-offs between SDGs and climate actions

While there are synergies, results in this systematic review reveal trade-offs between climate actions and SDGs. This complexity of balancing sustainable development goals with climate mitigation efforts requires integrated solutions to address these challenges effectively. Table 8 presents various trade-offs between Sustainable Development Goals (SDGs) and climate action, highlighting specific challenges and proposed solutions for each interaction. These trade-offs encompass key areas such as access to affordable energy, economic growth, sustainable infrastructure, food security, equity and justice, water security, gender equality, health and well-being, education, and biodiversity conservation. Each trade-off is associated with a corresponding SDG, climate action approach, and a suggested solution within the framework of the Just Energy Transition.

Trade-offs are particularly evident in sectors like agriculture, where intensive practices to feed populations contribute to GHG emissions and biodiversity loss. For example, Antwi-Agyei et al. [47] discuss how the use of irrigation may result in increased farm productivity (SDG 2) but adversely contribute to the emission of greenhouse gases simultaneously, creating trade-offs. Hence, balancing the need to feed a growing population while reducing the climate impact of agriculture and forestry requires managing trade-offs between land use for food production and greenhouse gas removal.

Moreover [31], asserted that energy transition involves shifting from fossil fuels to cleaner, renewable energy sources to reduce carbon emissions and combat climate change, aligning with SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action) and SDG 9 (Industry, Innovation, and Infrastructure). However, the transition to renewable energy sources may also have trade-offs, such as initial high costs, technological challenges, and potential impacts on existing industries and employment.

Furthermore, within SDG 1 (No Poverty) and SDG 9 (Industry, Innovation, and Infrastructure), building infrastructure to support all vulnerable human populations in adapting to climate change could lead to substantial Greenhouse Gas (GHG) emissions in the long term, making it more difficult to cap global warming at 1.5 °C [83]. Similarly, Sharifi [69] points out that the prevailing trend among cities worldwide is to concentrate exclusively on either mitigation or adaptation in their policy plans, which can result in trade-offs. From this perspective, mitigation efforts may adversely affect adaptation by heightening risks such as the urban heat island effect and flooding or by diminishing the livelihood opportunities of underprivileged and marginalized populations and giving rise to equity concerns (SDG 1). Conversely, adaptation measures

Table 7

Synergies between sustainable development goals (SDGs) and climate actions through the just energy transition.

Synergy	Sustainable Development Goal (SDG)	Climate Action Approach	Just Energy Transition Approach	References
Renewable Energy Expansion and Economic Growth	SDG 8: Decent Work and Economic Growth	Investing in renewable energy can create green jobs and spur economic growth	Investing in green jobs, and skills training; supporting innovation and technological advancements	[37,43,53, 58,68]
Sustainable Infrastructure and Innovation	SDG 9: Industry, Innovation, and Infrastructure	The development of sustainable infrastructure requires innovation	Investing in renewable energy infrastructure; promoting technological advancements	[48,75]
Energy Access and Poverty Eradication	SDG 1: No Poverty	Access to affordable, clean energy can alleviate poverty	Investing in renewable energy sources, energy efficiency measures; targeted subsidies, and social safety nets for vulnerable populations	[37,31]
Climate-resilient Agriculture and Food Security	SDG 2: Zero Hunger	Climate-smart agricultural practices enhance food security	Promoting sustainable agricultural practices, and resilient crop varieties; integrating climate adaptation strategies in food production	[30,48,52, 76,77]
Clean Energy and Air Quality Improvement	SDG 3: Good Health and Well-being	Transitioning to clean energy reduces air pollution, improving health	Transitioning to cleaner energy sources, sustainable transportation; pollution control measures	[74]
Climate Action and Clean Water Access	SDG 6: Clean Water and Sanitation	Climate action measures can protect water resources	Comprehensive water management strategies; integrating renewable energy with water infrastructure	[30]
Gender Equality and Sustainable Energy Access	SDG 5: Gender Equality	Women's empowerment through energy access and participation	Gender-inclusive energy policies, women's participation in energy sector; access to clean energy technologies, entrepreneurship	[59,66,78]
Education and Climate Literacy	SDG 4: Quality Education	Climate education fosters understanding and action	Integrating climate education in school curricula; promoting climate literacy among students and educators	[79]
Biodiversity Conservation and Ecosystem Restoration	SDG 15: Life on Land	Renewable energy projects can promote biodiversity conservation	Environmental impact assessments, nature-based solutions; responsible siting of renewable energy infrastructure	[30,52,66]
Sustainable Cities and Climate Mitigation	SDG 11: Sustainable Cities and Communities	Urban sustainability measures contribute to climate goals	Investing in green infrastructure, sustainable urban planning; promoting public transportation, active mobility	[30,74].
Land management and restoration	SDG 13: Climate Action	Healthy ecosystems contribute to achieve climate change	Considering the social and economic impacts of land use	[30,51,52, 65,74]
Natural disasters and the Economy	SDG 10: Reduced Inequalities	Cost-effective strategies are achievable through nature-based solutions	Investing in nature-based solutions	[80]

Table 8

Trade-offs between sustainable development goals (SDGs) and climate action through the just energy transition.

Trade-off	Sustainable Development Goal (SDG)	Climate Action Approach	Just Energy Transition Approach	References
Access to Affordable Energy vs. Rapid Decarbonization	SDG 7: Affordable and Clean Energy	Transition to renewable energy sources, energy efficiency measures	Investing in renewable energy sources, energy efficiency measures; targeted subsidies, and social safety nets for vulnerable populations	[31,43,69, 80]
Economic Growth vs. Stringent Emission Reductions	SDG 8: Decent Work and Economic Growth	Stricter climate policies may impact fossil fuel-dependent industries	Investing in green jobs, and skills training; supporting innovation and technological advancements	[42,44,81, 82]
Sustainable Infrastructure vs. Land-use Change	SDG 9: Industry, Innovation, and Infrastructure	Expansion of renewable energy infrastructure may affect land use and biodiversity	Careful planning, responsible siting of renewable energy projects; investing in energy storage solutions	[83]
Food Security vs. Bioenergy Production	SDG 2: Zero Hunger	Large-scale biofuel production may compete with food production	Promoting second-generation biofuels, sustainable agricultural practices; comprehensive land use assessments	[47,52,80, 81,84]
Poverty reduction vs GHG emissions	SDG 1: No Poverty	Investment in renewable energy sources; Promoting sustainable agricultural practices	Involving communities at risk of poverty in decision-making;	[69,83,80, 81]
Gender Equality vs. Energy Access and Transition	SDG 5: Gender Equality	Women are disproportionately affected by energy poverty and underrepresented in energy decision-making	Gender-inclusive policies, women's participation in the energy sector; access to clean energy technologies, entrepreneurship	[85]
Biodiversity Conservation vs. Renewable Energy Expansion	SDG 15: Life on Land	Renewable energy infrastructure may encroach upon natural habitats	Environmental impact assessments, precautionary approach to siting, investing in nature-based solutions	[84,80,86]

may increase greenhouse gas emissions through actions like reducing efficiency and boosting energy demand.

Additionally, agroforestry practices in the Sahel region have demonstrated trade-offs, such as the choice between fuelwood and crops and deciding whether to allocate land for more forests or increased cropping. This underscores the importance of making balanced land management decisions and considering water availability for agroforestry in relation to its impact on the water cycle [84]. Similarly, McElwee et al. [80] found that various interventions within the global land and agri-food sectors negatively affect Nature's Contributions to

People (NCPs) and the SDGs. These negative impacts are particularly evident in bioenergy (SDG 7: Affordable and Clean Energy), bioenergy with carbon capture and storage (SDG 13: Climate Action), afforestation efforts (SDG 15: Life on Land), and certain risk-sharing measures such as commercial crop insurance (SDG1; SDG 2; SDG 13). This highlights the delicate balance required between initiatives against climate change, environmental sustainability, and economic development.

Land-use and land-cover changes (LULCC) in urban areas (SDG 15), such as in Rome, have also shown an overall decline in the supply of ecosystem services, largely due to the expansion of urban areas at the

expense of agricultural land [86]. Finding a balance between agricultural and forestry practices to decrease emissions while still utilizing land effectively can be a difficult task. Trade-offs between SDGs and climate actions emphasize the critical need for transformative action that aligns with SDG 12 (Responsible Consumption and Production) and necessitates innovative, sustainable land management and food production strategies for a Just Energy Transition.

4.3. The role of local, social and community-driven approaches in energy transition

The discussion on energy transitions often leans heavily on frameworks that are focussed either on the on the science, technology, and society aspects (STS). While these paradigms provide valuable insights, they may underplay the critical roles of local knowledge and social dimensions in shaping sustainable energy solutions. For instance, Antwi-Agyei et al. [36] underscore the importance of integrating cross-sectoral considerations and local capacities in climate strategies, particularly in contexts like Ghana. Similarly, Favretto et al. [51] highlight the limitations of current land-use practices in South Africa, emphasizing the need for participatory approaches that consider community priorities.

Incorporating local knowledge systems can address gaps in one-size-fits-all approaches to energy solutions. As Selvakkumaran and Silveira [44] argue, electricity access strategies in Ethiopia, Kenya, and the Democratic Republic of Congo differ significantly due to socio-economic and geographic factors. By focusing on community-driven models and inclusive policy frameworks, these regions demonstrate the potential of integrating social and cultural contexts into renewable energy planning. Furthermore, Tamasiga et al. [87] highlighted that the energy transition requires social cohesion and capital to promote collective action, resilience, and public support. Strong community bonds foster trust, inclusivity, and cooperation, driving sustainable practices and climate policy acceptance. Integrating these elements with social protection ensures equitable burden-sharing and empowers vulnerable groups. These interconnected efforts create resilient, inclusive systems that are necessary for effective climate adaptation and mitigation.

Moreover, the role of social dimensions, such as equity and justice, is increasingly acknowledged as a cornerstone of sustainable transitions. Hägele et al. [3] emphasize the significance of inclusive decision-making and robust coordination mechanisms to balance environmental and social goals. This reinforces the need for a paradigm shift from purely technical solutions to approaches that embed local voices and social considerations at every stage of policy and project development. Acknowledging the role of local and social dimensions aligns with global calls for equity, inclusivity, and cultural relevance in addressing climate challenges.

4.4. Political ecology of the just energy transition

Categorizing literature through a political ecology lens offers valuable insights into the intersections of global climate action, socio-economic justice, and sustainable development (see Table 9). This approach, with its focus on power dynamics, equity, and governance frameworks, unravels complex relationships and deepens our understanding of the socio-political forces that shape economic outcomes within the Just Energy Transition. Power dynamics in climate action explores how power imbalances shape climate policies. This is essential for understanding how global forces, such as food price fluctuations driven by powerful entities, affect domestic economies. The studies by Swart & Raes [28] and Tol [29] suggest that international economic power dynamics influence national economic outcomes.

Governance and Institutional Frameworks emphasizes the role of institutions in climate policy outcomes. For example, Nyiwul [37] and Antwi-Agyei et al. [36] show how institutional arrangements can either ease or worsen the economic effects of these global factors.

Table 9

The references categorized based on the theory of political ecology.

Political Ecology Theme	Study References
Power Dynamics in Climate Action	Swart & Raes [28], Tol [29], Wilbanks & Sathaye [40], Kalafatis [42], Goklany [82], McElwee et al. [80]
Governance and Institutional Frameworks	Nyiwl [37], Antwi-Agyei et al. [36], Ngum et al. [38], Hoffmaister & Román [39], Kalafatis [42], Chuku [41], Venema & Rehman [43]
Equity and Justice in Climate Action	Mfon [48], Amesho et al. [53], Orchard et al. [66], Shrestha & Dhakal [30], Anukwonke et al. [59], R. Sultana et al. [78], Rainard et al. [85]
Social and Environmental Conflicts	Bonilla-Cedrez et al. [81], Antwi-Agyei et al. [47], Kalafatis [42], Ruban et al. [31], McElwee et al. [80], Elagib & Al-Saidi [84]
Local vs. Global Impacts of Climate Change	Pradhan et al. [27], Luttkhuis & Wiebe [2], Duguma et al. [21], Shrestha & Dhakal [30], Favretto et al. [51]
Sustainable Development and Capitalism	Kadaverugu et al. [75], Mfon [48], Choi et al. [65], Choi et al. [65], Ruban et al. [31], Shrestha & Dhakal [30]
Environmental and Resource Management	Woolf et al. [52], Leakey [76], Marino et al. [86], Ntawuruhunga et al. [74], Shrestha & Dhakal [30], Favretto et al. [51]
Land Use and Resource Exploitation	Venema & Rehman [43], Serôa Da Motta [83], Woolf et al. [52], Elagib & Al-Saidi [84], Ntawuruhunga et al. [74]

Equity and Justice in Climate Action highlights the inequalities climate policies may produce. This theme connects with your study's focus on how wealthier nations may better manage the impacts of food price fluctuations compared to developing countries. The works of Mfon [48] and Amesho et al. [53] provide a framework for understanding these disparities. Social and environmental conflicts highlight the tension between environmental sustainability and economic growth, illustrating how disputes over resource allocation can impact overall economic performance. It underscores how conflicts over resource allocation can affect economic performance. Studies like those of Bonilla-Cedrez et al. [81] and Ruban et al. [31] help explain how such conflicts influence national economies, especially in agriculture-dependent countries.

4.5. Biases and gaps in knowledge identified in the study

The systematic review conducted in this study highlights critical insights into the synergies and trade-offs of the just energy transition (JET) in the context of sustainable development goals (SDGs). However, the analysis also reveals significant biases and gaps in the current body of knowledge. Addressing these deficiencies is essential for ensuring a holistic and inclusive understanding of the JET and its broader implications.

4.5.1. Expanding the Scope: Integrating Interdisciplinary and localized perspectives

The study emphasizes the technical and policy aspects of JET, which, while important, fails to adequately capture the interdisciplinary and localized dimensions of the energy transition. Several key themes appear to be overlooked: social equity and inclusion, including gender dynamics and the impacts on marginalized communities; the role of Indigenous knowledge systems and cultural practices in shaping sustainable energy policies; and grassroots innovations along with community-driven solutions to address energy poverty and sustainability challenges. A growing body of work is exploring the intersection of energy transitions with socio-cultural factors. Future research could benefit from focusing on localized studies integrating social sciences, anthropology, and community engagement to provide a more nuanced understanding of JET. Funding agencies and academic institutions should encourage interdisciplinary research initiatives to bridge these thematic gaps.

4.5.2. Beyond technology and economics: Addressing political, cultural, and institutional dimensions

The analysis highlights technological and economic strategies as central to Just Energy Transition (JET), which inadvertently marginalizes the importance of political, cultural, and institutional factors. For instance, the role of governance structures, public participation, and cross-sectoral collaboration is less emphasized in the reviewed literature. The implications of this narrow focus are significant: it risks overlooking systemic barriers to implementation, such as institutional inertia and resistance to change. Moreover, policies derived from a technocratic approach may fail to gain public support or address socio-political inequalities. Future studies should, therefore, examine the institutional and political dimensions of JET, including case studies of governance frameworks, public-private partnerships, and community-based initiatives. Comparative research across diverse political and cultural contexts could provide actionable insights into best practices for inclusive energy transitions.

4.5.3. Addressing gaps in just energy transition research

A multi-pronged approach is necessary to bridge the gaps and biases identified in this study. First, broadening thematic coverage involves expanding research agendas to include underexplored themes such as social equity, indigenous knowledge, and localized energy solutions, which will require interdisciplinary collaborations. Second, enhancing inclusivity in research can be achieved by establishing global research networks and capacity-building initiatives to amplify the voices of underrepresented regions and communities in energy transition discourse. Finally, promoting policy-relevant research involves aligning academic research with the practical needs of policymakers and practitioners by prioritizing actionable insights and real-world applications.

5. Conclusion and policy recommendations

This study explored the interplay between the SDGs and climate action, focusing on identifying synergies and trade-offs through the lens of the JET. Focusing on the synergies and trade-offs between these two critical global agendas, the research sought to identify pathways to achieve climate mitigation and socio-economic justice. Moreover, in recognition of the importance of balancing environmental sustainability with equity and fairness, the study addressed the pressing need for an integrated approach to energy transition.

To achieve this, the study employed a systematic review methodology guided by the PRISMA protocol, which involved an in-depth and rigorous analysis of existing literature from the Web of Science and Scopus databases. The rationale behind adopting this approach was to bridge the knowledge gap concerning the interconnections between climate actions and the SDGs, specifically within the JET framework. Moreover, the analysis incorporated both qualitative and quantitative findings from various contexts. This allowed for an in-depth assessment of the complex dynamics between climate policies and sustainable development.

The results of the study reveal significant synergies between climate actions and SDGs, particularly in promoting renewable energy, economic growth, sustainable infrastructure, and poverty eradication. For instance, expanding renewable energy can contribute to SDG 7 (Affordable and Clean Energy) while supporting SDG 13 (Climate Action) by reducing carbon emissions. However, the research also identifies insights that are not immediately apparent. One such insight is the risk of increasing inequality and economic disruption if the energy transition is not managed inclusively. Additionally, the study underscores the critical role of decentralized energy systems in reducing energy poverty in remote areas, which directly supports SDG 10 (Reduced Inequalities). These decentralized systems provide energy access and help mitigate regional inequalities (SDG 10: Reduced Inequalities) by empowering marginalized communities through local job creation and energy independence. Additionally, JET can drive SDG 11

(Sustainable Cities and Communities) by promoting innovations in sustainable urban infrastructure and reducing carbon footprints while improving livelihoods.

Another interesting result of this study is identifying how JET strategies interact with land use, particularly in rural and agricultural settings. The study uncovered a critical trade-off: while renewable energy infrastructure often competes with agricultural land, creating conflicts with food security (SDG 2: Zero Hunger), it also presents opportunities for agroforestry systems that integrate clean energy production with sustainable land use. Though less explored, such synergies point to the potential of JET to advance climate mitigation and food security when supported by appropriate policies. Moreover, the study revealed that JET creates green jobs and stimulates economic growth (SDG 8: Decent Work and Economic Growth). On the contrary, it risks exacerbating inequalities if not kept in check. For instance, fossil fuel-dependent regions may experience severe economic disruptions, which could lead to increased poverty and unemployment. This trade-off, often underestimated, emphasizes the need for a just transition framework that includes comprehensive social protection measures and retraining programs for displaced workers.

Building on the analysis and findings of this study, the policy and practical recommendation include developing integrated frameworks that promote cross-sectoral collaboration and multi-stakeholder engagement. Furthermore, governments should prioritize investments in green infrastructure and renewable energy technologies that are inclusive and adaptable to diverse socio-economic contexts. Moreover, targeted subsidies and social safety nets should be made available and accessible to vulnerable populations to ensure equitable access to clean energy and reduce energy poverty. In addition, the pace of mobilizing finance for the energy transition can be improved by attracting private capital, promoting public-private partnerships to drive green innovation, and expanding decentralized renewable energy systems in off-grid and underserved regions. Additionally, enhanced capacity building, retraining, and upskilling are required in areas heavily reliant on fossil fuels, to ensure these communities are supported through the transition.

Nonetheless, the systematic review acknowledges certain limitations. While comprehensive, the reliance on existing literature may overlook emerging local experiences and innovations in rapidly changing environments. Additionally, while this review captured a broad range of contexts based on existing studies, it could not perform empirical assessments of JET, suggesting longitudinal research to validate the findings. Future research should focus on investigating the implementation of JET policies in diverse socio-economic settings, particularly in developing countries where the impacts of climate change and socio-economic inequalities are most pronounced.

CRedit authorship contribution statement

Phemelo Tamasiga: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Helen Onyeaka:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Conceptualization. **Mal-ebogo Bakwena:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Benita Kayembe:** Writing – review & editing, Writing – original draft, Data curation, Formal analysis, Conceptualization. **Valentine Dzingai:** Writing – review & editing, Writing – original draft, Formal analysis, Methodology. **Nancy Kgengwenyane:** Writing – review & editing, Writing – original draft, Conceptualization. **Agnes Ariho Babugura:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **El houssin Ouassou:** Writing – review & editing, Writing – original draft, Software, Conceptualization.

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This study does not require ethical approval.

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The authors confirm the accuracy of all data and findings utilized in this study.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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No data was used for the research described in the article.

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