Bibliometric Analysis of Sustainable Consumption Patterns and Food Waste Reduction

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ABSTRACT

Sustainable consumption and food waste reduction have become critical research areas due to their environmental, economic, and social implications. This study employs a bibliometric analysis using Scopus data and VOSviewer to examine research trends, influential publications, and global collaboration patterns in these fields. The findings reveal that sustainable development, food waste, and waste management are central themes, with growing emphasis on consumer behavior, circular economy, and supply chain efficiency. The co-authorship and country collaboration networks highlight strong regional clusters, with Europe and North America leading research efforts, while China and India are emerging as key contributors. The heatmap analysis indicates a transition from traditional environmental impact studies toward policy-driven and behavioral research approaches. Despite this progress, interdisciplinary integration and regional diversification remain key challenges, suggesting opportunities for enhanced collaboration and localized sustainability interventions. This study provides valuable insights for researchers, policymakers, and industry stakeholders to shape future strategies in sustainable food systems, waste management, and circular economy practices.

Keywords: Sustainable Consumption, Food Waste Reduction, Circular Economy, Bibliometric Analysis, VOSviewer

1. INTRODUCTION

Sustainable consumption is increasingly recognized as a cornerstone of environmental stewardship and social equity in the context of escalating global resource demands. This concept encompasses consumption practices that meet current needs without compromising the ability of future generations to satisfy their own, while ensuring that environmental degradation is minimized and resource efficiency is maximized. Scholars and policymakers alike have underscored the importance of integrating sustainability principles into everyday consumption decisions, arguing that doing so not only reduces environmental footprints but also fosters economic opportunities and improves quality of life [1]. Furthermore, transitioning to sustainable consumption requires a multidisciplinary approach that intertwines environmental science, economics, sociology, and policy studies. As global populations rise and economic activities intensify, the pressure to adopt sustainable practices grows ever more critical. Recent studies emphasize that shifts in consumer awareness and behavior can profoundly impact energy use, waste generation, and overall ecological balance [2], [3]. Thus, sustainable consumption is not merely an environmental imperative—it is a socio-economic strategy that bridges the gap between production and consumption, ultimately contributing to the broader realization of the Sustainable Development Goals (SDGs) [4].

Food waste reduction is an integral component of sustainable consumption, addressing one of the most pressing challenges of our time. Globally, food waste has emerged as a critical issue with significant environmental, economic, and social ramifications. According to the Food and Agriculture Organization (FAO), nearly one-third of all food produced for human consumption is

lost or wasted, representing a profound inefficiency in resource utilization. When food waste decomposes in landfills, it releases potent greenhouse gases—most notably methane—that contribute to climate change. Economically, the resources expended on producing, transporting, and storing food that ultimately goes to waste represent lost opportunities and squandered investments, while on a social level, the prevalence of food waste is particularly jarring in a world still grappling with food insecurity [5]. In response, research into innovative strategies for waste prevention, recycling, and redistribution has intensified, positioning food waste reduction as a critical pillar of sustainable development. Advances in technology, policy interventions, and consumer education are progressively reshaping food waste management along the entire supply chain, thereby enhancing resource efficiency and contributing to a circular economy.

Bibliometric analysis has emerged as a powerful and increasingly popular tool for systematically examining the evolution of research fields. This quantitative method employs statistical techniques to evaluate publication patterns, citation networks, and collaborative research efforts, thereby providing a comprehensive overview of an academic domain [6]. In recent years, bibliometric methods have been widely applied across disciplines such as environmental science, management studies, and social sciences to uncover research trends and identify knowledge gaps. In the context of sustainable consumption and food waste reduction, bibliometric analysis offers valuable insights into how research priorities have shifted over time, how thematic clusters have formed, and which seminal works have shaped the discourse. Tools like VOSviewer, CiteSpace, and SciMAT facilitate the visualization of complex citation networks, enabling scholars to pinpoint influential authors, pivotal studies, and collaborative clusters that drive the field forward [7]. By synthesizing large volumes of data, bibliometric analysis not only enriches our understanding of current research landscapes but also informs the direction of future investigations.

The convergence of sustainable consumption patterns and food waste reduction represents a dynamic and evolving field with significant implications for environmental sustainability and resource management. As challenges such as climate change, resource depletion, and food insecurity intensify, there is an increasing recognition that these issues are deeply interconnected and must be addressed through integrated approaches. Recent literature underscores the importance of understanding the interplay between consumption behaviors and waste management practices in formulating holistic strategies that support sustainable development [8], [9]. In this regard, bibliometric analysis provides a robust framework for mapping the landscape of research on these intertwined topics, revealing trends, patterns, and gaps that might otherwise remain hidden in the vast body of academic literature. By systematically examining publication trends, citation networks, and collaborative clusters, researchers can identify influential studies and discern emerging topics that are shaping the discourse. This comprehensive approach not only enriches academic understanding but also supports the development of effective policies and practical solutions aimed at reducing food waste and promoting sustainable consumption practices [10], [11]. Understanding these synergies is crucial for designing interventions that curb resource losses while promoting environmental stewardship on a global scale.

Despite the burgeoning volume of literature on sustainable consumption and food waste reduction, several critical challenges persist. First, existing studies are often fragmented, with researchers frequently focusing on isolated aspects of either sustainable consumption or food waste without fully addressing the complex interconnections between these domains. Second, the rapid

expansion of research in these fields has rendered it increasingly difficult for policymakers, researchers, and practitioners to identify seminal works, emerging trends, and critical knowledge gaps. This fragmentation hampers the development of comprehensive strategies and policies that are necessary to effectively reduce food waste and promote sustainable consumption practices. Moreover, the absence of a consolidated bibliometric analysis means that valuable insights into the evolution of these intertwined topics remain underexplored, limiting the potential for informed policy interventions and coordinated research efforts [12].

The objective of this study is to conduct a comprehensive bibliometric analysis of the scholarly literature on sustainable consumption patterns and food waste reduction. By systematically mapping publication trends, citation networks, and collaborative research clusters, this study aims to identify influential works, emerging topics, and existing research gaps within this dynamic field. Ultimately, the findings are expected to provide a robust foundation for future research and to guide policymakers in developing integrated strategies that promote both sustainable consumption and effective food waste reduction. This integrated approach not only seeks to advance academic discourse but also to facilitate the design of practical interventions that align with global sustainability goals.

2. LITERATURE REVIEW

The literature on sustainable consumption patterns has expanded significantly over the past two decades, reflecting a growing global awareness of the environmental and social implications of consumer behavior. Sustainable consumption, broadly defined, refers to the use of products and services that meet basic needs and improve quality of life while minimizing the consumption of natural resources and the generation of waste and pollution [13], [14]. Early works in this domain emphasized the importance of altering consumption behaviors to mitigate environmental degradation and ensure resource efficiency. Researchers have argued that a shift toward sustainable consumption is critical not only for reducing ecological footprints but also for fostering social equity and economic resilience [15]. This body of literature provides a robust conceptual framework that integrates environmental science, economics, and sociology, thereby establishing a multidisciplinary foundation for addressing the multifaceted challenges associated with consumption patterns in a globalized world.

Closely related to the broader discourse on sustainable consumption is the literature on food waste reduction, which has garnered considerable attention due to its environmental, economic, and social ramifications. Food waste is recognized as a critical inefficiency in the global food system, where approximately one-third of food produced for human consumption is lost or wasted. Scholars such as [16] have documented the severe consequences of food waste, highlighting its role in exacerbating food insecurity and contributing to greenhouse gas emissions through landfill decomposition processes. The environmental impact of food waste is particularly alarming, as decomposing organic matter releases methane—a greenhouse gas with a global warming potential significantly higher than that of carbon dioxide [17]. In addition, the economic costs associated with food waste are substantial, encompassing the wasted investments in production, transportation, and storage, alongside the opportunity costs linked to unmet nutritional needs. Consequently, the literature underscores the imperative of integrating food waste reduction strategies within the

broader sustainability agenda, calling for interventions that span from consumer education and behavioral change to policy reform and technological innovation [18], [19].

Bibliometric analysis has emerged as a critical methodological approach in the study of sustainable consumption and food waste reduction, offering a quantitative lens through which to examine the evolution of research trends and academic collaboration. Bibliometric techniques involve the statistical analysis of publications, citations, and authorship networks to identify influential works, emerging research clusters, and gaps in the literature [6]. This method has been widely adopted in various disciplines, including environmental science and management studies, for its ability to map the intellectual structure and trajectory of specific research fields. Tools such as VOSviewer, CiteSpace, and SciMAT have been instrumental in visualizing complex networks of citation and collaboration, thereby elucidating the relationships between key research themes and scholars [7]. The application of bibliometric analysis to sustainable consumption and food waste reduction research not only aids in synthesizing vast amounts of literature but also supports the identification of seminal works and research gaps that can inform future investigations. This methodological approach provides a systematic basis for understanding how academic interest and research outputs in these domains have evolved over time.

The integration of sustainable consumption and food waste reduction within the literature reveals a rich tapestry of interrelated themes that underscore the complexity of addressing global sustainability challenges. Several studies have highlighted that consumer behavior is central to both domains, where informed choices can significantly influence the effectiveness of sustainability initiatives. For instance, research indicates that consumers' awareness and attitudes toward sustainability directly impact their food purchasing and waste disposal behaviors [20]. This interplay is critical because it underscores the need for educational and policy interventions that simultaneously target sustainable consumption practices and food waste minimization. Moreover, the literature suggests that the synergies between these two fields are further enhanced when approached through integrated strategies that consider the entire supply chain—from production and distribution to consumption and waste management [21]. Such holistic approaches are vital in mitigating the adverse effects of unsustainable consumption and excessive food waste while promoting environmental stewardship and social well-being.

Recent bibliometric studies have provided deeper insights into the patterns and evolution of research on sustainable consumption and food waste reduction. By analyzing publication trends, citation networks, and collaborative patterns, scholars have been able to identify key turning points in the academic discourse. For example, early research in the early 2000s primarily focused on the conceptual underpinnings of sustainable consumption, emphasizing the need to rethink consumerism in light of environmental limits [22]. As global awareness of climate change and resource scarcity grew, subsequent research began to explore practical strategies for reducing waste, particularly in the context of food systems [23]. This evolution in focus is well captured by bibliometric analyses, which demonstrate a shift from theoretical explorations to empirical investigations and policy-oriented studies. The increasing prevalence of collaborative research efforts across disciplines, as revealed by co-authorship networks, further underscores the interdisciplinary nature of these sustainability challenges [6]. These analyses not only highlight the growing sophistication of the field but also identify emerging research clusters that are likely to drive future developments.

A notable trend in the literature is the recognition of the importance of a systems perspective when addressing sustainable consumption and food waste reduction. Studies employing life cycle assessment (LCA) and other systems analysis tools have underscored that interventions targeting a single stage of the supply chain may have limited effectiveness unless they are embedded within a comprehensive strategy that considers upstream and downstream impacts [24], [25]. This perspective is supported by research that advocates for circular economy models, which aim to close resource loops by integrating waste management, recycling, and reuse into the production and consumption process. In this context, bibliometric analyses have proven invaluable in identifying the cross-disciplinary dialogues that inform these integrated approaches. By mapping the intersection of research on sustainable consumption with that on food waste reduction, bibliometric studies provide evidence of how concepts from environmental science, economics, and policy studies converge to address the multifaceted nature of sustainability challenges. The synthesis of these fields is critical for developing interventions that are not only effective in reducing waste but also in promoting sustainable resource use on a global scale.

Despite the wealth of research in these domains, several gaps remain that warrant further investigation. While numerous studies have documented the adverse impacts of unsustainable consumption and food waste, there is a noticeable scarcity of research that systematically examines the causal relationships and feedback loops between these phenomena. For instance, while it is well-established that consumer behavior influences food waste generation, the specific mechanisms by which changes in consumption patterns lead to reductions in waste remain underexplored [26]. Moreover, the role of technological innovations and policy frameworks in mediating these relationships has not been sufficiently addressed. Bibliometric analyses reveal that while the volume of research is growing, there is a need for more integrative studies that bridge the theoretical and empirical gaps between sustainable consumption and food waste reduction. Such studies would provide a more nuanced understanding of how interventions can be optimized to address both issues concurrently, thereby contributing to the formulation of more effective sustainability strategies.

3. METHODS

The study employs a comprehensive bibliometric analysis exclusively using data from the Scopus database, with VOSviewer serving as the primary tool for network visualization and analysis. A systematic search was conducted in Scopus using a refined set of keywords including "sustainable consumption," "food waste reduction," "resource efficiency," and "environmental sustainability" to capture relevant peer-reviewed journal articles and conference proceedings published over the past two decades. The search strategy was designed to ensure the retrieval of a robust dataset representing the core literature on sustainable consumption patterns and food waste reduction. Once the data were extracted, records were carefully screened and cleaned to remove duplicates and irrelevant entries before being imported into VOSviewer. VOSviewer was then utilized to construct and analyze various network maps which helped in identifying the most influential publications, authors, and emerging research themes within the field (Zupic & Čater, 2015). Quantitative bibliometric metrics, including publication counts and citation frequencies, were calculated to further elucidate the development and trends in research.

4. RESULTS AND DISCUSSION

4.1 Network Visualization

Figure 1. Network Visualization
Source: Data Analysis Result, 2025
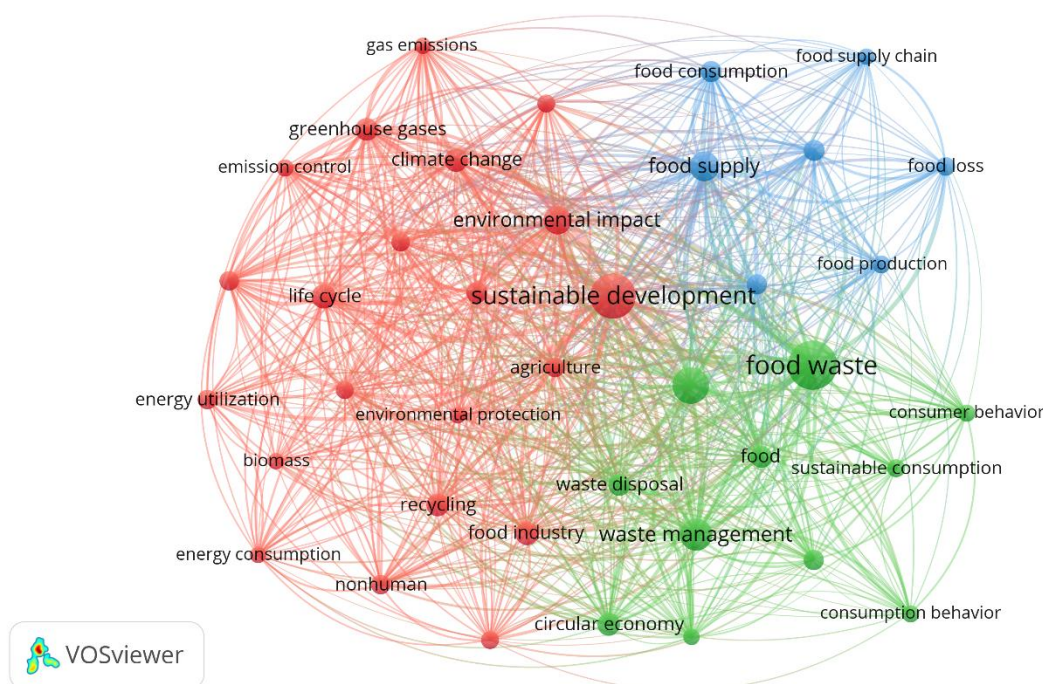
This bibliometric network visualization represents key research themes and their interconnections within the field of sustainable consumption, food waste reduction, and environmental sustainability. The network consists of multiple nodes, each representing a keyword, and the connections (edges) between them indicate co-occurrence relationships in the academic literature extracted from Scopus. The visualization is color-coded into three major clusters: red (environmental sustainability and climate impact), green (food waste management and circular economy), and blue (food supply and consumption behavior). The centrality of "sustainable development" in the network highlights its pivotal role in linking various aspects of food waste, consumption, and environmental impact.

The red cluster is focused on environmental and climate-related themes, including "climate change," "greenhouse gases," "environmental impact," and "energy consumption." This cluster suggests that a significant portion of the literature explores the relationship between sustainable consumption and broader environmental issues such as emissions, resource utilization, and energy efficiency. The presence of terms like "biomass" and "recycling" indicates an emphasis on waste-to-energy solutions and sustainable resource management. This cluster reflects the urgency of addressing sustainability challenges through policies that mitigate carbon footprints and promote environmentally responsible consumption patterns.

The green cluster is centered around "food waste," "waste management," and "circular economy," signifying research efforts dedicated to minimizing food loss and optimizing resource use through waste reduction strategies. Terms like "consumer behavior" and "sustainable consumption" suggest a strong focus on how individual choices impact food waste generation. The emphasis on "food industry" and "waste disposal" highlights the role of businesses and supply chains in creating sustainable solutions, reinforcing the need for systematic changes beyond individual consumer actions. This cluster underscores the interdisciplinary nature of food waste studies, involving economics, behavior analysis, and policy frameworks.

The blue cluster is primarily concerned with "food supply," "food consumption," and "food loss," indicating a focus on the logistical and systemic aspects of food waste. Keywords such as "food

supply chain" and "food production" suggest an interest in how inefficiencies in agricultural production, distribution, and retail contribute to food loss before it reaches consumers. The co-occurrence of "food consumption" within this cluster signifies the link between supply chain dynamics and consumer purchasing behavior. This cluster highlights the growing research interest in optimizing supply chain logistics, improving food distribution, and implementing policies that reduce inefficiencies in food systems. Overall, the visualization reveals how the intersection of sustainability, food waste, and environmental impact forms a complex research landscape requiring interdisciplinary collaboration to develop effective solutions.
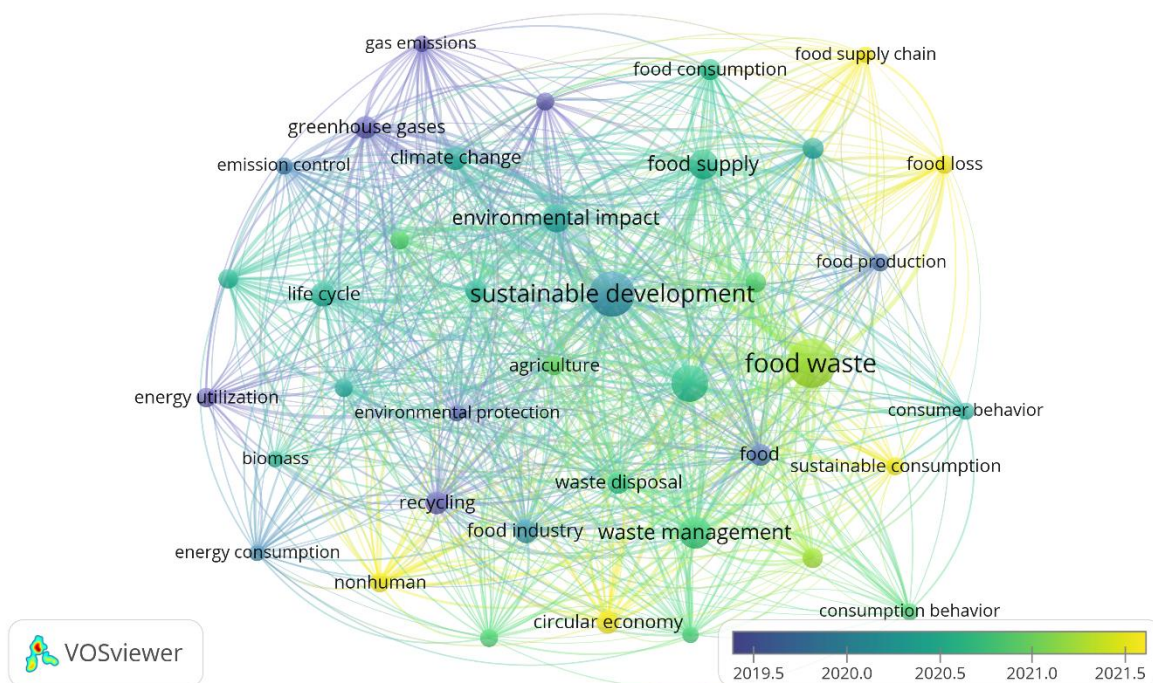
4.2 Overlay Visualization

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

This visualization, generated using VOSviewer, represents a bibliometric analysis of research trends related to sustainable consumption, food waste, and environmental sustainability based on Scopus data. The color gradient (from blue to yellow) indicates the temporal evolution of research themes, where blue represents older research (around 2019), green indicates studies from 2020–2021, and yellow represents the most recent topics (2021 onward). The network is built upon keyword co-occurrence analysis, showing relationships between major research topics and how they have evolved over time. "Sustainable development" appears at the center, highlighting its role as the core concept connecting various subtopics, including food waste, food supply, waste management, and environmental impact.

The left side of the network (blue to green clusters) contains older research themes, such as "climate change," "greenhouse gases," "life cycle," "biomass," and "energy consumption." These terms indicate that earlier research in this domain was more focused on the environmental impact of consumption patterns, including energy use, carbon emissions, and resource depletion. In contrast, more recent studies (represented in yellow) are shifting towards applied and behavioral aspects of food sustainability, with keywords such as "food supply chain," "food loss," "consumer behavior," and "sustainable consumption." This suggests an increasing focus on human-centered interventions to reduce food waste and improve resource efficiency.

The emergence of yellow-colored terms, including "circular economy," "sustainable consumption," and "food loss," indicates that recent research is moving toward practical solutions, policy interventions, and behavioral studies aimed at achieving sustainability. The interconnected nature of these themes suggests a growing recognition that food waste reduction is not just an environmental issue but also a socio-economic challenge that requires cross-sectoral collaboration. The network structure further reveals that food waste and waste management are gaining prominence as research priorities, reflecting the increasing urgency to transition toward sustainable consumption practices and circular economy models.

4.3 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title	Contributions
1766	[27]	Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health	Explores the relationship between human health and planetary sustainability, emphasizing the impact of environmental degradation on global health and advocating for integrated policies to address ecological and public health challenges.
991	[28]	Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications	Examines sustainable supply chain management practices and their role in achieving a circular economy, providing empirical evidence and case applications to support the transition to more resource-efficient and waste-reducing economic models.
583	[29]	A critical review of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies	Analyzes the economic and environmental disruptions caused by COVID-19, identifying opportunities for circular economy approaches to enhance resilience and sustainability in the post-pandemic era.
520	[30]	Strategies for feeding the world more sustainably with organic agriculture	Investigates the potential of organic agriculture to meet global food demands sustainably, assessing its environmental benefits and trade-offs compared to conventional agricultural systems.
404	[31]	Ability of Black Soldier Fly (Diptera: Stratiomyidae) Larvae to Recycle Food Waste	Demonstrates the efficiency of Black Soldier Fly larvae in converting food waste into usable biomass, presenting an innovative and sustainable solution for organic waste management.
366	[32]	The Next Generation of Sustainable Food Packaging to Preserve Our Environment in a Circular Economy Context	Explores advancements in sustainable food packaging technologies and their role in reducing environmental impacts, aligning with circular economy principles to minimize waste.
362	[33]	Feeding ten billion people is possible within four terrestrial planetary boundaries	Assesses the feasibility of feeding a growing global population while staying within planetary ecological limits, emphasizing the need for sustainable agricultural practices and resource management.

Citations	Authors and year	Title	Contributions
346	[34]	Membrane engineering in process intensification-An overview	Reviews advancements in membrane engineering for process intensification, highlighting its applications in sustainable industrial processes, energy efficiency, and waste minimization.
314	[35]	Review: Consumption-stage food waste reduction interventions – What works and how to design better interventions	Provides a systematic review of food waste reduction interventions at the consumption stage, identifying effective strategies and offering guidelines for designing more impactful waste reduction programs.
313	[36]	Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis	Conducts a mass flow analysis of food waste in the EU, quantifying waste generation across different product groups and supply chain stages to inform policy and waste reduction strategies.

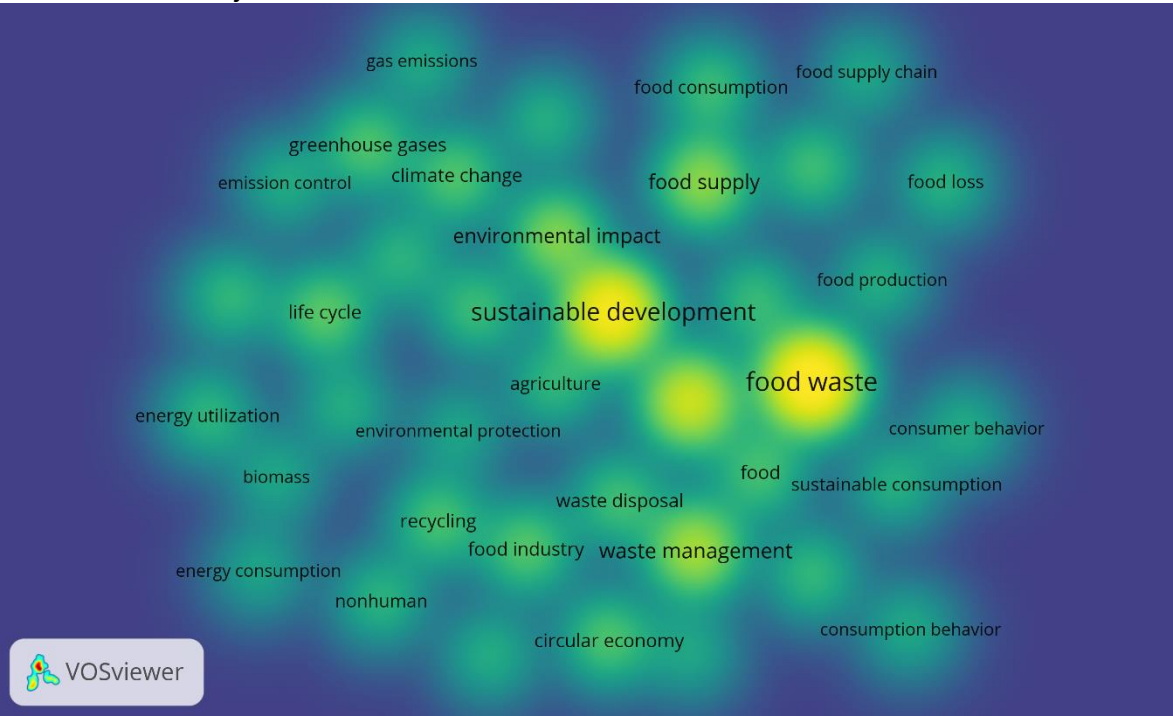*Source: Scopus, 2025*

4.4 Density Visualization

Figure 3. Density Visualization
Source: Data Analysis Result, 2025

This heatmap visualization generated using VOSviewer represents the density of research focus within the fields of sustainable development, food waste, and environmental impact based on keyword co-occurrence analysis. The yellow areas indicate the highest concentration of research attention, while green areas represent moderate focus, and blue or dark areas signify less emphasis in the analyzed literature. The most researched topics in this dataset are "sustainable development" and "food waste," as they appear in bright yellow, suggesting that these keywords are frequently mentioned together in publications. Other highly relevant areas include "waste management" and "environmental impact," highlighting their central role in discussions about sustainability and food waste reduction. The green clusters surrounding the central topics indicate emerging or moderately

explored areas of research, such as "consumer behavior," "sustainable consumption," "food industry," and "circular economy." These terms suggest that recent studies are shifting toward more practical and policy-driven aspects of sustainability, including behavioral interventions and economic models for reducing waste. Additionally, topics such as "climate change," "gas emissions," and "biomass" appear with lower intensity, indicating that while environmental concerns are still present in the discourse, the primary research focus is now moving toward systemic solutions like food waste reduction and waste management strategies.
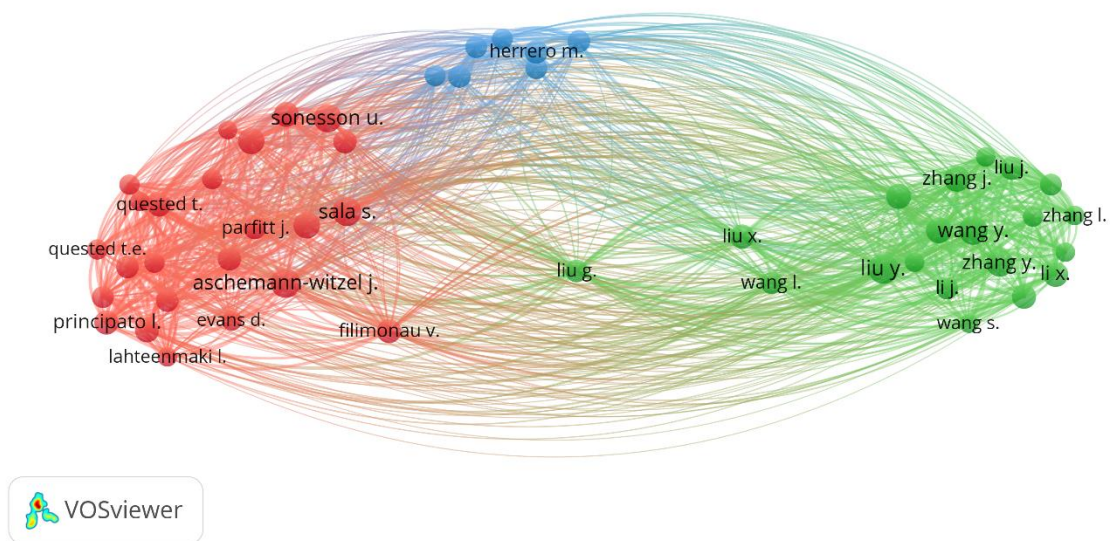
4.5 Co-Authorship Network

Figure 4. Author Visualization
Source: Data Analysis Result, 2025

This co-authorship network visualization generated using VOSviewer illustrates the collaborative structure among researchers in the field of sustainable consumption and food waste reduction. The different colored clusters represent distinct research groups, with nodes indicating individual authors and the connections (edges) signifying co-authorship relationships. The red cluster on the left includes key researchers such as Quested T., Parfitt J., and Sonesson U., who are likely focused on food waste measurement, consumer behavior, and intervention strategies. The green cluster on the right, which includes authors such as Zhang J., Liu Y., and Wang L., appears to represent a separate research community, potentially focusing on food waste management and supply chain sustainability. The blue cluster in the center, led by Herrero M., serves as a bridge between these two major groups, indicating cross-disciplinary collaboration.
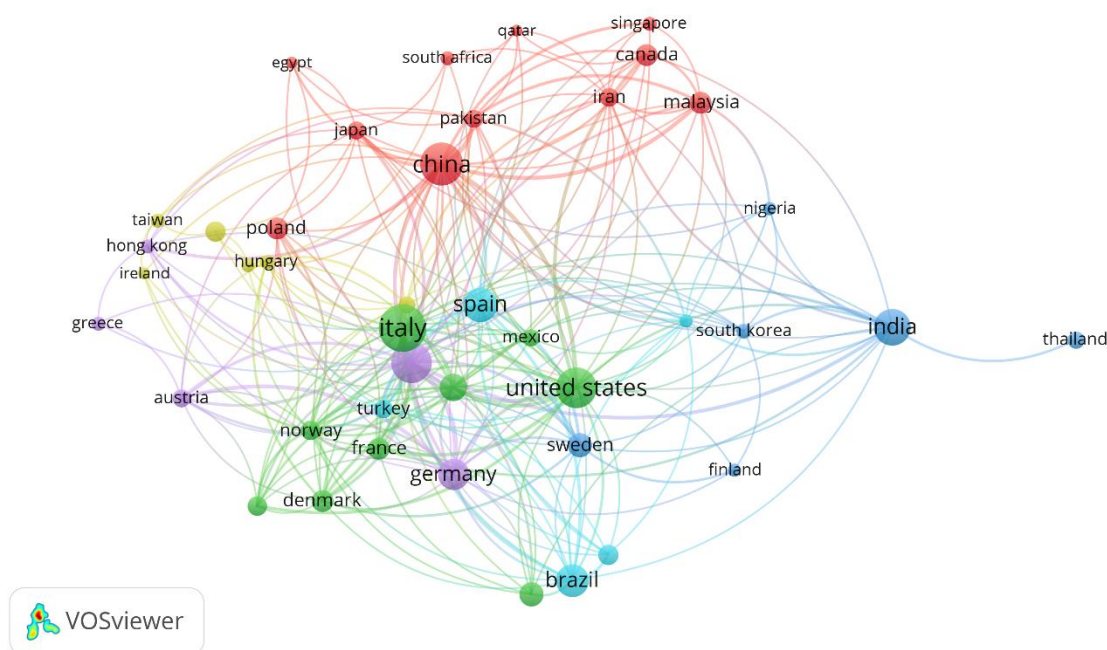
Figure 5. Country Visualization
Source: Data Analysis Result, 2025

This country-based collaboration network visualization, generated using VOSviewer, illustrates the global research collaboration patterns in the field of sustainable consumption and food waste reduction. Each node represents a country, while the connections (edges) between them indicate co-authorship relationships between researchers from different nations. The network is divided into several clusters, with China (red cluster), India (blue cluster), Italy (green cluster), Spain (teal cluster), and the United States (central node) acting as major research hubs. China's cluster is strongly connected with countries like Malaysia, Canada, and Iran, indicating regional collaboration within Asia and North America. India's cluster shows strong ties with South Korea, Nigeria, and Thailand, suggesting active research partnerships in South Asia and Africa. The United States, Italy, Spain, and Germany form a highly interconnected central group, highlighting strong transatlantic and European collaborations in sustainability research.

Discussion
1. Research Trends in Sustainable Consumption and Food Waste Reduction

The bibliometric analysis conducted in this study provides valuable insights into the evolution of research on sustainable consumption patterns and food waste reduction. The network visualizations of keywords, co-authorships, and country collaborations reveal a dynamic and interdisciplinary research field, increasingly shaped by global sustainability challenges. The findings suggest that sustainable development, food waste, and waste management are central topics, with growing interest in circular economy approaches, consumer behavior, and supply chain efficiency. These results align with previous studies that emphasize the importance of integrating sustainability into food production, consumption, and waste management systems [37], [38].

One of the key takeaways from the keyword co-occurrence analysis is the increasing focus on behavioral and systemic interventions to reduce food waste. Traditionally, research in this field emphasized environmental impact, greenhouse gas emissions, and energy efficiency—as seen in earlier clusters dominated by terms like "climate change," "life cycle," and "biomass." However, recent studies highlight the role of consumer awareness, supply chain logistics, and regulatory

policies in addressing food waste [39], [40]. This shift reflects the realization that food waste is not just an environmental issue but also a socio-economic challenge requiring a multi-stakeholder approach.

2. The Role of Bibliometric Analysis in Understanding Research Gaps

The bibliometric approach employed in this study has been instrumental in identifying influential research, collaboration networks, and emerging trends. The most impactful literature (Table 1) highlights seminal works that have shaped the discourse on sustainability, circular economy, and food waste management. The study by [28], which discusses planetary health and sustainability, is the most cited, indicating its foundational role in linking environmental health with sustainable consumption. Similarly, [28] provide empirical evidence on the transition towards a circular economy, reinforcing the growing academic and policy interest in closed-loop systems for food and resource management. Moreover, the co-authorship network visualization reveals clusters of researchers working within distinct but interconnected domains. The red cluster, comprising researchers like Quested T., Parfitt J., and Sonesson U., appears to focus on food waste quantification and reduction interventions. The green cluster, dominated by Zhang J., Liu Y., and Wang L., suggests a focus on food supply chains and waste management from an economic and logistical perspective. The blue cluster, featuring Herrero M., appears to bridge these two major areas, indicating cross-disciplinary collaborations between environmental scientists and supply chain researchers. This finding suggests that while strong intra-group collaborations exist, further interdisciplinary integration could enhance holistic solutions to food waste reduction.

3. Global Collaboration Patterns in Sustainability Research

The country collaboration network visualization reveals that sustainability research is a highly globalized effort, with strong regional clusters and cross-border collaborations. The United States, Italy, and Spain form a densely connected central hub, demonstrating significant research partnerships in Europe and North America. China and India emerge as major research hubs in Asia, with China exhibiting strong ties with Malaysia, Iran, and Canada, while India collaborates extensively with South Korea, Nigeria, and Thailand. These patterns suggest that while certain countries act as regional leaders in sustainability research, transcontinental collaboration remains somewhat limited. This observation is consistent with previous studies that highlight Europe's leadership in sustainability research and policy development [33]. The European Union's Green Deal and Circular Economy Action Plan have likely contributed to increased research collaboration in sustainable food systems, waste reduction, and environmental protection [33]. Meanwhile, the growing presence of China and India in sustainability research reflects their expanding role in global environmental governance. Given the significant environmental impact of food waste in these countries, future research should explore how policy mechanisms, technological advancements, and consumer awareness initiatives can further integrate sustainability principles into their food systems.

4. Emerging Research Themes and Future Directions

The heatmap visualization provides a spatial representation of the most frequently studied topics in the field. The highest concentration of research activity surrounds "sustainable development," "food waste," and "waste management," suggesting that these areas have been the primary focus of recent academic discourse. However, some emerging topics—such as "consumer behavior," "food loss prevention," and "circular economy"—are gaining prominence, indicating a shift towards more applied and solution-oriented research. One of the key takeaways from this study is the need for greater emphasis on interdisciplinary research and policy integration. The analysis suggests that while technical solutions for food waste reduction (e.g., food recycling, waste-to-energy technologies) are well-established, there is still a lack of research on behavioral interventions

and systemic policy changes. For instance, research on consumer education, nudging strategies, and behavioral economics in food waste prevention remains underrepresented despite its potential to significantly reduce waste at the household and retail levels [35]. Additionally, the findings highlight opportunities for expanding research into underexplored regions. While Europe, North America, and China dominate the academic landscape, there is relatively little research originating from Africa, Latin America, and Southeast Asia—despite the fact that food insecurity and waste management challenges are particularly pressing in these regions. Future studies should aim to address regional disparities by conducting localized case studies, policy analyses, and community-driven research initiatives.

5. Implications for Policy and Practice

The findings of this study have several important implications for policymakers, industry stakeholders, and sustainability advocates. First, the growing emphasis on circular economy principles suggests that governments and businesses should prioritize closed-loop food systems. Policies that incentivize food waste reduction, support sustainable packaging, and promote resource-efficient supply chains can help bridge the gap between sustainable consumption and food waste management [32]. Second, the role of consumer behavior in food waste prevention underscores the need for education campaigns, behavioral nudges, and incentive programs to encourage sustainable consumption habits. Research indicates that simple interventions—such as portion control, expiration date awareness, and food sharing platforms—can significantly reduce food waste at the household level [36]. Policymakers should leverage behavioral insights and digital technologies to develop scalable interventions that align with cultural and regional food consumption patterns. Finally, the international research collaboration patterns suggest that greater cross-border cooperation is needed to develop global strategies for food waste reduction. While regional initiatives such as the EU's Farm to Fork Strategy and China's food waste reduction campaigns are promising, global frameworks—such as the United Nations Sustainable Development Goals (SDG 12.3 on food waste reduction)—should be reinforced through joint research programs, knowledge-sharing platforms, and policy harmonization efforts.

CONCLUSION

This study provides a comprehensive bibliometric analysis of research on sustainable consumption and food waste reduction, revealing key trends, research gaps, and opportunities for future exploration. The findings suggest that sustainability research is shifting from purely environmental concerns towards more applied and policy-driven approaches, with increasing emphasis on circular economy strategies, consumer behavior, and supply chain efficiency. While Europe and North America dominate global research efforts, emerging contributions from China, India, and Brazil indicate a growing diversification in sustainability scholarship. Future research should focus on enhancing interdisciplinary collaboration, expanding regional representation, and developing actionable policy recommendations to bridge the gap between sustainability theory and real-world application. By leveraging global research networks, technological innovations, and policy interventions, stakeholders can work towards a more sustainable and resilient food system that minimizes waste, conserves resources, and promotes equitable consumption patterns worldwide.

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