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A Bibliometric Analysis of Green Investment Trends and Developments

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ABSTRACT

This study presents a bibliometric analysis of green investment research, examining its trends, thematic focus, and developments from 2000 to 2024 using data from Scopus and Web of Science. The analysis reveals that foundational topics such as energy production, cost management, and process efficiency dominate the field, while recent research emphasizes green finance, technological innovation, and regional development. Key drivers include regulatory frameworks, technological advancements, and evolving financial mechanisms, while barriers such as regional disparities, limited sectoral representation, and inconsistent sustainability metrics persist. Emerging themes like digital technologies, R&D investment, and supply chain sustainability highlight opportunities for future research and innovation. The findings emphasize the need for interdisciplinary approaches and policy interventions to address gaps and scale green investments globally. This study provides actionable insights for researchers, policymakers, and practitioners, contributing to the discourse on sustainability and the strategic role of green investment in achieving global environmental goals.

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1. INTRODUCTION

Over the past two decades, the global discourse on sustainability has shifted from being a marginal topic to a central agenda for governments, corporations, and financial institutions alike. The concept of green investment, which involves allocating financial resources to environmentally sustainable projects and enterprises, has gained increasing traction in response to the urgent challenges posed by climate change, resource depletion, and environmental degradation. According to the United Nations Environment Programme (UNEP), global green finance investments have grown significantly, surpassing $600 billion in 2022 [1]. This growth underscores the critical role of green investments in mitigating environmental risks while fostering economic growth. Consequently, green investments are not merely a reaction to environmental crises

but are strategic imperatives that drive innovation and sustainable development.

The adoption of green investment strategies is further accelerated by global frameworks such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). These frameworks emphasize the need for financial systems to align with sustainability principles by promoting low-carbon technologies, renewable energy, and resource-efficient practices (OECD, 2021). Private and institutional investors are increasingly incorporating Environmental, Social, and Governance (ESG) criteria into their portfolios, which enhances the appeal of green investment as both a profitable and ethical option [2]. However, the effectiveness of these investments depends on a robust understanding of their trends, challenges, and impacts, a knowledge gap that bibliometric studies can effectively address.

Bibliometric analysis is a powerful tool for systematically mapping the intellectual landscape of green investment research. This method quantifies academic publications, identifies influential authors, journals, and institutions, and reveals thematic trends over time [3]. Green investment, as an interdisciplinary field, intersects with areas such as finance, environmental science, and public policy. Understanding how these disciplines converge in academic literature provides critical insights into how green investment is conceptualized and operationalized globally. By visualizing citation networks and analyzing thematic clusters, bibliometric studies can uncover hidden patterns and future research directions, offering valuable guidance to policymakers, practitioners, and scholars.

Despite its growing importance, the field of green investment is characterized by significant disparities in regional adoption, institutional practices, and academic contributions. For instance, while developed economies such as the United States and European Union have pioneered green financial mechanisms, emerging markets in Asia, Africa, and Latin America are increasingly contributing to global green investment flows [4]. The diversity of regional practices reflects variations in policy environments, financial market maturity, and societal priorities. Bibliometric analysis serves as an essential approach to understanding these regional disparities and highlighting how global research output addresses—or fails to address—localized challenges in green investment practices.

Although the importance of green investment is widely recognized, significant gaps remain in understanding the development and trajectory of this field within the academic literature. Previous studies have primarily focused on the financial performance of green investments or their environmental impacts, leaving the broader intellectual landscape underexplored. For example, questions regarding the dominant research themes, collaboration networks, and the evolution of methodologies in this domain have received limited attention [5]. Furthermore, the lack of a comprehensive review of bibliometric patterns has hindered stakeholders from effectively navigating the complexities of this rapidly evolving field. Without such an analysis, identifying research priorities, evaluating the effectiveness of current approaches, and forecasting future developments in green investment remains challenging.

This study aims to conduct a comprehensive bibliometric analysis of green investment trends and developments to bridge the identified knowledge gaps. By analyzing academic publications indexed in major databases, the study will provide a systematic overview of the intellectual structure and evolution of green investment research. Specifically, it seeks to identify the most influential authors; examine thematic trends and emerging topics; and map citation networks to reveal collaboration patterns. This research not only contributes to academic discourse but also offers actionable insights for policymakers, financial institutions, and other stakeholders striving to advance

sustainable development through green investment.

2. LITERATURE REVIEW

2.1 Defining Green Investment

Green investment, often synonymous with sustainable or eco-friendly investment, refers to the allocation of financial resources to projects, businesses, or financial instruments that promote environmental sustainability. These include investments in renewable energy, energy efficiency, sustainable agriculture, water conservation, and waste management [1]. The conceptual foundation of green investment lies in the alignment of financial objectives with environmental goals, creating a dual benefit of economic returns and ecological protection [6]. The growing emphasis on Environmental, Social, and Governance (ESG) factors in financial decision-making has further popularized green investment, with ESG-focused funds reaching $1.7 trillion globally in 2022 [7]. Scholars have debated the precise scope and definition of green investment. While some focus on the environmental aspect, others incorporate social and governance dimensions, arguing that a comprehensive approach ensures long-term sustainability [8]. These differing perspectives underscore the complexity and interdisciplinary nature of green investment, highlighting the need for a systematic review of its evolving trends.

2.2 Global Trends and Developments in Green Investment

Green investment has experienced exponential growth over the last decade, driven by international agreements such as the Paris Agreement and the UN Sustainable Development Goals (SDGs). Developed economies, particularly in North America and Europe, have pioneered green financing mechanisms, including green bonds, carbon credits, and renewable energy funds [9]. These regions benefit from robust regulatory frameworks, mature financial markets, and strong institutional support, which collectively create favorable environments for green investments.

Conversely, emerging markets in Asia, Latin America, and Africa are increasingly contributing to global green investment flows. For instance, China and India have emerged as leaders in renewable energy investments, accounting for nearly 50% of global solar capacity additions in 2022 [10], [11]. However, these regions face challenges such as regulatory uncertainty, limited access to capital, and socio-political instability, which hinder the full realization of their green investment potential [5].

The literature also highlights significant disparities in the adoption of green investments across sectors. While energy, transportation, and construction dominate global green investment portfolios, sectors such as agriculture and manufacturing remain underrepresented [12]. This imbalance raises questions about the inclusivity and comprehensiveness of green investment strategies and

underscores the need for targeted interventions in underfunded sectors.

2.3 *Drivers of Green Investment*

Multiple drivers influence the growth and adoption of green investment. Regulatory policies, such as carbon pricing, renewable energy subsidies, and environmental standards, play a critical role in incentivizing sustainable financial practices [11]. Governments and international organizations have introduced green bonds and tax credits to mobilize private capital for sustainable development projects [13]. Technological advancements are another key driver, enabling cost-effective solutions in renewable energy, energy efficiency, and waste management. Innovations such as smart grids, electric vehicles, and carbon capture technologies have significantly reduced the cost of green projects, making them more attractive to investors [14]. Additionally, changing consumer preferences and corporate social responsibility (CSR) initiatives have increased the demand for green products and services. Companies are recognizing the reputational and competitive advantages of adopting sustainable practices, further boosting the appeal of green investments [14]. However, the literature emphasizes that these drivers must be supported by consistent policy frameworks and robust financial instruments to achieve long-term sustainability.

2.4 *Barriers to Green Investment*

Despite its rapid growth, green investment faces several barriers that limit its scalability and impact. One of the primary challenges is the lack of standardized metrics for measuring and reporting sustainability outcomes. While frameworks such as the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD) provide guidance, inconsistencies in ESG reporting hinder investor confidence and market transparency [7]. Another barrier is the limited access to capital in developing economies. High upfront costs, long payback periods, and perceived risks deter private investors from financing green projects in these regions [5]. Moreover, political instability, weak regulatory frameworks, and insufficient infrastructure exacerbate these challenges, creating a vicious cycle of underinvestment. Behavioral factors also play a role in hindering green investment. Investors often exhibit short-term biases, prioritizing immediate returns over long-term sustainability. This mindset is particularly prevalent among institutional investors, who are driven by quarterly performance metrics [6]. Overcoming these barriers requires a combination of policy reforms, financial innovation, and cultural shifts in investment practices.

2.5 *Bibliometric Studies on Green Investment*

Bibliometric analysis provides a systematic approach to understanding the intellectual landscape of green investment research. By analyzing citation networks, co-authorship patterns, and thematic clusters, bibliometric studies reveal the

evolution of research trends and identify influential authors, journals, and institutions [3]. These insights are crucial for identifying research gaps and guiding future studies.

Previous bibliometric studies have highlighted the interdisciplinary nature of green investment research, which spans fields such as finance, environmental science, and public policy. For example, a bibliometric review by [15] identified energy transition, climate finance, and ESG integration as emerging themes in green investment literature. Similarly, [15] mapped the global research collaboration network, revealing strong connections between North American and European institutions but limited participation from developing countries. However, the literature lacks comprehensive bibliometric analyses that capture the latest trends and developments in green investment. Most existing studies focus on specific themes or regions, leaving a fragmented understanding of the field. Addressing this gap requires a holistic approach that integrates diverse perspectives and methodologies.

3. METHODS

This study employs a bibliometric analysis approach to systematically examine the trends and developments in green investment research. Data were collected from the Scopus database, ensuring a comprehensive and high-quality dataset of peer-reviewed academic publications. The search was conducted using relevant keywords such as "green investment," "sustainable finance," and "ESG" within the title, abstract, and keywords sections, covering a time frame from 2000 to 2024. The bibliometric tool VOSviewer was used to visualize citation networks and thematic clusters. Key metrics, including the most influential authors was identified. Additionally, thematic evolution analysis was conducted to map the progression of research topics over time.

4. RESULTS AND DISCUSSION

4.1 Citation Analysis

Table 2. Top Cited Research

Citations	Authors and year	Title
2064	[16]	A comparative overview of hydrogen production processes
1676	[17]	Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health
1553	[18]	The influence of green innovation performance on corporate advantage in Taiwan
1432	[19]	Green revolution: Impacts, limits, andthe path ahead
1141	[20]	Recovery and recycling of lithium: A review
1095	[21]	The driver of green innovation and green image - Green core competence
929	[22]	The moderating effects of institutional pressures on emergent green supply chain practices and performance

Citations	Authors and year	Title
803	[23]	Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action
703	[24]	China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0"
701	[25]	Thermolysis of waste plastics to liquid fuel. A suitable method for plastic waste management and manufacture of value added products-A world prospective

Source: Publish or Perish Output, 2024

4.2 Keyword Co-Occurrence Analysis

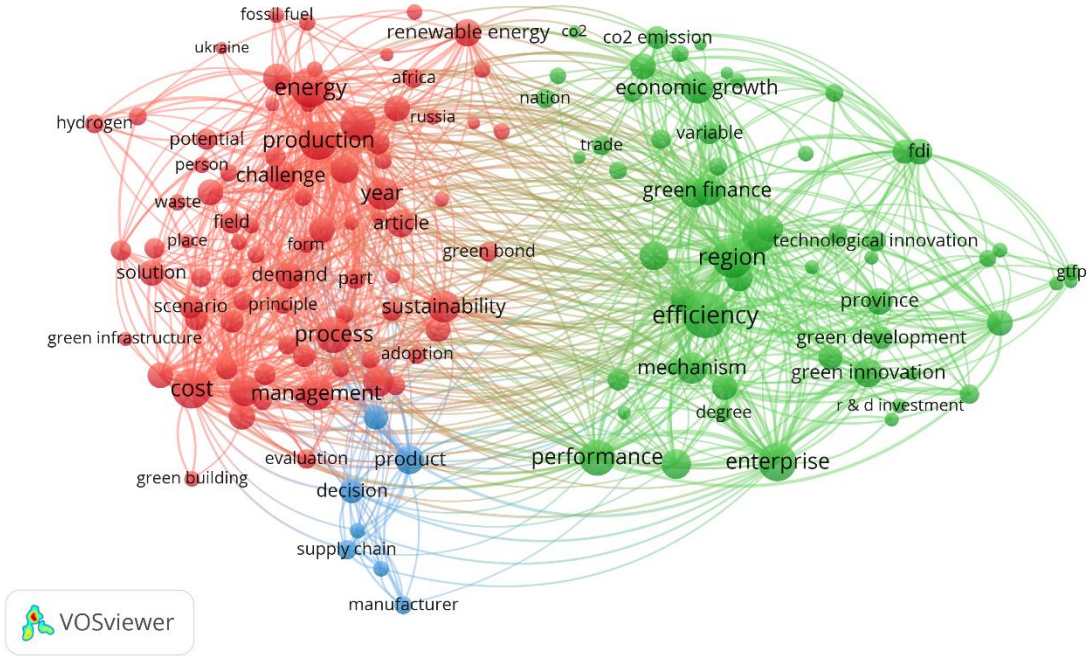

Figure 1. Network Visualization
Source: Data Analysis Result, 2024

The network visualization reveals three distinct thematic clusters, represented by red, green, and blue nodes. The red cluster predominantly focuses on themes related to "energy," "production," "management," and "process," emphasizing the technical and operational challenges of green investment, particularly in the context of renewable energy and industrial sustainability. These topics are tightly interconnected, highlighting the role of production processes and energy costs as critical components of green investment discussions. In contrast, the green cluster explores topics associated with "region," "efficiency," "economic growth," and "green finance." This cluster delves into macroeconomic and regional perspectives of green investment, suggesting a strong focus on policy mechanisms, regional development, and the integration of technological innovation in achieving efficiency and sustainability. The presence of terms like "green innovation," "FDI," and "economic growth" underscores the strategic importance of green finance as a driver of regional development.

The size of the nodes reflects their prominence within the research field, indicating frequently occurring terms and central concepts. "Energy," "region," and "efficiency" emerge as dominant nodes, underscoring their significance in green

investment discourse. "Energy" is a central theme in the red cluster, reflecting its foundational role in sustainability initiatives and green investments. Similarly, "region" in the green cluster highlights geographical variations in green investment practices and the need for localized strategies. Furthermore, terms such as "renewable energy," "green finance," and "technological innovation" appear as bridges between clusters, demonstrating their cross-cutting relevance across multiple domains of green investment research. These nodes act as thematic linkages, connecting technical, economic, and policy-driven discussions within the literature.

The visualization reveals significant interconnections between clusters, represented by overlapping edges. For example, the relationship between "renewable energy" in the red cluster and "green finance" in the green cluster indicates the financial mechanisms required to support energy transitions. Similarly, "efficiency" serves as a common thread linking discussions on technological innovation, cost management, and performance across clusters. These interconnections highlight the interdisciplinary nature of green investment research, where economic, technological, and regional dimensions are deeply intertwined. The visualization also suggests that achieving sustainability requires a holistic approach that integrates these diverse aspects.

The blue cluster, though smaller in size, focuses on "supply chain," "manufacturer," and "product," suggesting an emerging interest in green investments within the context of industrial and supply chain sustainability. This area appears less explored compared to the dominant red and green clusters, indicating potential opportunities for further research. Moreover, terms like "green infrastructure," "green building," and "adoption" in the periphery of the red cluster suggest emerging topics that are gaining traction but have yet to achieve central prominence in the field. Overall, the visualization underscores the multifaceted nature of green investment research, with established themes in energy and finance and growing interest in industrial sustainability and technological adoption. The interconnectedness of the clusters emphasizes the need for integrative strategies that address both macroeconomic and technical challenges.

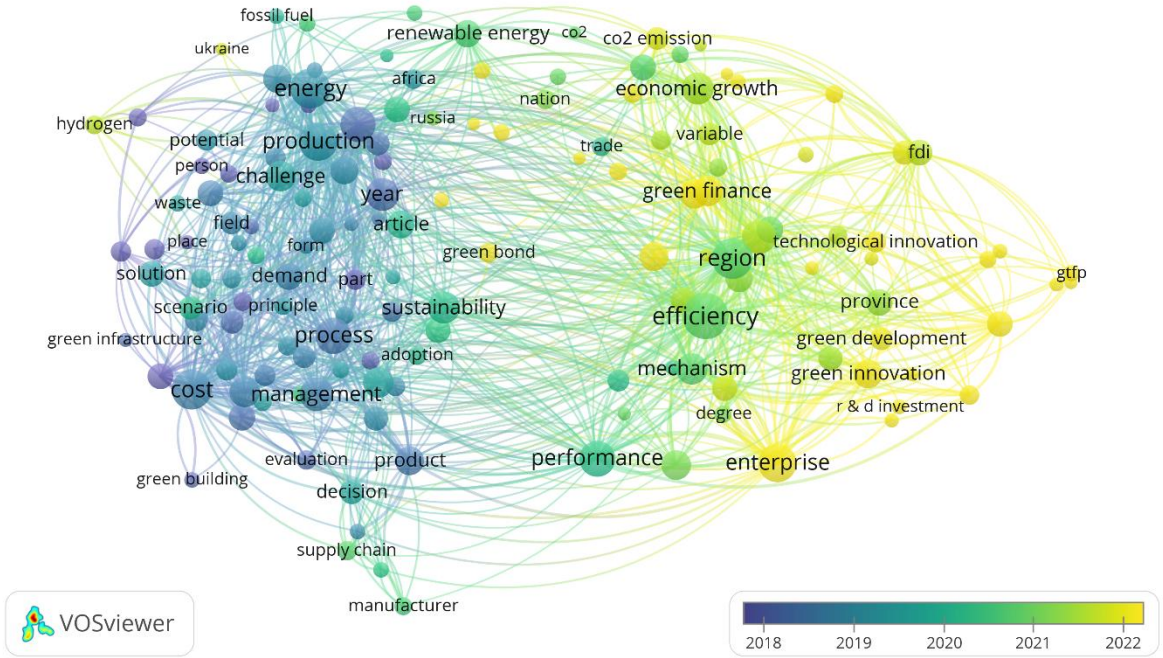

Figure 2. Overlay Visualization

Source: Data Analysis Result, 2024

The visualization incorporates a timeline (2018–2022) to indicate the temporal progression of research topics in green investment. The color gradient from blue to yellow illustrates how certain topics have evolved over time. For instance, earlier research (blue nodes) focused heavily on foundational topics such as "energy," "production," "cost," and "process." These topics highlight initial challenges and the technical aspects of integrating sustainability into production systems. In contrast, newer research trends (yellow nodes) concentrate on "green innovation," "technological innovation," and "green development," reflecting a shift toward forward-looking and technology-driven solutions for sustainable development.

The yellow nodes, representing more recent research, highlight emerging themes such as "green innovation," "R&D investment," and "technological innovation." These topics suggest growing interest in leveraging advanced technologies and research-driven strategies to address sustainability challenges. Additionally, terms like "region," "efficiency," and "performance," which transition from green to yellow, indicate a sustained focus on improving regional economic growth and enterprise efficiency through sustainable investments. The evolving timeline underscores the dynamic and adaptive nature of green investment research, with newer studies responding to technological advancements and global sustainability priorities.

The interconnectedness across different time periods reflects the interdisciplinary nature of green investment research. Earlier foundational topics such as "energy," "cost," and "management" remain strongly linked to newer themes like "green finance" and "technological innovation." This continuity suggests that while the field is evolving, the core challenges of energy production and cost management continue to inform the development of innovative financial and technological solutions. Furthermore, the presence of terms like "region" and "enterprise" in the more recent research highlights increased collaboration between academic, industrial, and governmental stakeholders to address regional and enterprise-level sustainability goals. The visualization reveals not just the progression of themes but also the sustained integration of older and newer concepts, reinforcing the importance of a holistic approach in green investment research.

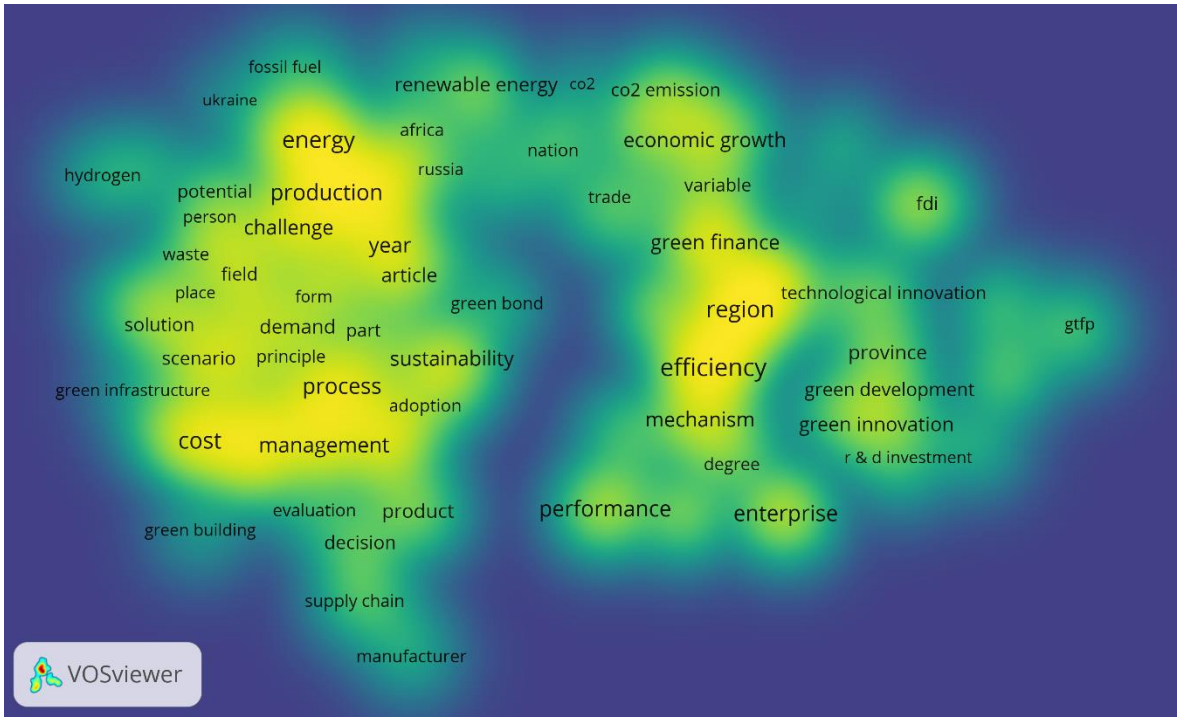

Figure 3. Density Visualization

Source: Data Analysis, 2024

The heatmap visualization highlights the concentration of research activity across various themes in the field of green investment. Areas with bright yellow regions, such as "energy," "production," "management," and "process," indicate high research density and focus. These terms suggest that foundational aspects of green investment, particularly related to energy production and cost management, have garnered significant attention from researchers. The prominence of these terms underscores the critical role of energy-related challenges in shaping the discourse on sustainability and green finance. Conversely, the less bright but still notable yellow areas around "green finance," "region," and "efficiency" indicate emerging but growing interest in the macroeconomic and regional dimensions of green investment. Terms such as "technological innovation" and "green innovation" on the right side of the heatmap show developing trends in leveraging innovation and R&D for sustainable development. The heatmap demonstrates a balanced focus between well-established topics and newer, innovation-driven themes, illustrating the dynamic and evolving nature of green investment research while identifying gaps in less-explored areas like "supply chain" and "green building."

Discussion

1. Key Themes in Green Investment Research

The bibliometric analysis highlights several dominant themes in green investment research. Core topics such as "energy," "production," "management," and "process" emerge as central areas of focus, reflecting the foundational importance of addressing energy and resource efficiency in green investment practices. These themes indicate that much of the research has concentrated on operational and technical challenges, particularly in renewable energy, energy transition, and industrial production processes. This aligns with global efforts to decarbonize energy systems and promote the adoption of clean technologies [26]. Simultaneously, the growing focus on "green finance," "efficiency," and "region"

underscores the increasing recognition of macroeconomic and policy-driven dimensions of green investment. These topics reflect a shift toward integrating sustainability within regional economic frameworks and financial systems, particularly through mechanisms such as green bonds, foreign direct investment (FDI), and public-private partnerships. This shift demonstrates the broadening scope of green investment research, moving beyond technical solutions to explore economic and institutional enablers of sustainability.

2. Regional and Sectoral Disparities

One notable finding from the bibliometric analysis is the significant disparity in regional and sectoral focus within green investment research. The prominence of terms like "region" and "economic growth" indicates that green investment is increasingly framed within the context of regional development and economic policies. However, much of the research has historically focused on developed economies, particularly North America and Europe, where regulatory frameworks, market maturity, and institutional support are more robust [4]. In contrast, emerging markets, despite their growing contribution to global green investment flows, remain underrepresented in the literature. Sectorally, the findings reveal a concentration of research in energy, transportation, and infrastructure, with relatively limited attention to agriculture, manufacturing, and supply chains. While energy-related investments are critical for reducing carbon emissions, the underrepresentation of other sectors suggests gaps in the holistic application of green investment principles. For example, the manufacturing and agricultural sectors play crucial roles in global emissions but remain less studied in terms of green financing and sustainability interventions[27]. Addressing these disparities is vital for creating inclusive green investment strategies that cater to diverse regional and sectoral needs.

3. Emerging Trends and Innovation

The emergence of themes such as "technological innovation," "green innovation," and "R&D investment" in recent years reflects the growing importance of leveraging technology to achieve sustainability goals. Innovations in digital technologies, such as blockchain, artificial intelligence (AI), and big data analytics, are transforming how green investments are managed and monitored. For instance, blockchain can enhance transparency in green finance by tracking the allocation and utilization of funds, while AI-driven tools can optimize resource allocation and improve decision-making in sustainability projects [13]. Furthermore, the emphasis on "green development" and "efficiency" suggests that recent research is exploring how technology-driven solutions can enhance operational efficiency and reduce costs, thereby making green investments more attractive to stakeholders. The integration of technological innovation into green investment practices not only improves financial performance but also accelerates progress toward environmental goals. However, these innovations require supportive policies, capacity-building efforts, and cross-sector collaboration to maximize their impact.

4. Barriers to Green Investment

Despite the advancements highlighted in the literature, green investment faces several persistent barriers that limit its scalability and effectiveness. The lack of standardized metrics for measuring and reporting sustainability outcomes remains a significant challenge. While frameworks such as the Global Reporting Initiative (GRI) and Task Force on Climate-related Financial Disclosures (TCFD) provide guidance, inconsistencies in ESG reporting reduce transparency and deter investor confidence [1]. These gaps underscore the need for universally accepted methodologies that can enhance accountability and comparability in green investment practices.

Financial barriers are particularly pronounced in developing economies, where

limited access to capital, high perceived risks, and weak regulatory frameworks hinder the adoption of green financing mechanisms. Terms such as "cost" and "challenge" in the bibliometric analysis highlight the ongoing struggles to make green projects financially viable, especially in regions with limited institutional support. Overcoming these barriers requires targeted financial instruments, such as concessional loans, blended finance, and de-risking mechanisms, to incentivize private sector participation and bridge funding gaps.

Behavioral and cultural barriers also play a role, as short-term profit motives often outweigh long-term sustainability goals in investment decisions. This mindset, prevalent among institutional investors, underscores the need for awareness campaigns and education initiatives to promote the value of sustainable investing. Addressing these barriers requires a multi-stakeholder approach that combines policy reforms, financial innovation, and cultural shifts in investment practices.

Opportunities for Future Research

The bibliometric analysis reveals several opportunities for future research in green investment. The limited focus on certain sectors, such as agriculture and supply chain, highlights the need to explore how green investment principles can be applied to underrepresented areas. For instance, sustainable agriculture practices, resource-efficient supply chains, and green manufacturing processes are critical for achieving global sustainability goals but remain underexplored in academic literature [5]. Another promising area is the intersection of green investment with social equity and inclusive development. While the literature emphasizes economic and environmental dimensions, the social implications of green investments—such as their impact on job creation, community development, and social well-being—are less studied. Integrating these dimensions into green investment research can provide a more holistic understanding of its potential to contribute to sustainable development. The growing role of digital technologies also presents opportunities for research. Future studies can investigate how tools like blockchain, AI, and IoT can be effectively integrated into green finance systems to enhance transparency, efficiency, and scalability. Additionally, examining the regulatory and ethical implications of these technologies can provide valuable insights for policymakers and practitioners.

Policy Implications

The findings of this study have important implications for policymakers. The emphasis on "green finance," "region," and "efficiency" suggests that supportive policy frameworks are essential for scaling green investments. Policies that incentivize renewable energy adoption, provide tax credits for sustainable projects, and promote green bonds can mobilize private capital and accelerate the transition to a low-carbon economy (UNEP, 2023). Regional disparities in green investment highlight the need for localized strategies that address specific challenges and opportunities. For instance, developing economies require policies that improve access to capital, strengthen regulatory frameworks, and build institutional capacity. Public-private partnerships (PPPs) can also play a critical role in overcoming financial and operational barriers by combining public funding with private expertise. Standardizing ESG reporting and sustainability metrics is another key priority. Policymakers and regulatory bodies must work toward creating universally accepted frameworks that enhance transparency, accountability, and investor confidence in green finance markets. Collaborative efforts involving governments, financial institutions, and international organizations are essential for achieving these goals.

Limitations of the Study

While this bibliometric analysis provides valuable insights, it is important to acknowledge its limitations. The study relies

on data from Scopus and Web of Science, which, although comprehensive, may exclude relevant publications from other databases or grey literature. Additionally, the analysis focuses on published academic research and may not capture real-world practices and innovations in green investment. Another limitation is the focus on keyword-based analysis, which may overlook implicit themes or emerging topics not explicitly mentioned in the literature. Future studies can address these limitations by incorporating a broader range of data sources and employing qualitative methods to complement bibliometric findings.

5. CONCLUSION

This study provides a comprehensive bibliometric analysis of green investment research, revealing its dynamic evolution and interdisciplinary nature. The findings highlight a strong emphasis on energy production, cost management, and process efficiency as foundational topics, while recent trends focus on green finance, technological innovation, and regional development. Despite these advancements, significant challenges persist, including regional disparities, sectoral underrepresentation, and a lack of standardized metrics for sustainability reporting. Addressing these gaps will require collaborative efforts from policymakers, financial institutions, and researchers, particularly to enhance access to green financing in developing economies and promote innovation-driven solutions. By integrating economic, environmental, and social dimensions, green investment has the potential to drive sustainable development and foster a more equitable, low-carbon future. This study underscores the importance of continuous research and strategic policy interventions to unlock the full potential of green investment in addressing global sustainability challenges

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