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Article

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Advancing Sustainable Development through the lens of Energy Efficiency: A Systematic Literature Review

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ABSTRACT

The global focus on Sustainable Development (SD) encompasses social, economic, and environmental concerns. Energy efficiency plays a crucial role in this transition, defined as efforts to reduce energy consumption by lowering service demand. It is widely recognized as one of the most cost-effective, tested, and accessible strategies to achieve SD, fostering economic growth, social progress, and carbon reduction. To understand the interplay between energy efficiency and SD, a comprehensive review is needed. This study examines previous research on SD through the lens of energy efficiency, utilizing the SCOPUS database to select 46 publications from 2006 to 2022. These studies are categorized by year, publishers, journals, country, sectors, citations, data analysis methods, and sustainable dimensions. The classification helps identify gaps, such as the lack of a unified research framework. Advanced nations conducted 30.43% of the studies, with most research focusing more on environmental aspects than economic or social ones. This study expands the literature by highlighting connections between energy efficiency and SD, aiding scholars and practitioners in promoting sustainable development alongside energy efficiency. Consequently, the literature review focused on empirical research.

Keywords: Energy Efficiency, Sustainable Development, Systematic Literature Review
JEL Classifications: Q40, Q56

1. INTRODUCTION

Sustainable Development (SD) is any "development that addresses the issues of the present without undermining the capacity of people in the future to address their own issues," or more broadly, development that meets current needs without compromising future generations' ability to meet theirs. SD has become a significant global concern, highlighted by the United Nations' "The Future We Want" from the 2012 Rio+20 Conference (Filho et al., 2022). Although the conference did not yield major treaties or funding, it impacted SD by fostering institutional changes and addressing the role of the green economy and global challenges (Manulak, 2023). Global SD requires collective efforts, with OECD countries working with partners to align development assistance with SD goals. Park et al. (2015) notes that focus on sustainability began with the 1972 Stockholm Conference, establishing the SD paradigm to improve future generations' welfare. This concept aligns with the "Social Contract Theory," emphasizing environmental preservation and resource sustainability for economic and social advancement. Activities causing environmental degradation are unsustainable in the long term. Alam et al. (2023) observe that both developed and developing nations are competing for development, often validating increased energy needs through supply-side measures, such as new power plants and fossil fuel exploration. Fossil fuel use, a major greenhouse gas source, drives societal and economic growth but exacerbates global warming and ecological disruptions (Aktar et al., 2020). Nations must balance emission reductions with economic growth, aiming for sustainable development. Energy efficiency (EE) is key for evaluating environmental initiatives, correlating environmental impact with economic outcomes, and promoting social progress (Müller et al., 2015).

EE enhances the triple bottom line (TBL), integrating economic, social, and environmental performance (Elkington, 1998). Climate change impacts on developing economies could reduce GDP growth significantly (Marques et al., 2019). Many studies have explored EE's impact on economic, social, and environmental performance (Charmondusit et al., 2014). However, there is a lack of comprehensive analysis on EE's role in SD within a unified decision-making framework. Various reviews and bibliometric studies have included EE in SD research (Camarasa et al., 2019; Trianni et al., 2018). These often focus on policy and incentives, like Zhang and Yuan (2019) on energy performance contracts and Li et al. (2021) on a two-decade review. There remains a need for research on an integrated framework assessing EE across economic, environmental, and social dimensions (Abreu et al., 2017).

The objective of this study is to use a systematic literature review (SLR) methodology to provide a comprehensive overview of the existing literature on the intersection of energy efficiency (EE) and Sustainable Development (SD). Systematic reviews have proven effective in building multidisciplinary consensus (Kraus et al., 2020). To understand the essential concepts of EE's role in global sustainability, an SLR will locate and synthesize relevant research using structured, transparent, and reproducible methods. There has been insufficient study on integrating EE into a comprehensive decision-making framework within SD. This study aims to fill this gap, compare global research trends, and help academics and professionals prioritize factors and theories to maximize the understanding and impact of EE and SD. This study updates the literature by highlighting synergies between EE and SD and addressing factors influencing their acceptance. It includes all relevant studies, methods, and findings, something previous research lacked. Forty-six papers from renowned publishers on EE's role in SD's three aspects are reviewed using the SLR technique, which identifies emerging topics. The SLR helps determine the dimensions, scope, domain, data sources, methodologies, and models in EE and SD literature. This study uses algorithmically generated SLR results to explore EE's potential to achieve SD goals and suggests areas for further research. An ontological approach classifies the available literature on EE and SD, structuring the content and its interpretation. A database of relevant terms and content from 2006-2022 is developed to trace the history of studying EE and SD.

The paper is organized into six sections: Background information, an evaluation of literature on the acceptance and implementation of energy efficiency, a summary of the methodology, detailed findings and results from the systematic literature review, general conclusions and implications, research limitations with suggestions for further study, and the conclusion.

2. LITERATURE REVIEW

2.1. Energy Efficiency (EE)

Energy efficiency (EE) measures the effective use of energy resources by comparing energy inputs and outputs (Cui et al., 2014). Broadly, EE involves using technology or actions to complete tasks with the same quality while reducing energy consumption, especially in OECD countries. Patterson (1996) clarified that EE means achieving the same output or service with less energy. Developing relevant indicators is crucial for systematically assessing EE improvements. Miller and Blair (1985) introduced energy intensity as an economy-wide metric for EE improvements through behavioral, technological, and economic changes. Previous research identifies three main changes in EE: Increased environmental awareness leading to stricter energy regulations (Adom et al., 2018; Vaninsky, 2009), advancements in pollution control technology reducing resource consumption while maintaining productivity (Mielnik and Goldemberg, 1999; Richmond and Kaufmann, 2006), and economic shifts from energy-intensive sectors to less energy-intensive ones like services and technology. EE gained prominence in energy strategies post the 1973 oil shock and is a vital tool for sustainability analysis. Conventional energy generation and consumption have significant economic, social, and environmental impacts, making EE crucial for SD (Türkoğlu and Kardoğan, 2018). Fowlie and Meeks (2020) highlight EE's potential to reconcile economic growth and SD, particularly in emerging economies. Sustainable economies must protect environmental quality (Caiado et al., 2017), making EE essential for addressing the economy-environment conflict. Known as the "first fuel," EE can significantly reduce greenhouse gas emissions and pollutants. EE initiatives also create jobs, reduce poverty, and foster sustainability. Rosen (2009) argues that EE is more advantageous than renewable energy for sustainability since all energy resources have some environmental impact. Enhancing EE can mitigate problems associated with carbon emissions, linking EE directly to SD.

2.2. Sustainable Development (SD)

The concept of Sustainable Development (SD) has been explored through various perspectives, including the creation of a vision (Lee, 1993), promotion of value change (Clark, 1989), advancement of moral growth (Gladwin et al., 1995), societal reorganization (Gore, 1992), and facilitation of transformative processes aimed at achieving a better future (Gladwin et al., 1995). The foundational definition was provided by the World Commission on Environment and Development, known as "The Brundtland Commission," describing SD as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Cassen, 1987). This definition emphasizes the advancement of society while considering the limits of life-sustaining ecosystems and has gained global acceptance from various organizations (Gladwin et al., 1995). Since the commission's report, numerous competing perspectives on sustainability have emerged, highlighting the concept's complexity and moral dimensions. Consequently, many believe that SD will remain a challenging concept to define precisely for some time (Beckerman, 1995). Like democracy and liberty, interpretations of SD vary in its early stages, as new paradigms typically arise from novel foundations without a comprehensive set of rules (Kuhn and Sternfeld, 1970). Management scholars are encouraged to engage actively in this evolving debate, as progress involves confrontation between opposing views (Kuhn and Sternfeld, 1970).

In 2015, the United Nations (UN) introduced the 17 Sustainable Development Goals (SDGs) within the Urban Agenda

(HABITAT III), accompanied by various measurable indicators (Chaitanya et al., 2016). These SDGs serve as a global blueprint for SD, considering their specific characteristics, strengths, and weaknesses at different levels. Examples of SD include "resilient," "eco," "smart," "intelligent," and "knowledge" cities (De Jong et al., 2015). Jeffrey Sachs' book "The Age of Sustainable Development" evaluates the SDGs from an SD perspective, highlighting SD as both a comprehensive worldview and a pragmatic approach to addressing global challenges (Sachs et al., 2022). SD aims to promote individual well-being and happiness despite significant challenges at various levels. SD involves using resources sustainably to ensure their availability for future generations (Mohieldin, 2017). Evers (2018) links SD to organizational principles that achieve human development goals while preserving natural systems' ability to provide necessary services and resources. Thus, SD seeks to promote social development, ecological stability, and economic growth (Gosling-Goldsmith, 2018). Ukaga et al. (2011) emphasized transitioning from harmful socio-economic activities to those with positive environmental, economic, and social outcomes. The growing global economy and limited natural resources underscore SD's importance Hák et al. (2016). SD involves balancing material progress, natural system preservation, and societal well-being, focusing on economic growth, environmental conservation, and social equity, which form an inseparable entity (Kolk, 2016). Cancino et al. (2018) suggest assessing a nation's sustainable value through three aspects: social value (e.g., diversity, equality, community development), economic value (e.g., growth, profitability, resilience), and ecological value (e.g., renewable resource use, emission reduction, biodiversity preservation). Environmental factors include assessing natural world's carrying capacity and efforts to maintain ecosystem health (Brodhag and Talière, 2006). Goodland and Daly (1996) emphasize sustainable use of natural capital for economic inputs and waste management, suggesting resource use should match regeneration rates, and pollution should integrate into ecosystems sustainably (Diesendorf, 2000; Evers, 2018). The earth's systems have inherent limits, and continuous expansion pressures these limits, raising concerns about long-term viability (Måns et al., 2017). In this context, energy efficiency is a key indicator of progress toward SD, potentially offering a path to achieving it (Prandecki, 2014).

2.3. Energy Efficiency and Sustainable Development

Energy efficiency (EE) has become a key component of sustainable development, addressing economic, environmental, and social challenges (Rogers et al., 2008). Energy, from both non-renewable and renewable sources, is crucial for economic growth as it underpins the manufacturing sector. The rapid increase in global population has led to the overuse of natural resources to meet energy demands (Li et al., 2021). However, this extensive use of natural and non-renewable energy sources leads to environmental issues such as global warming, climate change, and environmental degradation. Additionally, increased energy consumption in industries and households causes energy price volatility, negatively impacting economic growth (Ma' et al., 2021). Renewable energy, generated from replenishable resources, aims to enhance energy independence and mitigate environmental issues like global warming and climate change. With rising global energy demands, there is growing interest in renewable energy as an alternative to non-renewable sources, potentially contributing to sustainable development and long-term economic prosperity (Sebri and Ben-Salha, 2014). According to the USA Energy Information Administration (EIA) 2016 study, global energy demand is expected to increase by 48% by 2040. This surge in energy usage could worsen environmental problems, necessitating policies to improve environmental quality, promote renewable energy, and reduce pollution for sustainable development.

EE and renewable energy are subjects of significant scholarly interest. Kolosok et al. (2021) analyzed data from 28 European Union economies (1990-2018) using Python, finding a positive correlation between renewable energy and energy efficiency indices, except for energy productivity. Wang et al. (2020) studied factors influencing renewable energy consumption in G20 economies, revealing a strong positive relationship between research and development investment, policy implementation, energy efficiency, and renewable energy consumption. Dhakouani et al. (2019) explored scenarios for renewable energy adoption in Tunisia, concluding that EE measures significantly boost renewable energy use and reduce grid reliance, due to decreased energy consumption from improved efficiency (Abolhosseini et al., 2021). EE and renewable energy also play crucial roles in reducing pollution emissions in emerging economies (Akram et al., 2020). Gielen et al. (2019) projected a 63% increase in EE and renewable energy by 2050 compared to 2015 levels, potentially reducing global carbon emissions by 94%. The International Energy Agency (IEA) report (2014) noted that multiple impacts of EE contribute to sustainable development, despite their complexity and overlap. Therefore, EE emerges as a pivotal concept for achieving enhanced sustainability in nations or organizations (Wu et al., 2023).

3. METHODOLOGY

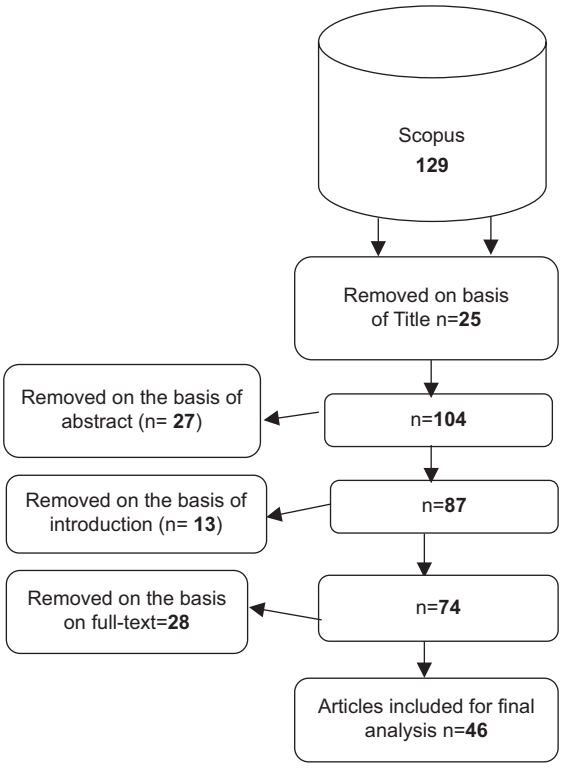
Previous research is crucial for the development of new knowledge (Mohamed Shaffril et al., 2021). A literature review is a systematic procedure that functions as the backbone of any investigation, facilitating gradual scientific progress by building upon previous discoveries (Salisu et al., 2021). During the process of doing a literature review, scholars engage in the analysis, interpretation, and critical evaluation of the preexisting corpus of knowledge. The approach facilitates the discovery of patterns in previous outcomes, enhances understanding of the breadth and intricacies of current knowledge, and enables the identification of areas that warrant additional investigation. The utilization of a systematic review as a methodology holds great potential in the consolidation of existing knowledge, hence fostering cohesion within the field (Kraus et al., 2020). The main rationale of doing an SLR was to methodically locate and incorporate pertinent research by utilizing well-organized, transparent, and replicable techniques throughout all phases of the review procedure (Mohamed Shaffril et al., 2021). The process described involves the synthesis of empirical data to effectively handle a particular research problem in a manner that is both systematic and replicable. It aims to comprehensively integrate all available published information on the matter and critically assess the reliability and credibility of said data (Lame, 2019). The methods used in this SLR are consistent with those

outlined by (Xiao and Watson, 2019). The fundamental reason for following these principles is that they provide evidence-based support for the subject being studied, and they have functioned as a widely used guide for conducting a great many systematic reviews (Manz, 2019). Using SLR, this study deconstructs the intricate relationship between energy efficiency (EE) and SD to identify the most crucial determinants and offers a paradigm that accounts for them. Figure 1 details the procedures followed to build the framework for the study using SLR.

3.1. Literature Search Process

We searched Scopus (www.scopus.com) databases for analysis. Researchers from numerous disciplines commonly use this database, particularly for management research (Pardo-Jaramillo et al., 2020). Scopus is an extensive interdisciplinary database containing citations and abstracts from academic publications, trade periodicals, books, patents, and proceedings of conferences (Abdullahi et al., 2023). The package of tools enables the tracking, analysis, and visualization of search data. Scopus currently encompasses a comprehensive collection of 39,743 titles, comprising 25,000 titles that are presently accessible and 14,558 titles that had been eliminated from the system, primarily consisting of earlier iterations (Abdullahi et al., 2023). A database of this nature has the potential to function as a concise synopsis of scientific research. Hence, the Scopus database has emerged as an essential tool for scholars on a global scale. Provided that, the Scopus database is also a suitable data set for the present study context, since highly cited papers and hot papers are representative of the corresponding field. At the start, the research employed a set of keywords and search terms, both in combination and individually, utilizing the Boolean operators "AND" and "OR" as well as advanced search techniques: "Energy efficiency" and "Sustainable Development," "Energy Efficiency and Economic Impact," "Energy efficiency and Environmental Impact," "Energy Efficiency and Social Impact". Similarly, as depicted in figure 1 above the literature was retrieved in October 2022 which returned 129 articles. The publications were chosen because they include sufficient data to warrant inclusion in the review. The demand for accurate SD evaluations has led to a significant increase in energy efficiency (EE) research. The review does not include articles that were published before 2006 for sound overviews. Additionally, limiting the inclusion of older articles can help prevent the propagation of potentially flawed understanding and ensure that research in the field continues to progress effectively. All the chosen papers cover research on energy efficiency (EE) as well as associated research into the economic, environmental, and social dimensions of sustainable development. In addition, this review solely considered 1st-time, English-language empirical investigations and conceptual frameworks. Meta-analyses and systematic reviews were also included in the collection.

Figure 1: The selection process



3.2. Literature Selection Process

The preliminary stage of the study involved identifying and removing duplicate data. Following this, the titles and abstracts of the articles were reviewed based on predetermined inclusion criteria. Relevant articles underwent a thorough examination and analysis of their methods and discussion sections. Open code was utilized via Excel and Mendeley software, and the findings were independently reviewed by the authors to minimize bias (Thomé et al., 2016). Disagreements were discussed until consensus was reached. Figure 1 illustrates the systematic literature review (SLR) framework, showing the process of paper selection from the database. Initially, 129 publications were identified. In the second phase, 25 articles were excluded as irrelevant. The abstracts of the remaining 104 articles were then reviewed, leading to the exclusion of 27 more articles, leaving 77. A thorough evaluation of each article's introduction in Step 4 led to the exclusion of 13 more articles. The remaining 64 articles were assessed in detail, resulting in the rejection of 18 based on their full text. Finally, 46 articles met the established inclusion criteria and were selected.

The snowball method was then used to investigate references within the remaining 46 articles, employing both backward and forward searches of their citations (Xiao and Watson, 2019). Specifically, snowballing involves using the reference list or citations of a paper to identify additional relevant papers. This process was complemented by a systematic review of where the papers were referenced and cited. Backward snowballing started with analyzing the reference lists and removing articles that did not meet the research criteria, such as language, peer-review status, publication year, and type of publication. After eliminating duplicates, the relevant articles were included in the study. Forward snowballing involved identifying new papers based on those citing the examined papers, using Google Scholar. If initial information was insufficient, further details were reviewed, from abstracts to full texts if necessary. This rigorous process did not yield additional papers but provided valuable perspectives. Consequently, the final compilation for this SLR consists of 46 articles.

4. FINDINGS OF THE SYSTEMATIC LITERATURE REVIEW (SLR)

Based on a comprehensive evaluation of numerous studies, it can be argued that while the research on the influence of energy efficiency (EE) on sustainable development (SD) has matured, it still lacks sufficient scope and depth. Several reviews have attempted to articulate the impact of EE on various aspects of SD within a unified framework. For instance, Hanley et al. (2006) highlighted the importance of EE for sustainability, Barker et al. (2007) examined industrial energy-efficiency policies, and Ringel et al. (2016) along with Krarti et al. (2017) reviewed recent national EE policies. Medina et al. (2016) assessed the impact of EE growth, and Singh et al. (2018) investigated the effects of new investments in energy-efficient appliances. Marques et al. (2019) explored the interplay between EE, investment, environmental quality, and sustainable growth. The role of EE in promoting environmental sustainability has been discussed by de Melo and de Martino Jannuzzi (2015). Hanaoka et al. (2009) specifically examined the importance of enhancing energy intensity. Studies by Sathaye et al. (2012) focused on ceiling fan efficiency, as well as EE's role in mitigating greenhouse gas emissions (Kermeli et al., 2015; Yoon et al., 2017). Glomsrød and Wei (2016) assessed EE's impact within global climate policy frameworks, and Duan et al. (2017) examined endogenous EE improvements. Parikh and Parikh (2016) explored consumer awareness impacts on buying EE appliances, and Gu et al. (2019) assessed technological progress in energy. Additional studies include Kamal et al. (2019), who evaluated the impacts of EE policies on electricity consumption and CO2 emissions, and Mahmood and Marpaung (2014), who separately analyzed the effects of carbon tax and its coordination with EE on economic sustainability. Cantore et al. (2016) investigated the relationship between EE and economic sustainability, while Rajbhandari and Zhang (2018) estimated the causal relationship between EE and economic growth. Sakai et al. (2019) addressed how the 'efficiency-led growth engine' mechanism operates within the economy, and Liu et al. (2019) focused on autonomous EE improvements. Employment benefits associated with EE measures were explored by Mirasgedis et al. (2014), Oliveira et al. (2014a) estimated the net employment impact of building energy efficiency improvements, and Garrett-Peltier (2017) examined the impact of the clean energy transition, while Costantini et al. (2018) assessed private and public actions for EE.

Equally, Hartwig et al. (2017) reviewed the social and economic impacts of an ambitious energy efficiency (EE) scenario. On the other hand, Delgado et al. (2014) analyzed both direct and indirect economic and environmental effects of an EE plan. Similarly, Du et al. (2019) evaluated the economic and environmental impacts of EE initiatives. Other studies focused on the economic and employment effects of EE programs (Bataille and Melton, 2017; Yushchenko and Patel, 2016). However, Pui and Othman (2017) critically analyzed the influence of fuel efficiency on emissions control within the context of sustained economic growth. Another study by Hartwig and Kockat (2016) assessed the impact of building retrofit measures on the economy and employment, while Weldu and Al-Ghamdi (2019) evaluated the sustainability of retrofitting existing buildings, considering economic and environmental aspects. Su et al. (2017) analyzed the combined effects of high electricity prices and subsequent improvements in energy efficiency. Lastly, Krarti and Dubey (2018) examined the financial and ecological consequences of implementing expansive EE programs.

4.1. Sustainability Dimensions

The current body of literature has consistently emphasized the necessity of achieving a balanced alignment among the three fundamental dimensions of sustainability-economic, environmental, and social—in order to successfully implement energy efficiency (EE) measures. Governments and organizations must ensure that their strategic objectives are aligned with the principles of the Triple Bottom Line (TBL), integrating economic, environmental, and social considerations. Neglecting any of these dimensions in strategic planning can hinder the realization of tangible benefits derived from EE adoption. The review conducted in this study identified the key sustainability dimensions most commonly addressed, as illustrated in Table 2 and Figure 2, respectively.

Table 1: Elements of the sustainable development and the specific impacts of energy efficiency

Elements of sustainable development	Contribution of energy efficiency	Relevant indicators
Economic	Stable Economic development	Economic growth
Social	Ensuring sustainable livelihoods	Creation of employment
Environmental	Reduce environmental damage from energy use.	CO_2 emissions

Source: Rogers et al (2008) and IEA (2014)

Figure 2: Annual Growth of Publications

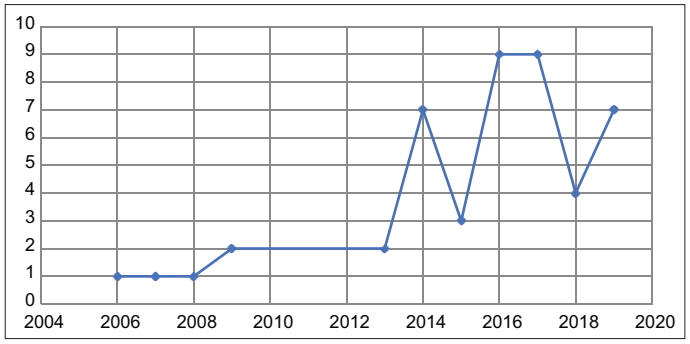


Figure 3: Frequently Studied Sectors of the Economy

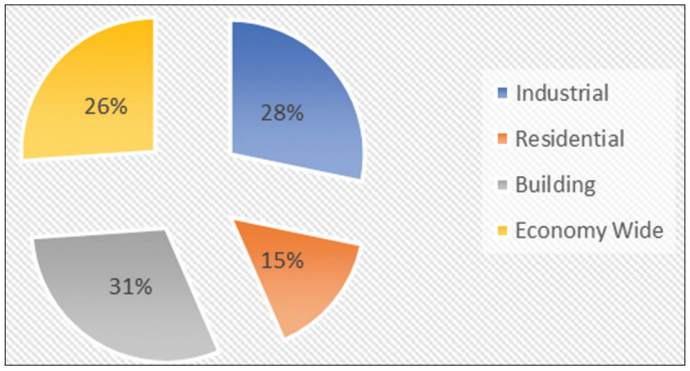


Table 2: Sustainability dimensions considered in the literature

Structure Type	Dimension (s)	Author/Year	Context	Sector
1 Pillar	Social	(Cantore et al., 2017)	Africa	Multi-sectoral
		(Oliveira et al., 2014a)	Portugal	Building
	Environmental	(Kober, 2015)	Multi-case studies	Multi-sectoral
		(Kermeli et al., 2015)	Multi-case studies	Aluminium Industries
		(Gu et al., 2019)	China	Energy Technology
		(Sathaye et al., 2012)	China/India/USA	Ceiling Fan Technology
		(Hanaoka et al., 2009)	US/EU/India/chin	Multi-Sector
		(Sinha, 2015)	India	Construction
		(Du et al., 2019)	China	Building
		(Kamal et al., 2019)	Qatar	Residential
		(Pacheco et al., 2012)	Review	
	Economic	(Cantore et al., 2016)	Developing OECD	Multi-sectoral
		(Rajbhandari and Zhang, 2018)	India	Agriculture/service/industry
		(Singh et al., 2018)	Taiwan	Residential
		(Su et al., 2017)	UK	Iron and Steel Industry
		(Sakai et al., 2019)	US	Energy sector
		(Gillingham et al., 2011)	Regional	Residential/Commercial/Industrial
		(Liu et al., 2019)		Multi-sectoral
2 Pillars	Social and Environmental	(Garrett-Peltier, 2017)	USA	Industrial
	Economic and Environmental	(Hanley et al., 2006)	Scotland	Production
		(De Melo and De Martino Jannuzzi, 2015)	Brazil	Building
		(Hanley et al., 2009)	Scotland	Government
		(Mahmood and Marpaung, 2014)	Pakistan	Multi-sector
		(Yoon et al., 2017)	South-Korea	Local Government
		(Bataille and Melton, 2017)	Canada	Manufacturing
		(Marques et al., 2019)	EU	Industrial
		(Pui and Othman, 2017)	Malaysia	Petroleum
		(Pardo Martínez and Silveira, 2013)	Sweden	Manufacturing
		(Delgado et al., 2014)	Spain	Multi-Sectoral
		(Weldu and Al-Ghamdi, 2019)	Qatar	Building
		(Barker et al., 2007)	UK	Industrial/Power
		(Krarti and Dubey, 2018)	UAE	Building
		(Duan et al., 2017)	OECD	Power
		(Kober, 2015)	US/EU/India/chin	
	Social and Economic	(Scott et al., 2008)	USA	Building/Residential
		(Oliveira et al., 2014b)	Portugal	Building
		(Barker et al., 2016)	Multi Case Studies	Multi Sectoral
		(Mikulić et al., 2016)	Croatia	Building
		(Parikh and Parikh, 2016)	India	Household Electricity
		(Hartwig et al., 2017)	Germany	Industry/Service/Residential
3 Pillars	Social, Environmental and Economic	(Yushchenko and Patel, 2016)	Switzerland	Residential
		(Mirasgedis et al., 2014)	Greece	Building
		(Choi et al., 2014)	Ohio USA	Industrial Building
		(Krarti et al., 2017)	Qatar	Building
		(Chaturvedi and Shukla, 2014)	India	Building/Industrial/Transport
		(Medina et al., 2016)	Spain	Multi-Sector

4.2. Annual Growth of Publication

The classification presents a frequency distribution of 46 publications, organized by their publication year (Figure 2). Notably, in the earlier period (2006-2008), there was limited awareness, with only 6.52% of articles documented. Subsequently, there was an increase in studies in 2009, marking a growth rate of 4.35%. From 2013 to 2017, there was a notable uptrend in research output, except for a temporary decline in 2015, possibly due to the growing recognition of the complexities of integrating triple bottom line considerations. Research on the correlation between energy efficiency (EE) and sustainable development experienced a significant surge in scholarly interest from 2009 onward, with a consistent annual increase in published works. This trend indicates a heightened recognition among scholars and professionals of the importance of adopting sustainable practices for a more sustainable future.

4.3. Most Active Journals and Top Publishers

Table 3 presents the distribution of publications on EE and SD across various academic journals, highlighting the most active publishers in this field. The data reveal that the Journal of "Energy Efficiency" leads with seven publications, followed by Energy Economics, Energy Policy, and Journal of Cleaner Production, each with four publications. The 46 analyzed papers were categorized based on their respective journals, indicating strong support for sustainability research across various publications. Additionally, three journals contained three publications each, two journals had two publications each, and 22 journals had a single publication

Table 3: Most active journals and top publishers

Publisher	Journal name	TP
Elsevier	Energy Efficiency	7
	Energy Policy	4
	Energy Economics	4
	Energy	3
	Applied Energy	2
	Ecological Economics	1
	Economic Modelling	1
	Renewable and Sustainable Energy Reviews	1
Taylor and Francis	Economic research-Ekonomska istraživanja	1
	Construction management and economics	1
	Climate Policy	1
	Economic Systems Research	1
Springer	Mitigation and Adaptation Strategies for Global Change	1
	Climatic change	1
	Environmental Science and Pollution Research	1
MDPI	Sustainability Switzerland	1
	Energies	1

Table 4: Highly cited articles

Author	Title	Year	TC
(Hanley et al., 2006)	The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis.	2006	114
Barker et al.	Macroeconomic effects of efficiency policies for energy-intensive industries: the case of the UK Climate Change Agreements, 2000-2010	2007	92
Scott et al.	The impact of DOE building technology energy efficiency programs on US employment, income, and investment.	2008	50
Hanley et al.	Do increases in energy efficiency improve environmental quality and sustainability?	2009	253
Ringel et al.	Towards a green economy in Germany? The role of energy efficiency policies.	2016	55
Garrett-Peltier	Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model	2017	61

each, underscoring the breadth of publishers contributing to this area of study. Notably, Elsevier emerges as the most prominent publisher, with involvement in 23 journals, reflecting its significant presence in this research domain. Researchers can leverage this information to identify relevant publishers and journals for future research endeavors.

4.4. Highly Cited Articles

Citation analysis has become a standard method for assessing the impact and significance of scholarly works (Ding and Cronin, 2011). The number of citations an article receives is often considered an indicator of its quality and influence in the academic community. Table 4 presents the six most cited papers on the intersection of EE and SD, each with over 50 citations. The article titled "Do increases in energy efficiency improve environmental quality and sustainability?" stands out with 253 citations, emphasizing the significant influence of energy policies and economic structure on the environmental impact of EE. Despite acknowledging the rebound effect of EE, the study suggests that improving energy efficiency remains a valuable strategy. Another highly cited paper, "The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis," has garnered 114 citations. It highlights the presence of economy-wide rebound effects as a potential factor contributing to the limited reduction in energy consumption in buildings despite advancements in EE.

4.5. Publications by Countries/Economic Status

This section evaluates the current state of the most significant nations contributing to research on EE and SD. Data for this systematic literature review was gathered from the Scopus database, which includes articles authored by researchers from various countries. Table 5 illustrates the proportional contribution of each country, categorized according to their economic status as either developed or developing. The selection of research articles was based on the countries represented by the authors. India emerges as the leading contributor with 4 articles (8.69%), followed by China, Qatar, and Germany, each with three publications. Nine research studies were identified, encompassing various countries worldwide. Three of these studies were conducted at a global level, assessing efficiency across multiple nations, while one international study focused on a specific sector across various countries. Based on the UN Report (2011), countries were classified into developed and developing categories. The analysis reveals that 30.43% of articles originated from advanced nations, while 21.74% were attributed to emerging economies.

Table 5: Publications by countries/economic statuses

Country	No. of Articles	Percentage	Category
Scotland	2	4.35	Developed
UK	2	4.35	Developed
USA	2	4.35	Developed
Swedish	1	2.17	Developed
Germany	3	6.52	Developed
Pakistan	1	2.17	Developing
Bilbao	1	2.17	Developed
Greece	1	2.17	Developed
Hamilton	1	2.17	Developed
Portuguese	1	2.17	Developing
Spain	1	2.17	Developed
India	4	8.69	Developing
Switzerland	1	2.17	Developed
Brazil	1	2.17	Developed
Croatia	1	2.17	Developed
China	3	6.52	Developing
Malaysia	1	2.17	Developing
Canada	1	2.17	Developed
Qatar	3	6.52	Developing
Africa	1	2.17	Developing
South Korea	1	2.17	Developing
Taiwan	1	2.17	Developing
EU	2	4.35	Developed
UAE	1	2.17	Developing
World Regions	9	19.56	Including Developed and Developing

4.6. Methodology/Models

Analyzing data involves examining, modifying, and presenting information to draw conclusions, provide recommendations, and support key decisions across various domains. Different fields utilize a diverse range of data analysis techniques, often referred to by various names. Researchers commonly employ different models and data analysis methods, including the CGE approach, Input-Output analysis, econometric analysis, costing approach, system dynamic approach, Top-down/bottom-up model, global change assessment approach, and macroeconomic model, among others. Table 6 outlines the frequency of data analysis methodologies utilized in the selected papers. According to this study, the Input-Output model was employed in 8 articles (17.39%), followed by the CGE model with 7 articles (15.22%). Additionally, the ASTRA macroeconomic model and Vector Error Correction Model were each used in 3 articles (6.52%) respectively. Data analysis methods with fewer than three published studies are also listed in Table 6.

5. DISCUSSIONS OF THE FINDINGS

The analysis of our research results underscores the critical importance of energy efficiency (EE), not only from an environmental perspective but also considering its economic and social implications as essential components for achieving long-term value and advancing sustainable development (Kolk, 2016). Strategic alignment among the Triple Bottom Lines (TBLs) by nations and organizations is imperative for realizing the full benefits of EE adoption (Metaxas and Psarropoulou, 2021). Neglecting any dimension of the TBLs in strategic planning can hinder the comprehensive realization of EE advantages. Successful EE implementation requires the seamless integration of economic, environmental, and social considerations (Gosling-Goldsmith, 2018; Zhai and Chang, 2018). However, our content analysis reveals a notable focus on the environmental aspect in prior research, with relatively less attention given to the economic and social dimensions. While some studies have combined the economic and environmental dimensions, integration across all three dimensions remains scarce. Specifically, our analysis indicates that only a small fraction of studies effectively integrates the economic, environmental, and social dimensions, highlighting a need for greater emphasis on achieving balance across the TBLs in EE research.

The study highlights a notable disparity in the implementation of energy efficiency (EE) between industrialized and developing nations. Industrialized nations have seen more prevalent adoption of EE initiatives, often attributed to factors such as greater financial resources, advanced technologies, and supportive government policies (Garrett-Peltier, 2017; Hartwig et al., 2017; Mirasgedis et al., 2014; Sakai et al., 2019; Yook et al., 2018). In contrast, developing countries face challenges in implementing EE measures due to limited resources and technological capabilities (Cantore et al., 2016; Darlington and Hayes, 2019; de Melo and de Martino Jannuzzi, 2015; Kamal et al., 2019; Krarti et al., 2017;

Table 6: Most used methodologies/models

Models	Author (s)	No. of papers	Percentage
Input-Output analysis	(Delgado et al., 2014; Hartwig and Kockat, 2016; Medina et al., 2016; Mikulić et al., 2016; Oliveira et al., 2014; Yushchenko and Patel, 2016;Garrett-Peltier, 2017; Singh et al., 2018)	8	17.39
Computable General Equilibrium (CGE) Model	(Du et al., 2019; Glomsrød and Wei, 2016; Hanley et al., 2009; Hanley et al., 2006; Liu et al., 2019; Mahmood and Marpaung, 2014; Pui and Othman, 2017)	7	15.22
ASTRA macroeconomic model	(Ringel et al., 2016; Su et al., 2017; Sakai et al., 2019)	3	6.52
Vector Error Correction Model	(Rajbhandari and Zhang, 2018; Sinha, 2015; Marques et al., 2019)	3	6.52
Top–Down/Bottom–Up Modelling	(Barker et al., 2007; Krarti and Dubey, 2018)	2	4.35
Life Cycle Assessment (LCA) Method	(Choi et al., 2014; Weldu and Al-Ghamdi, 2019)	2	4.35
A Bottom-Up, Computational Model	(Kermeli et al., 2015; Krarti et al., 2017)	2	4.35
Survey Method	(Parikh and Parikh, 2016; Yoon et al., 2017)	2	4.35
Econometric Analysis	(Cantore et al., 2016; Costantini et al., 2018)	2	4.35
Sector Energy Technologies (Imset) Model	(Scott et al., 2008)	1	2.17
Quantitative Decomposition Analyses Using the Extended Kaya Identity	(Hanaoka et al., 2009)	1	2.17
Decomposition Analysis and A Production Frontier Model	(Pardo Martínez and Silveira, 2013)	1	2.17
Bottom-Up Energy Analysis System (BUENAS)	(Sathaye et al., 2012)	1	2.17
Combination Of Bottom-Up Models with An Extended Dynamic Input-Output Model	(Hartwig et al., 2017)	1	2.17
Global Change Assessment Model (GCAM)	(Chaturvedi and Shukla, 2014)	1	2.17
Global Energy System Model (TIAM-ECN)	(Kober, 2015)	1	2.17
Marginal Abatement Costs Curves (MACC) Method	(de Melo and de Martino Jannuzzi, 2015)	1	2.17
Global Simulation Model E3MG	(Barker et al., 2016)	1	2.17
RGEEM (Regional General Equilibrium Energy Model)	(Bataille and Melton, 2017)	1	2.17
Integrated Assessment Model (E3METL)	(Duan et al., 2017)	1	2.17
Diff-GMM method	(Gu et al., 2019)	1	2.17
	(Weldu and Al-Ghamdi, 2019)	1	2.17
System Dynamics Model	(Kamal et al., 2019)	1	2.17

Weldu and Al-Ghamdi, 2019). However, the study suggests that developing countries can play a significant role in EE adoption through collaborative efforts with industrialized nations.

Multinational corporations (MNCs) operating in developing countries can facilitate the transfer of EE technologies and best practices from industrialized nations. This collaboration can help address environmental challenges in developing countries and promote sustainable development. Additionally, financial assistance and technical support from industrialized nations can aid developing countries in implementing effective EE strategies. Therefore, there is a pressing need to prioritize EE initiatives in developing economies such as India, Brazil, China, and Africa. Successful implementation in these countries can serve as a model for other developing nations, contributing to global efforts to enhance energy efficiency and mitigate environmental impacts.

The systematic literature review (SLR) underscores the pivotal role played by prominent journals and publishers in advancing research on energy efficiency (EE) and sustainable development (SD). Notably, the analysis reveals that publications on EE and SD are not confined solely to sustainability-focused journals but are also found in other interdisciplinary publications. Among the publishers, Elsevier stands out as the most prolific, contributing significantly to the body of knowledge in this domain with 23 publications during the assessment period. Furthermore, the SLR highlights that most studies have focused on examining the impact of EE on SD within specific domains or sectors, with the building sector being the most extensively studied (Figure 3). Accounting for 31% of the articles analyzed, research in this area emphasizes the increasing demand for energy-efficient buildings driven by the overarching goal of achieving sustainability. Studies underscore the urgent need to enhance building energy efficiency to mitigate environmental risks, particularly in developing and emerging economies. However, the SLR also points out that other sectors remain relatively understudied, with fewer investigations conducted in multi-sectoral domains. While some research delves into the industrial and residential sectors, there is still a need for more comprehensive studies that span across multiple sectors to provide a holistic understanding of the implications of EE for SD. Overall, the findings underscore the importance of interdisciplinary research and collaboration across various sectors to address the complex challenges of achieving sustainable development through energy efficiency initiatives.

The use of different models, such as the Input-Output (I-O) Model and the Computable General Equilibrium (CGE) Model, highlights the diverse approaches employed in analyzing energy efficiency (EE) policies and their impact on sustainable development (SD). The I-O model, for instance, is praised for its ability to forecast various economic, social, and environmental effects within industries as they interact with each other under changing economic conditions. On the other hand, the CGE model offers a more comprehensive view of the economy, considering the interdependencies among various sectors and households. However, it's important to note that the data analysis techniques employed in the literature often lack a statistical foundation, potentially impacting the reliability of the findings. While these hypothetical analyses provide valuable insights, the absence of statistical rigor may introduce uncertainties in the conclusions drawn from the research. Furthermore, the review of EE policy analysis across different countries reveals a mix of outcomes, with some studies reporting favorable impacts while others highlight adverse effects. These discrepancies can be attributed to various factors, including the levels of analysis within or between nations, the use of different samples over time, and the diverse research methodologies employed. Additionally, variations in sustainability practices among nations and their contextual differences contribute to the observed discrepancies in research outcomes. Overall, the existing body of evidence underscores the complexity of evaluating the impact of EE policies on sustainable development, emphasizing the need for robust methodologies and interdisciplinary approaches to provide a comprehensive understanding of the subject matter.

6. CONCLUSION

The present study undertakes a systematic literature review to map the synergies between energy efficiency (EE) and sustainable development (SD). Articles selected for analysis were categorized based on various criteria, including publication year, publishers and journals, country focus, addressed sectors, citation count, data analysis methodologies, and explored sustainable features. Through organized tables and figures, the study offers insights into the connections between EE and sustainability documented in the literature. While a significant amount of research exists on the impact of EE on SD, several pressing opportunities for future study are identified, including exploring EE's contribution to SD in African countries and empirically investigating its economic, social, and environmental impact within a single research framework, addressing common challenges like the rebound effect. The primary aim is to enhance understanding of EE's significance in advancing SD through comprehensive evaluation. The study's findings, future directions, and limitations provide opportunities for uncovering overlooked aspects of EE and SD, contributing to the body of research in this field. By systematically reviewing a substantial number of publications, the study enhances the reliability of its findings and sheds light on the synergistic effects resulting from integrating EE and SD. It aims to catalyze further research in sustainability and EE, serving as a valuable resource for knowledge development and addressing gaps in the existing literature by offering an in-depth review of the research agenda in EE and its sustainability impacts.

The study's findings suggest that while existing literature extensively highlights energy efficiency (EE) as crucial for sustainable development (SD), there's a notable oversight regarding the integration of Triple Bottom Line (TBL) components within research frameworks. This oversight impedes the achievement of a balanced economy, environment, and society. To advance towards SD, future research on EE should prioritize integrating these three sustainability elements. UN reports on SDG progress reveal concerning trends, including accelerated natural resource extraction since 2000, a faster increase in global material footprint compared to population and economic growth, and a positive correlation between per capita material footprint and income level. Despite the "common but differentiated responsibilities"

principle, global development falls short of a collective journey, with disparities in affluence leading to environmental and social imbalances. These discrepancies challenge the effectiveness of EE as a sole solution, with energy economists noting the rebound effect as a limiting factor. To fully grasp the EE-SD nexus, future studies should expand to include literature addressing EE's impact on all three SD dimensions, considering the rebound effect.

Government programs worldwide prioritize sustainable development (SD), recognizing the effectiveness of energy efficiency (EE) in reconciling economic growth with environmental preservation (Jin and Kim, 2019). However, the focus of research on EE and SD has been primarily on prosperous countries in Europe and America, with some attention to Asian nations but notably lacking in poor countries, particularly in Africa. This underscores the importance of emerging nations like India and China in advancing EE research. While existing studies have explored EE's impact on sectors like building, industrial, and residential, there's a need for future research to balance Triple Bottom Line (TBL) considerations by examining neglected sectors like the public sector, service industry, and supply chain. Various models and data analysis techniques, such as Computable General Equilibrium (CGE), Input-Output analysis, and econometric analysis, are commonly used by researchers. For instance, the Input-Output model was employed in 8 articles, while the CGE model was utilized in 7 articles. However, there's a potential for further research to test alternative models, such as the Social Accounting Matrix (SAM), to assess EE's impact on SD concerning public expenditure.

The literature review in this study primarily focuses on empirical investigations, limiting the scope of relevant articles to those within this category. However, there are numerous pertinent articles outside the realm of empirical investigation that were not included in this report. Future research could benefit from a larger sample size by considering a wider range of article types and research methods. Additionally, this research exclusively utilizes Scopus, available at www.scopus.com, as the sole database. While Scopus is a comprehensive abstract and citation repository for peer-reviewed content, other databases such as Web of Science, IEEE, Google Scholar, EBSCO, and Dimensions offer additional resources that could enhance future searches. By leveraging these resources collectively, significant advancements could be made. Moreover, focusing solely on academic journal articles written in English may overlook relevant studies published in other languages or alternative forms of scholarly publications. Finally, it's important to acknowledge that the identification of publications relies on keyword analysis, which may lead to the oversight of publications that align with the study's subject but lack the necessary keywords in their title or abstract.

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