

SURVEY ARTICLE

A Comprehensive Literature Review of Sustainable Finance and Ecological Resilience: Theoretical Basis and Practical Paths

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ABSTRACT

With the mounting pressure on the global ecological environment, the allocation of financial resources must be premised on promoting the green transformation of the economic system. Issues related to sustainable finance and regional ecological resilience have become research hotspots in current fields such as environmental economics and finance. This paper presents a comprehensive review on the relationship between sustainable finance and regional ecological resilience. By sorting out the core connotations, evolutionary contexts and measurement methods of sustainable finance and regional ecological resilience, and based on environmental finance theory, ecological resilience theory and regional sustainable development theory, it analyzes the interaction mechanisms between sustainable finance and regional ecological resilience as documented in the literature across different national and regional contexts, based on a bibliometric and thematic synthesis of empirical studies. Furthermore, it provides policy references and practical guidance from the perspectives of improving the sustainable financial system and strengthening the regional ecological governance mechanism.

1 | Introduction

As ecosystem degradation and climate shocks continue to intensify, issues such as frequent extreme weather events, air and water pollution, and biodiversity loss have led the public to recognize the close connection between ecological balance and human survival. Globally, there is a growing emphasis on the scientific assessment and systematic governance of ecosystems, along with efforts to coordinate the complexity of environmental factors. Traditional ecological governance models—such as establishing protected areas, controlling pollutant emissions, and conserving rare species—focus primarily on passive defense against natural disasters or static remediation of environmental problems. These models typically plan and manage ecological conditions based on specific points in time, making it difficult to adapt to the

dynamic changes of ecosystems (Smulders and Gradus 1993; Bovenberg and Smulders 1995). At present, many countries are gradually adopting systematic governance frameworks to replace localized traditional environmental governance models. These frameworks emphasize long-term monitoring and quantitative assessment of ecosystem structure, function, and dynamic processes; focus on identifying critical ecological thresholds and vulnerability characteristics; and integrate multidimensional environmental elements, cross-regional governance entities, and multi-scale policy instruments to promote a synergistic pathway that balances ecological protection, climate adaptation, and sustainable resource use (Jabareen 2013; Meerow et al. 2016). Based on a profound understanding of ecosystems' ability to resist external disturbances and maintain core functions, the concept of ecological resilience has emerged, offering a new

perspective and governance paradigm for understanding and enhancing ecosystems' capacity for adaptation and regeneration under multiple pressures.

Sustainable finance originates from the concept of sustainable development. In 1987, the United Nations World Commission on Environment and Development, in its report *Our Common Future*, defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Subsequently, several international documents—including the Rio Declaration on Environment and Development, Agenda 21, and the 2030 Agenda for Sustainable Development—have gradually made sustainable development a global consensus. The key to sustainable development lies in directing capital toward areas related to the Sustainable Development Goals (SDGs). The United Nations estimates that achieving the 2030 SDGs requires \$5–7 trillion per year globally. Sustainable finance channels capital into sustainable development fields, shifting from an initial focus on financial scale expansion toward enhancing the credibility and quality of financial products, with a focus on product development, environmental information disclosure, climate risk management, and other areas (Ohioma and Anwar 2026). The traditional valuation model centered solely on financial performance is gradually being replaced by a comprehensive value assessment system that integrates environmental, social, and governance benefits, prompting financial markets to pay greater attention to long-term value and tail-risk prevention (Tepetepe and Obokoh 2025). On the other hand, sustainable finance has given rise to a rich array of financial instruments, including green credit, green bonds, sustainability-linked bonds, ESG funds, climate derivatives, and more, thereby expanding the investment and financing boundaries of capital markets, optimizing capital allocation structures, and directing substantial social capital toward low-carbon transitions, ecological protection, and green technology innovation (Migliorelli 2021).

This paper conducts a bibliometric analysis (BA) of the relevant literature on ecological resilience and sustainable finance, aiming to answer the following questions:

- How has research in the fields of sustainable finance and ecological resilience evolved?
- What are the measurement methods for sustainable finance and ecological resilience found in empirical studies?
- How is the relationship between sustainable finance and regional ecological resilience explained in the literature?
- Which journals and authors have demonstrated outstanding dissemination influence, and how is this influence distributed across the literature? (While no dedicated ranking table is provided, related citation and collaboration analyses are discussed in Sections 4.2 and 4.6.)
- What policy implications can be drawn from the existing literature?
- What emerging issues require broader discussion?

This paper selects 337 empirical papers published between 2000 and 2026 in the economics category of the Web of Science (WoS)

and conducts a bibliometric analysis. This method does not require strict homogeneity of research subjects, has broad applicability, effectively reduces research bias caused by subjective judgment, and systematically organizes the research trajectory and knowledge structure (Junni et al. 2013; Zupic and Čater 2015). The structure of this paper is as follows: Section 2 elaborates on the relevant concepts and their evolution; Section 3 introduces the bibliometric method in general; Section 4 explains the specific classification implemented for the bibliometric analysis; Section 5 presents the research results; Section 6 discusses the implications and limitations of the existing literature and proposes issues for further exploration; Section 7 summarizes and concludes.

2 | Definition and Evolution of Core Concepts

2.1 | Sustainable Finance

The concept of sustainable finance originated from socially responsible investment (SRI) in the 1970s. Initially, no unified framework existed, and its core characteristic was primarily the exclusion of negative lists, focusing on ethical and compliance dimensions (Albuquerque et al. 2019). In 1974, the Federal Republic of Germany established the world's first "ethical bank" (GLS Bank) specializing in social and ecological business, marking one of the earliest practical explorations of sustainable finance internationally. In the 1980s, American scholars began to discuss socially responsible investment, emphasizing that pension funds should assume social responsibilities, and identified the difficulty of standardizing social performance as a major obstacle in pension fund practice (Ferris and Rykaczewski 1986). In the early 1990s, several scholars derived the theme of sustainable finance from the key factors contributing to the success of socially responsible investment (Camey 1994; Diltz 1995). Cowan (1998) regarded sustainable finance as an interdisciplinary field combining environmental economics and finance, with its core being the use of financial market mechanisms to solve environmental problems.

As financial sectors and academic research increasingly focused on ecological issues, around 2000–2010, with the successive introduction of landmark frameworks such as the Equator Principles, the United Nations Principles for Responsible Investment (UN PRI), and the Green Bond Principles, sustainable finance entered a phase of unified rules, broad institutional participation, and market expansion. At the regional level, the European Union's adoption of the Sustainable Finance Disclosure Regulation (SFDR) and the Non-Financial Reporting Directive (NFRD) in subsequent years also served as important milestones that catalyzed academic research on mandatory ESG disclosure and its effects on capital markets. The ESG concept began to be integrated into the asset allocation and risk management processes of mainstream financial institutions (Chemmanur et al. 2010). At this stage, sustainable finance was no longer a niche form of responsible investment but gradually became a major direction for financial market development, laying the institutional foundation for the subsequent large-scale expansion of the global sustainable finance system. Academic research during this period is characterized by two aspects. First, it focused on understanding and applying socially responsible investment in industry, using equilibrium pricing models that analyze how environmental

factors influence corporate behavior to reveal the internal logic by which green investment constrains corporate pollution through capital market mechanisms (Statman 2000; Heinkel et al. 2001; Bello 2005). Second, it called for broadening the research scope to include new issues such as corporate investment strategies, climate change, and financial product design (Heinkel et al. 2001; Labatt and White 2002; Van Der Laan and Lansbury 2004; Scholtens and Dam 2006). These studies have provided important theoretical support for the development of sustainable finance.

From 2010 to the present, sustainable finance has gradually evolved from fragmented responsible investment into a systematized governance paradigm deeply integrated with climate action and the Sustainable Development Goals. Different scholars have analyzed sustainable finance from various perspectives. Some scholars approach it from the three-layer relationship among enterprises, financial markets, and social value, viewing sustainable finance as a bridge linking micro-level agent behavior, financial intermediation mechanisms, and overall social welfare. That is, through financial instruments and investment decisions in financial markets, enterprises implement environmental governance and practices, generating social value that includes environmental improvement, ecological optimization, and long-term sustainable development (Chang et al. 2022; ElBannan 2024). Other scholars have reviewed theories related to financial performance, risk management, and sustainable investment, emphasizing that the essence of sustainable finance is to embed non-financial sustainability factors into investment decisions, consider environmental and social dimensions, and practice sustainable principles, thereby highlighting the environmental, developmental, and institutional attributes of investment. In addition, the literature from this period involves various types of market-based financial instruments that address corporate environmental externalities and manage environmental risks, providing substantial empirical evidence for the practical application of sustainable finance (Kitzmueller and Shimshack 2012; Baker and Nofsinger 2012).

Numerous international organizations have also articulated and summarized the concept of sustainable finance. For example, the 2015 United Nations Environment Program (UNEP) report. The Financial System We Need: Aligning the Financial System with Sustainable Development proposed that a sustainable financial system is one that creates, values, and handles financial assets, serving the long-term needs of an inclusive and environmentally sustainable economy by shaping real wealth. The 2030 Agenda for Sustainable Development reveals a broader connotation and goal of sustainable finance, namely, an integration of financial activities that achieves environmental, economic, social, and governance sustainability while highlighting a country's financial leadership, providing customized financial solutions for the transformation and upgrading of traditional manufacturing industries as well as for the cultivation of strategic emerging industries and future industries (Cunha et al. 2021). In 2018, the G20 Sustainable Finance Study Group defined sustainable finance as financing that directly or indirectly supports the Sustainable Development Goals (SDG) framework and promotes strong, sustainable, balanced, and inclusive growth, along with related institutional and market arrangements. Additionally, the European Commission's Action Plan on Financing Sustainable Growth provides a relatively broad definition of sustainable

finance, considering it as the appropriate consideration of ESG factors in investment decisions to increase long-term investment in sustainable activities. Globally, sustainable investment policies are evolving with key characteristics including legislation-driven standardization of frameworks, mandatory environmental information disclosure, inclusive transition finance, and deepened climate risk management (Folqué et al. 2021).

As the functions and impacts of sustainable finance in addressing environmental issues become increasingly prominent, its connotation has grown deeper and broader, overlapping with concepts such as green finance, carbon finance, climate finance, and ESG. According to a review of the existing literature, sustainable finance covers the widest scope, pursuing a triple balance of economic, environmental, and social benefits. It not only focuses on environmental protection and the sustainable use of ecological resources but also addresses multiple aspects of social governance, including labor rights, corporate finance, and public welfare (Jin et al. 2023). Green finance focuses on environmental benefits and specifically refers to the provision of financing, investment, risk management, and other services for projects related to environmental protection, energy conservation, clean energy, green transportation, and green buildings. It includes not only financial flows but also the legal, economic, and institutional frameworks that support its operation, and it represents the main environmental dimension of sustainable finance (Lindenberg 2014). Carbon finance is a core instrument of green finance in addressing climate change, with a relatively narrow scope. It focuses on financial activities such as investment, financing, trading, and risk management related to carbon assets, including carbon emission rights, carbon allowances, and CCER (China Certified Emission Reductions). Comparing sustainable finance with the concept of ESG, ESG investing emphasizes the systematic incorporation of non-financial factors into assessments and serves as the core evaluation dimension and decision-making basis for sustainable finance, while sustainable finance is the financialized, market-based, and large-scale practical vehicle for ESG principles (Asmi et al. 2025).

2.2 | Literature Discussion on the Ecological Resilience

The term "resilience" originates from physics, where it refers to the ability of a system to return to its original state after experiencing an external shock. The ecologist Holling (1973) introduced the concept into ecology, describing it as the capacity of an ecosystem to absorb, persist, and recover its balance after a brief, sudden disturbance. Nijkamp and Reggiani (1992), whose research was not focused on ecological environments, viewed the system as a single, stable equilibrium state and argued that the higher a system's resistance to shocks and the shorter its recovery time, the greater its resilience. As resilience theory has been applied across various disciplines, some scholars have begun to consider its evolutionary characteristics. In the context of behavioral psychology, evolutionary resilience refers to an individual's ability to actively adapt and recover when facing adversity, setbacks, trauma, or significant stress (Newman 2005).

Many economic and social issues have also begun to emphasize the evolutionary characteristics of resilience, proposing that

resilience is an ongoing process rather than a return to a stable state (Reggiani et al. 2002; Simmie and Martin 2010). Resilience may optimize a system's response to shocks and create more opportunities for innovation and development, while regional resilience refers to a region's ability to avoid potential losses from shocks and its adaptive responses. Before the 1970s, mainstream ecology was dominated by the equilibrium paradigm, which held that ecosystems would return to a single stable equilibrium after disturbances. Subsequently, the evolution of the ecological resilience concept has followed a trajectory from static to dynamic, from single equilibrium to multiple stable states, and from ecosystems to coupled social-ecological systems. This evolutionary path not only reflects the deepening of scientific understanding but also responds to the practical need for sustainability governance in the context of global environmental change. For the purpose of this review, "ecological resilience" is primarily understood as ecosystem resilience in a narrow sense—the capacity of an ecosystem to absorb disturbances and maintain core functions—unless explicitly stated otherwise. However, when the cited literature adopts the broader "social-ecological resilience" framing (e.g., by including human adaptation or institutional learning), that distinction is noted in the discussion. This conceptual boundary ensures consistency in the subsequent bibliometric and mechanism analyses.

3 | Literature Search Process

Sustainable finance, through instruments such as green credit, green bonds, and ecologically oriented funds, directs capital precisely toward areas including ecological restoration, pollution control, carbon emission reduction, biodiversity protection, and sponge city construction. This helps enhance the buffering capacity and recovery capacity of ecosystems, thereby promoting the level of ecological resilience. However, the academic research that explicitly links the two remains very fragmented. Most of the existing literature either discusses the impact of financial instruments on the ecological environment in isolation, or separately analyzes the constraints that ecological resilience imposes on regional economies. Few studies have deeply explored questions such as "how sustainable finance contributes to the improvement of ecological resilience" or "how ecological resilience in turn affects the financial system." Therefore, conducting a literature search is a necessary prerequisite for identifying the current state, hotspots, and gaps in this interdisciplinary field.

3.1 | Keyword Selection

The first step in the literature search process is to accurately select core keywords based on the research topic. This paper aims to investigate the implementation effects of sustainable finance and the determinants of ecological resilience, while highlighting the relationship between the two. Therefore, keyword selection revolves around these two core concepts. For "sustainable finance," the related keywords are "Sustainable Finance" and "Green Finance"; for "ecological resilience," the related keywords are "Ecological Resilience" and "Regional Ecological Resilience." Boolean operators are used to construct keyword combinations, forming a precise retrieval logic to ensure comprehensive coverage of relevant literature at the intersection

of the two major themes. Although "Climate Finance" and "ESG investing" are closely related concepts, pilot searches revealed that including them as core keywords introduced a substantial volume of literature focused on macro-level climate policy or broad corporate governance, which were often not directly linked to ecological resilience. Therefore, the search strategy was deliberately narrowed to "Sustainable Finance" and "Green Finance" to maintain thematic precision.

We selected the Web of Science Core Collection as the source for literature analysis based on the following considerations. First, compared with journal databases such as Elsevier or Scopus, Web of Science extensively indexes globally influential academic journals, covering multiple sub-databases including SCIE, SSCI, and AHCI. This aligns with the interdisciplinary nature of sustainable finance research, which spans the natural and social sciences, and provides effective support for tracing the origins of knowledge and identifying frontier issues. Second, all documents included in the Web of Science database are published in journals that have undergone rigorous quality screening. The quality assessment framework is continuously maintained and updated by Clarivate's professional editorial team, ensuring the credibility and comparability of research findings. Third, Web of Science's built-in analytical tools and compatible export formats meet the requirements of bibliometric analysis. The data export formats are fully compatible with mainstream bibliometric software such as VOSviewer, CiteSpace, and Bibliometrix, and its complete citation indexing structure supports in-depth knowledge network analysis. This high-quality structured data are a prerequisite for the subsequent analysis in this study.

3.2 | Literature Screening

After determining the database, the next step is the retrieval process. This paper adopts the Boolean logic retrieval method, using Boolean operators to combine search terms and precisely define the literature scope within the WoS database. The search strategy uses the following core keywords: ("Sustainable Finance" OR "Green Finance") AND ("Ecological Resilience" OR "Regional Ecological Resilience"). Synonyms are combined using the OR operator to ensure high recall of relevant literature, while different conceptual domains are linked using the AND operator. The initial search yielded 8043 related documents.

First, the initial search results are strictly screened. The document type is limited to "ARTICLE", excluding non-original and non-core research documents such as conference papers, reviews, conference abstracts, and editorial materials. Second, to focus on core areas highly relevant to our research topic, the subject categories are restricted to Environmental Sciences, Green Sustainable Science Technology, Economics, Environmental Studies, and Management within the Web of Science system. It is acknowledged that relevant research on sustainable finance may also appear in sociology or political science journals (e.g., focusing on social movements or policy diffusion). Confining the search to the five categories above inevitably omits such contributions, but this trade-off was necessary to maintain disciplinary coherence and analytical tractability. During the specific operation, to ensure that documents whose core issues are closely related to sustainable finance and regional ecological resilience are not

omitted from our results even if they do not contain the aforementioned keywords, we expand the retrieval dimensions by incorporating the United Nations Sustainable Development Goals (SDGs). Additional keywords include: Climate Action; Industry, Innovation and Infrastructure; Affordable and Clean Energy; Responsible Consumption and Production; Decent Work and Economic Growth; Life on Land; Life Below Water; and Clean Water and Sanitation. The elements covered by these keywords have a certain degree of synergy with our core keywords.

In the implementation of the Boolean logic method, the field tag TS we use denotes Title, Abstract, and Keywords, and we select $((TS = ("Sustainable Finance^{**}") OR TS = ("Green Finance^{**}") OR TS = ("Ecological Resilience^{**}") OR TS = ("Regional Ecological Resilience^{**}")) OR ((TS = ("Sustainable Finance^{**}") OR "Green Finance^{**}" OR "Climate Action^{**}" OR "Affordable and Clean Energy^{**}" OR "Responsible Consumption and Production^{**}" OR "Decent Work and Economic Growth^{**}" OR "Life on Land^{**}" OR "Life Below Water^{**}" OR "Clean Water and Sanitation^{**}")) AND TS = ("Ecological Resilience^{**}"))$. In addition, the symbol ** allows searching for all words that begin with the specified term, regardless of their endings."

The time span for journal articles covered in this paper is set from January 1, 2016, to March 30, 2026. There are two main reasons for this choice. First, since 2016, sustainable finance policies in several developed economies and some developing countries have gradually begun to be implemented intensively, providing relatively mature conditions for empirical research on policy evaluation. Second, research on sustainable finance and ecological resilience started relatively late. Most journal articles published before 2016 on these two topics were primarily theoretical in nature, did not reflect the relationship between the two, or lacked measurable indicators and quantifiable empirical testing. In contrast, over the past decade, the openness and availability of multi-source data in documents indexed by the WoS database have shown a significant upward trend, providing a solid data foundation for in-depth interdisciplinary systematic research.¹

Finally, following the above retrieval strategy and screening criteria, combined with manual reading of abstracts and full texts to eliminate irrelevant or duplicate articles, a total of 217 journal articles were obtained. By research type, these include 15 theoretical papers and 181 empirical and case-based papers. Figure 1 illustrates the overall screening process.

4 | Literature Classification Criteria and Bibliometric Results

The selected literature focuses on the "implementation effects of sustainable finance" and the "determinants of ecological resilience," exploring whether sustainable finance can truly direct capital toward environmentally friendly and socially inclusive economic activities, as well as the ability of ecosystems to maintain functions, reorganize, and adapt after disturbances. This paper classifies the literature screened above based on five dimensions: research perspective, temporal evolution stage, research method, and geographical region.

4.1 | Classification by Research Perspective and Literature Characteristics

In terms of research perspective, we classify the above literature into three types: the environmental performance assessment perspective, the ecological resilience enhancement perspective, and the incentive and constraint mechanism perspective. The environmental performance assessment perspective focuses on quantifying the direct net impact of sustainable finance on environmental indicators such as pollutant emission reduction and carbon emission intensity. The ecological resilience enhancement perspective concentrates on how ecosystems reorganize and adapt to changes after being disturbed. The incentive and constraint mechanism perspective emphasizes how to convert ecological environmental externalities (pollution costs) into internal decision-making variables for micro-level agents, driving them to invest in ecological restoration and resilience building. These three perspectives form a complete analytical chain. This paper further subdivides the mechanism perspective into three categories: market mechanisms, government mechanisms, and dual integration mechanisms. Market mechanisms include the application of sustainable finance instruments, differentiated capital requirements, environmental information disclosure, and so forth. Government mechanisms include fiscal green subsidies, direct appropriations, tax reductions and exemptions, transfer payments (ecological compensation), government green procurement, and so forth. Dual integration mechanisms emphasize the synergy among government, markets, and social organizations.

To systematically identify the knowledge structure and thematic development of the research field on sustainable finance and regional ecological resilience, this paper conducts a co-occurrence network analysis of keywords from 181 sample documents using VOSviewer software. The results are shown in Figure 2. The overall network exhibits a complex topological structure with multiple centers and multiple clusters, which can be divided into six thematic clusters. The core nodes are "sustainable finance" and "ecological resilience". As network hubs, these two nodes radiate widely across the thematic groups with high centrality and high connection density, confirming the core status and theoretical integration function of these two concepts in this research field.

In terms of the content composition of the thematic clusters, the six clusters each present distinct research focuses. The first cluster (blue) takes "ESG", "green bond", "governance", "financing constrain", and "investor" as core nodes, focusing on sustainable finance instruments and corporate governance mechanisms, revealing the micro-level transmission logic among green bonds, ESG ratings, and corporate financing constraints. The second cluster (red) takes "panel data", "environmental regulation", "green development", "heterogeneity analysis", and "natural experiment" as main nodes, representing an institution- and policy-oriented empirical research path, with a particular focus on how environmental regulation affects regional ecological resilience through green development mechanisms, relying heavily on panel data and quasi-natural experimental designs. The third cluster (green) takes "country", "energy", "renewable energy", "CO2 emission", "sustainable development",

Literature search query in WoS: 8043 Articles

• **Document type:**Articles

• **Language:**English

• **WoS category:**Environmental Sciences, Green & Sustainable Science & Technology, Economics, Environmental Studies, Management

• **Search query:** ((TS=("Sustainable Finance*" OR TS=("Green Finance*")) AND TS=("Ecological Resilience*" OR "Regional Ecological Resilience*")) OR ((TS=("Climate Action*" OR "Affordable and Clean Energy*" OR "Responsible Consumption and Production*" OR "Decent Work and Economic Growth*" OR "Life on Land*" OR "Life Below Water*" OR "Clean Water and Sanitation*") AND TS=("Ecological Resilience*"))))

Relevance assessment

- 1st Process: Remove duplicates.
- 2nd Process: Remove articles lacking data.
- 3rd Process: Read the title and abstract and scrutinise the body of the article.
 - Exclude non-empirical articles.
 - Exclude articles reviewing the existing literature (literature reviews, meta-analysis and/or bibliometrics).
 - Exclude articles focusing only on a single dimension (either sustainable finance or ecological resilience without coupling analysis).

Categorisation of relevant articles: 217

Articles

- Empirical methodology
- Type of sustainable finance
- Ecological resilience dimension
- Country/region
- Sustainable Development Goals (SDGs) dimension
- Mechanism of action

Excluded articles:

- D: Duplicates
- R: Reviews of previous articles (bibliometric analysis, meta-analysis, or narrative reviews)
- TMB: Theoretical and/or model-based articles
- OT: Articles focusing only on a single dimension (sustainable finance or ecological resilience without coupling analysis), or other articles outside the topic

FIGURE 1 | Overall screening process of the bibliometric analysis.

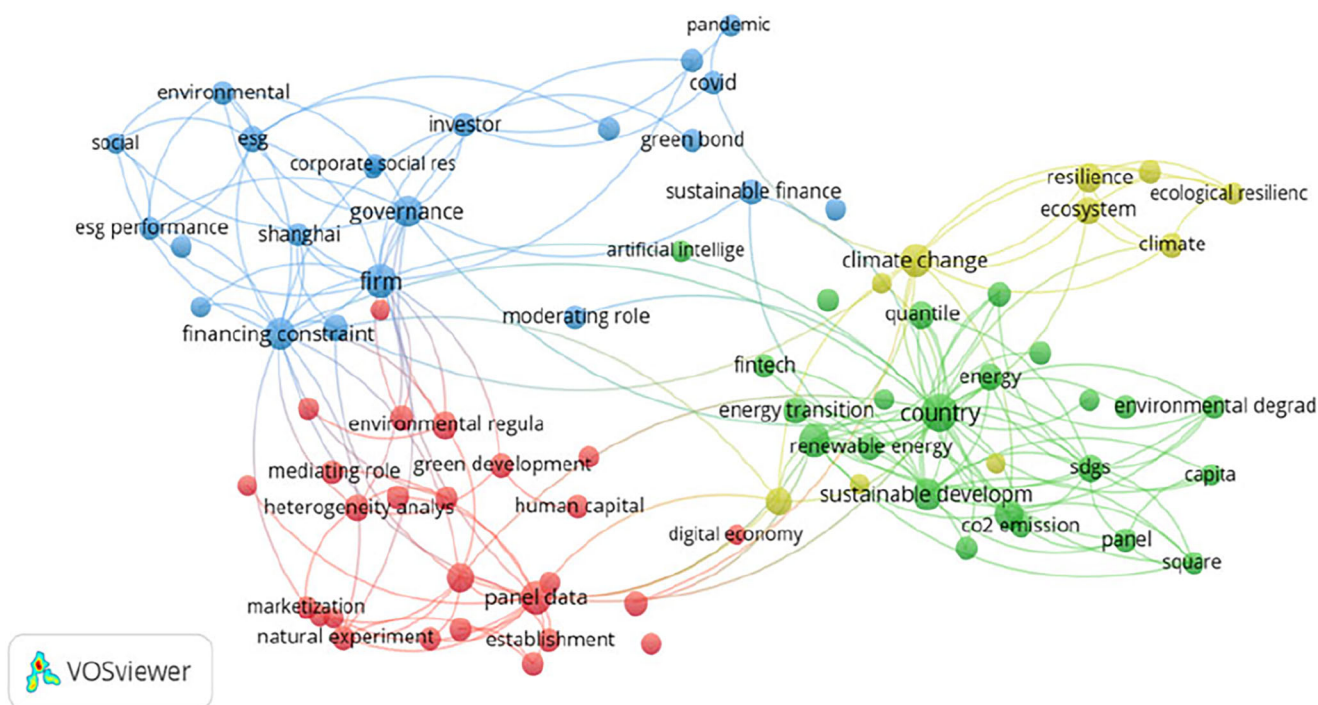


FIGURE 2 | Six thematic clusters. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

and “SDGs” as core nodes, forming an ecology-energy transition research group, emphasizing the synergistic pathways for carbon emission control, renewable energy investment, and the achievement of the Sustainable Development Goals (SDGs). The fourth cluster (yellow) takes “resilience”, “ecological resilience”, “ecosystem”, “climate”, and “environmental degradation” as core nodes, directly corresponding to the core analytical units of this paper, revealing the multidimensional connotations of the ecological resilience concept and its intrinsic relationship with the climate system. An intriguing observation is that “panel data” and “natural experiment” form an independent cluster (the red group), suggesting that empirical methodology itself has become a defining research theme in this field. Although this reflects growing attention to causal identification, it also raises the question of whether less quantifiable but equally important institutional and cultural factors—such as informal governance or local ecological knowledge—risk being underrepresented in the literature.

Notably, the node size of the fourth cluster is somewhat smaller compared to others, suggesting that “ecological resilience”—despite being a core concept of this review—remains a relatively peripheral theme in the existing empirical literature on sustainable finance. This implies that much of the research still uses ecological resilience as a conceptual backdrop rather than a directly measured or modelled outcome variable.

4.2 | Classification by Temporal Evolution Stage and Literature Characteristics

We designed the following combination chart (bar and line) to reflect the annual publication volume and average citation counts (Figure 3). Based on the trend of the bar chart, it is not difficult

to see that from 2016 to 2026, the number of publications related to sustainable finance and ecological resilience shows a clear increasing trend. According to the temporal evolution stages, we divide all the screened literature into three phases: the emergence phase, the growth phase, and the deepening phase. As shown in Figure 3, the emergence phase (2016–2018) represents the initial stage of cross-disciplinary research on sustainable finance and regional ecological resilience, with annual publication volumes remaining at a low cumulative level. During this phase, some pioneering policy attempts were made, but academic impact exhibited a certain lag, and no systematic theoretical framework or empirical paradigm had yet been formed; research focused primarily on concept introduction and theoretical exploration. The second phase is the growth phase (2019–2022), during which publication volume showed a significant upward trend, with an average of approximately 15 papers per year. This is closely related to the intensive implementation of green finance policies globally, the rapid spread of ESG investment concepts, and the increasing maturity of ecological resilience assessment methods. The third phase is the deepening phase (2023–2026), during which the number of publications accounts for more than 60% of the total sample. Empirical research gradually becomes mainstream, research topics expand in multiple directions, and research methods extend from traditional econometric analysis to spatial econometrics, dynamic panel GMM, nonlinear regression, and incorporate cutting-edge tools such as system modeling and simulation analysis. Beyond the increase in publication volume, the label “deepening phase” is supported by qualitative improvements: theoretical frameworks have become more sophisticated (e.g., incorporating non-linear and threshold effects), research methods have extended from traditional panel regression to spatial econometrics, dynamic GMM, and machine learning, and empirical settings now cover a wider range of countries and institutional contexts. This represents a maturation of the

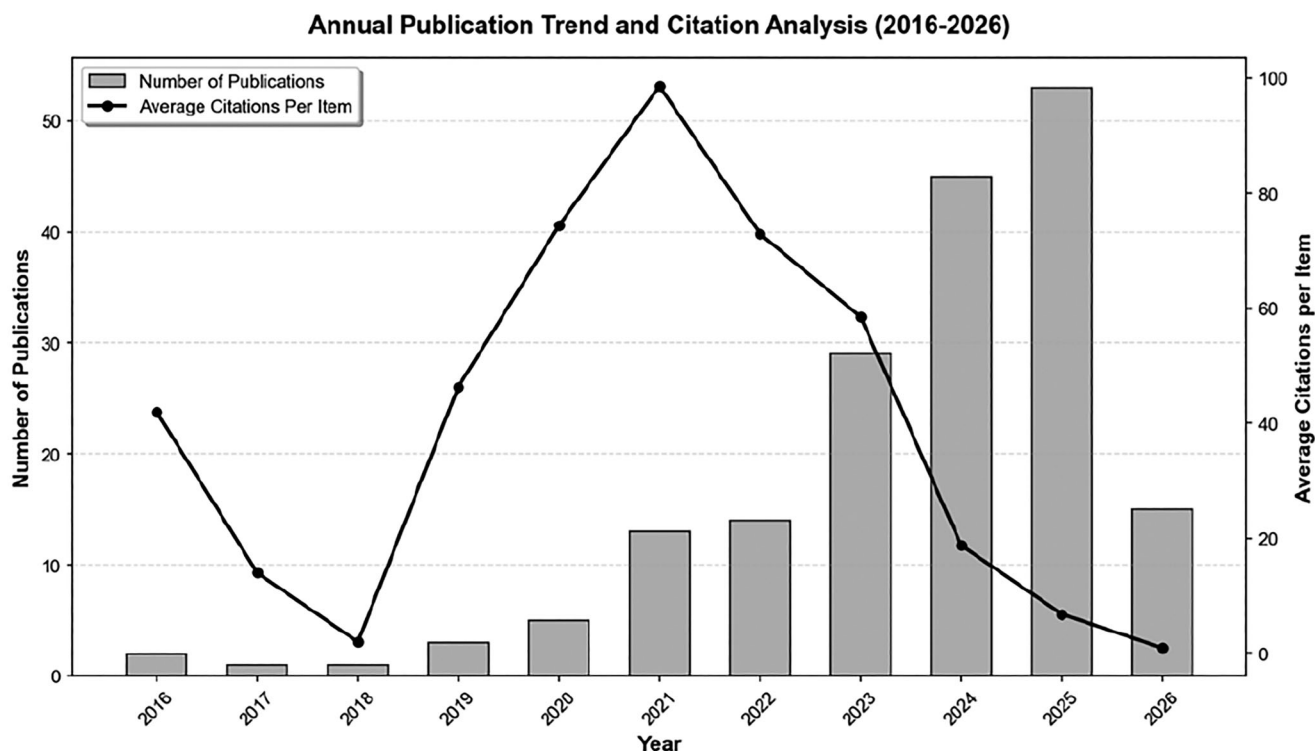


FIGURE 3 | Annual publication volume and cumulative average citations.

field rather than merely quantitative expansion. Figure 3 also presents the overall citation situation of the literature. The black line graph reflects the average number of citations received by papers published in each year, calculated from their publication date up to March 2026. In terms of trends, the average annual citations from 2016 to 2018 show a slight decline, indicating that early research in this field received limited attention, the impact of the findings was relatively weak, and high-value research outputs were scarce. From 2018 to 2021, there is a sharp increase, signaling that research in this area entered an explosive phase. This suggests that the frequent occurrence of global pollution issues and extreme climate events, along with the promotion of sustainable finance policies and ecological environment protection policies, triggered active academic attention and response. High-quality review or empirical studies emerged intensively, rapidly accumulating citations. After that, from 2022 to 2026, there is a slow downward trend. This does not imply a decline in the academic value of such research; rather, it indicates that as the research field of sustainable finance and ecological resilience gradually matures, some scholars no longer chase hot topics but instead focus on deepening and subdividing specific issues. Examples include financial valuation models for specific ecosystem services, default risk measurement of resilience bonds, and infrastructure investment thresholds under different climate scenarios. As a result, although the citation range of individual papers narrows relatively, the practical application value of each paper becomes higher. The average annual citations per paper by publication year are displayed in Figure 4. A concise narrative around citation peaks and troughs further enriches this temporal picture. For instance, the 2023 paper by Chen et al. on “Environmental, social, and governance (ESG) performance and financial outcomes” garnered 463 citations in its publication

year, signaling a pronounced shift in research focus from macro-level policy effects (e.g., Sinha et al. 2021 on green financing and SDGs) toward micro-level financial performance and ESG integration. Similarly, the surge in citations during 2020–2022 coincides with a cluster of highly cited works on digital finance and carbon emissions (e.g., Zhang and Liu 2022), reflecting the rapid digitalization of financial systems amid the COVID-19 pandemic.

Next, we compiled and organized a table of the most highly cited papers in different years, including the article title, author(s), number of citations, journal name, and the journal’s current impact factor. It is not difficult to see that the citation counts of the most highly cited papers vary considerably across years. For example, a 2018 study titled “how involved are banks in environmental protection and promoting sustainability? Comparative view: romania and iceland” was cited only twice in that year, while a 2023 study titled “Environmental, social, and governance (ESG) performance and financial outcomes: Analyzing the impact of ESG on financial performance” received 463 citations in the year of publication. The annual trend of the most highly cited papers is also quite consistent with the “average number of citations per paper in the year of publication.” Information on the most highly cited papers each year from 2016 to 2026 is summarized in Table 1.

Tracing the thematic evolution of these most-highly-cited papers reveals a clear trajectory: early research (2016–2018) focused on specific ecosystem services (e.g., water harvesting, mangrove forests) and international climate policy regimes. From 2019 to 2022, the emphasis shifted to green finance instruments and their role in achieving the Sustainable Development Goals (SDGs),

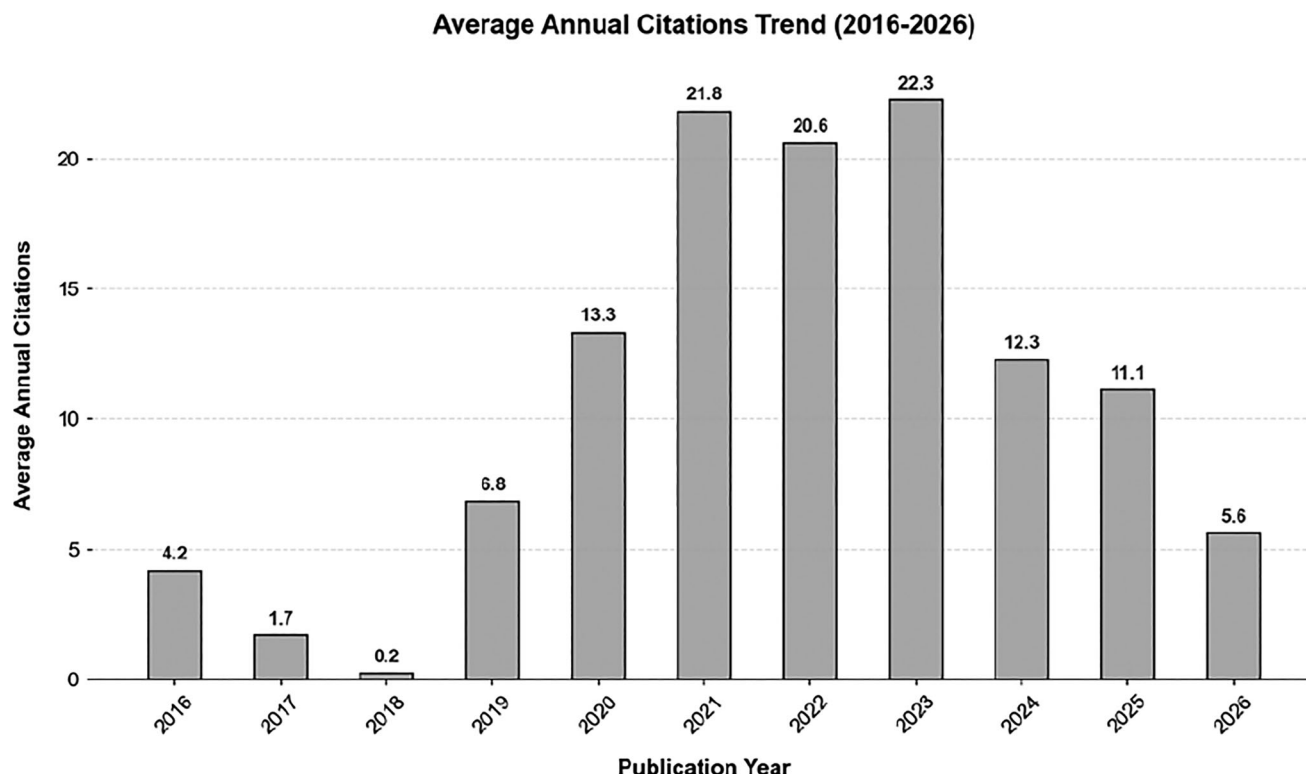


FIGURE 4 | Average number of citations per paper in the year of publication.

often using quantile or spatial econometric methods. Since 2023, ESG performance, digital finance, and geopolitical risk have emerged as dominant themes, indicating that the field has matured from sectoral environmental applications to systemic financial and governance architectures.

4.3 | Distribution of Literature by Level of Research Object

Given that most of the journal papers we selected conduct empirical research based on sample data, this paper classifies the screened literature into three types according to the level of research object: macro, meso, and micro. Macro-level samples include countries, major urban agglomerations, and major river basins; a total of 71 papers in the sample literature take macro-level research objects. Meso-level samples cover provincial-level administrative regions, prefecture-level or county-level cities, and industries; there are 58 such papers. Micro-level samples are represented by listed companies, a specific type of enterprise, or farm households. The slightly lower number of micro-level studies (52 papers) compared to macro (71) and meso (58) studies may be attributable to the limited availability of firm-level green finance data, especially in earlier years. Many green credit or green bond datasets at the enterprise level only became publicly accessible after 2018, constraining earlier micro-empirical research. Starting from the behavioral responses of micro-level agents, the main issues analyzed include how elements such as financing constraint alleviation, green technology innovation, and livelihood diversification constitute the micro-foundations of regional ecological resilience; there are 52 papers in this category.

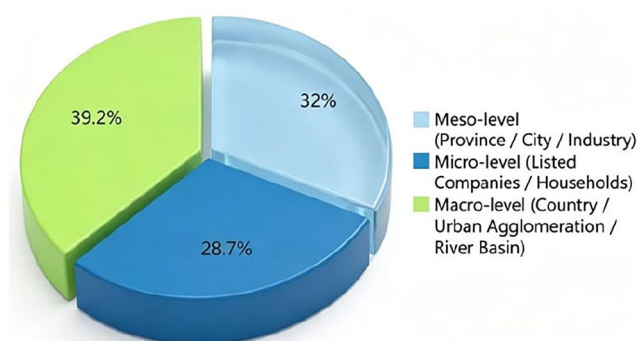


FIGURE 5 | Statistical distribution of literature by three types of research objects. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/terms-and-conditions)]

The statistical distribution of literature by the three types of research objects is presented in Figure 5.

4.4 | Description of Research Methods in the Literature

In the empirical research literature on sustainable finance and regional ecological resilience, the research methods employed exhibit a distinctly diversified landscape. There are quantitative empirical approaches represented by panel data linear regression and instrumental variable tests, as well as qualitative case analysis approaches represented by single-case thick description and multi-case comparison. Moreover, these two approaches are gradually moving toward integration, jointly constituting the methodological foundation for knowledge production in this field.

TABLE 1 | Information on the most highly cited papers each year from 2016 to 2026.

Year	Number of citations	Document title	Paper author(s)	DOI	Journal	Impact factor
2016	71	Assessing the implications of water harvesting intensification on upstream-downstream ecosystem services: A case study in the Lake Tana basin	Dile, YT, Karlberg, L, Daggupati, P, Srinivasan, R, Wiberg, D, Rockström, J	10.1016/j.scitotenv.2015.10.065	Science of The Total Environment	8 (2024)
2017	14	Correlating negotiation hotspot issues, Paris climate agreement and the international climate policy regime	Dovie, DBK, Lwasa, S	10.1016/j.envsci.2017.07.010	Environmental Science & Policy	5.2 (2024)
2018	2	HOW INVOLVED ARE BANKS IN ENVIRONMENTAL PROTECTION AND PROMOTING SUSTAINABILITY? COMPARATIVE VIEW: ROMANIA AND ICELAND	Badulescu, D, Gunnlaugsson, SB, Badulescu, A, Morutan, RA	N/A	JOURNAL OF ENVIRONMENTAL PROTECTION AND ECOLOGY	0.507 (2021)
2019	62	Stakeholder preferences for payments for ecosystem services (PES) versus other environmental management approaches for mangrove forests	Thompson, BS, Friess, DA	10.1016/j.jenvman.2018.12.032	Journal of Environmental Management	8.4 (2024)
2020	204	The role of environmental entrepreneurship for sustainable development: Evidence from 35 countries in Sub-Saharan Africa	Sun, HP, Pofoura, AK, Mensah, IA, Li, L, Mohsin, M	10.1016/j.scitotenv.2020.140132	Science of the Total Environment	8 (2024)
2021	254	Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling	Sinha, A, Mishra, S, Sharif, A, Yarovaya, L	10.1016/j.jenvman.2021.112751	Journal of Environmental Management	8.4 (2024)
2022	357	Influence of digital finance and green technology innovation on China's carbon emission efficiency: Empirical analysis based on spatial metrology	Zhang, ML, Liu, Y	10.1016/j.scitotenv.2022.156463	Science of the Total Environment	8 (2024)

(Continues)

TABLE 1 | (Continued)

Year	Number of citations	Document title	Paper author(s)	DOI	Journal	Impact factor
2023	463	Environmental, social, and governance (ESG) performance and financial outcomes: Analyzing the impact of ESG on financial performance	Chen, SM, Song, Y, Gao, P	10.1016/j.jenvman.2023.118829	Journal of Environmental Management	8.4 (2024)
2024	72	The impact of geopolitical risk, institutional governance and green finance on attaining net-zero carbon emission	Hunjra, AI, Azam, M, Verhoeven, P, Taskin, D, Dai, JP	10.1016/j.jenvman.2024.120927	Journal of Environmental Management	8.4 (2024)
2025	35	The impact of digitization on environmental sustainability: New insights from G20 nations	Dai, JP, Zhou, BJ, Meng, WM	10.1016/j.jenvman.2025.127225	Journal of Environmental Management	8.4 (2024)
2026	14	Achieving carbon neutrality goal in European countries: the role of green technology innovation, renewable energy, and financial development	Zhou, DJ, Obobisa, ES, Ayamba, EC	10.1007/s10668-024-04989-5	Environment, Development and Sustainability	4.2 (2024)

4.4.1 | Linear Regression Analysis of Panel Data

Panel data linear regression is currently the most widely used quantitative method in this field. It simultaneously accounts for cross-sectional differences and time-series variations. The method effectively controls for unobservable individual fixed effects and time effects. As a result, it identifies the net effect of sustainable finance inputs on ecological resilience outcome variables in cross-period comparisons across multiple countries, provinces, or cities. Existing studies mainly employ fixed effects (FE) models and random effects (RE) models, and use the Hausman test to determine the appropriateness of model selection. Some studies further introduce two-way fixed effects (Two-way FE) models to simultaneously control for time trends and regional individual heterogeneity, thereby improving the internal validity of the estimation results.

Regarding the basic findings of existing studies, most regression results support that sustainable finance has a significant positive promoting effect on regional ecological resilience. However, a minority of studies report negative or insignificant effects. For instance, some cross-country analyses find that in high-income countries with already stringent environmental regulations, additional green credit may have no marginal effect on ecological resilience, or may even crowd out other forms of environmental investment. These counterexamples typically occur under conditions of institutional saturation or poor policy design, highlighting the importance of context dependence. However, the effect size exhibits substantial differences across countries with different income levels, different policy and institutional backgrounds, and regions with different degrees of fiscal dependence, indicating that the impact of sustainable finance on ecological resilience is significantly context-dependent. In addition, some studies conduct subgroup regressions based on geographical region, stage of economic development, or financial market maturity, revealing significant heterogeneity between developing and developed countries—the positive relationship between green credit and ecological resilience is more pronounced in less developed regions, which is highly consistent with the theoretical prediction of the capital scarcity hypothesis.

4.4.2 | Application of Instrumental Variable Methods

Although panel regression can effectively control for the interference of observable variables, the endogeneity of sustainable finance remains a major challenge in identifying its causal effects. Regions with higher levels of ecological resilience themselves tend to attract more green capital, leading to estimation bias due to reverse causality between sustainable finance and ecological resilience. To address this issue, the instrumental variable (IV) method has been increasingly widely used in recent literature.

The instrumental variables adopted in existing studies mainly fall into three categories. The first is the historical level of financial development or the density of banking institutions at the regional level. Such indicators are highly correlated with the current scale of green credit but have no direct effect on current ecological outcomes. The second category consists of policy-shock instrumental variables, such as the timing of the

establishment of regional green finance reform and innovation pilot zones, using the exogenous policy implementation timing as a source of identification. The third category includes natural geography-based instrumental variables, such as a region's initial resource endowment or climate vulnerability index. The validity of instrumental variables is typically tested through weak instrument tests (F-statistic), over-identification tests (Sargan/Hansen test), and local average treatment effect (LATE) estimation. Overall, studies employing instrumental variable methods provide relatively robust support for the benchmark conclusions of panel regression and further confirm the positive causal effect of sustainable finance inputs on regional ecological resilience. However, the absolute magnitude of the effect is usually smaller than that from OLS estimates, suggesting that simple regression tends to overestimate the causal effect to some extent. From an econometric perspective, this discrepancy may reflect two non-mutually-exclusive phenomena: upward bias in OLS estimates due to omitted variables or reverse causality, and the fact that IV methods typically recover a Local Average Treatment Effect (LATE) for “complier” regions, which can be smaller in magnitude than the Average Treatment Effect (ATE) that OLS implicitly targets.

4.4.3 | Application of Case Study Methods

Although quantitative empirical approaches can provide evidence on overall trends and average causal effects, they struggle to deeply reveal the internal mechanisms and institutional conditions through which sustainable finance promotes regional ecological resilience. For this reason, the case study method, with its capacity for detailed portrayal of complex processes and high sensitivity to institutional contexts, plays an irreplaceable complementary role in this field. Among the studies that adopt case study methods, there are two forms: single-case study and multi-case comparative analysis.

The single-case study method is primarily suitable for in-depth mechanism analysis of specific regions or typical policy practices. Its theoretical contribution lies in revealing the internal logic of causal chains through detailed process tracing, rather than pursuing statistical generalizability. In the existing literature, single-case studies focusing on China's green finance reform and innovation pilot zones (e.g., Zhejiang Province, Guizhou Province), the development of the European green bond market, and the issuance of sovereign green bonds by typical countries around the world have systematically demonstrated how sustainable finance can form an internal pathway for enhancing regional ecological resilience through capital allocation mechanisms, incentive-compatible policy designs, and the co-evolution of financial and ecological governance institutions.

Multi-case comparative research conducts systematic cross-case analysis of multiple cases selected for theoretical sampling to identify common logics and sources of variation in how sustainable finance affects regional ecological resilience across different institutional environments, development stages, and policy contexts. Compared with single-case studies, the multi-case approach has higher external validity and can test the applicability boundaries of theoretical propositions in different settings while retaining mechanistic insights. By comparing

groups of countries or regions with highly developed versus relatively lagging green finance policies, such studies systematically present how institutional factors moderate the pathways through which sustainable finance influences ecological resilience.

4.4.4 | Integrated Application of Empirical and Case Study Methods

Some studies combine empirical analysis with case study methods, thereby addressing the issue of conditional complexity that cannot be handled by relying solely on statistical regression. In this combined approach, empirical analysis is responsible for testing general trends and net effects between variables, providing external validity for the research. Case study methods, in turn, delve into specific contexts to uncover dependency, mutual exclusivity, substitution, and triggering relationships among conditions, thus revealing “which combinations of conditions, under which circumstances, can lead to high ecological resilience.” The integration of the two is particularly suitable for a “nested” or “triangulation” logic within mixed methods. For example, researchers may first use regression to identify key conditions and then identify multiple conditional pathways that promote resilience enhancement. In addition to nesting and triangulation logics, a few reviewed studies employed a sequential design, where qualitative exploration (e.g., semi-structured interviews or pilot case studies) precedes large-sample quantitative testing. This mode helps generate contextualized hypotheses and identify relevant variables that might otherwise be omitted in purely regression-based approaches.

In terms of the methods used in existing research, empirical literature occupies an absolutely dominant position in quantity, while pure case studies amount to only seven papers, though they possess unique advantages in in-depth mechanistic explanation. It is worth noting that a recent wave of mixed-method studies employing an “empirical + case” design has emerged. These studies use quantitative empirical analysis to establish overall effects and case process tracing to reveal underlying mechanisms, forming an effective methodological complementarity between the two approaches. This trend toward methodological integration not only responds to the mechanistic puzzles in research on sustainable finance and ecological resilience but also points to an important direction for future methodological development in this field.

4.5 | Distribution of Literature by Geographical Region

4.5.1 | Based on the Overall Geographical Distribution

In the empirical research literature on sustainable finance and regional ecological resilience, the geographical distribution presents a markedly uneven pattern. Overall, research is highly concentrated in China and developed countries in Europe and North America, while emerging market countries such as India, Brazil, and those in Southeast Asia have produced relatively few studies on related topics. In addition, cross-national comparative

studies on sustainable finance have shown a growing trend in terms of quantity.

China has become a core force in research in this field, accounting for 41.1% of the total selected literature. This high concentration originates from China’s systematic promotion of policy practices since 2016, including the construction of green finance reform and innovation pilot zones (hereinafter “green finance pilot zones”), carbon market pilots (i.e., regional Emission Trading Schemes, ETS), and ESG information disclosure systems. The research focuses on regions such as the Yangtze River Delta, the Pearl River Delta, the Yellow River Basin, and the Yangtze River Economic Belt, primarily using multi-scale comparisons to reveal the differentiated effects of sustainable finance policies under varying regional development stages, resource endowments, and governance structures.

Research by European and American scholars constitutes the second largest cluster, accounting for 32.6% of the total literature. It focuses primarily on policy evaluation under the EU Green Deal framework and institutional analysis of the U.S. climate finance system. In contrast to China’s policy-driven research, European and American literature places greater emphasis on market mechanisms and long-term institutional evolution, such as the impact of regulatory frameworks like the EU Sustainable Finance Disclosure Regulation (SFDR) and the Task Force on Climate-related Financial Disclosures (TCFD) on capital market behavior. Beyond these substantive drivers, the observed differences may also partially reflect divergent “research habit” or “path dependencies” across academic communities. Chinese scholars, often working within policy-evaluation frameworks funded by government agencies, tend to focus on regionally differentiated policy effects; their European and North American counterparts, embedded in longer traditions of financial economics, are more inclined to study market mechanisms and institutional design, even when examining similar environmental outcomes. Geographically, the research covers the 27 EU member states and U.S. states, with particular attention to green finance pioneer countries such as Germany, France, and the Netherlands, as well as policy-innovative regions like California and New York.

Research from India, Brazil, and Southeast Asian countries (such as Malaysia, Thailand, and Indonesia) accounts for 18.2% of the total (33 out of 181 papers). Although the proportion of research by scholars from these countries is relatively low, it has the fastest growth rate (averaging 27.6% annually from 2020 to 2023). This body of research highlights the coordination of the dual “development-environment” goals, focusing more on how to enhance ecological resilience under capital constraints. For example, Indian scholars have explored the effects of green bonds on adaptive investment in agricultural ecosystems; Brazilian research focuses on innovation in sustainable finance instruments for the protection of the Amazon rainforest. The Southeast Asian literature largely revolves around transboundary river basin governance and blue finance. These studies provide important supplements for understanding the effectiveness of sustainable finance under conditions of institutional incompleteness.

Global or cross-country comparative studies account for only 8.3% of the total (15 out of 181 papers). Such studies construct cross-country panel datasets to systematically examine the heteroge-

neous effects of sustainable finance on ecological resilience. Some studies find that the marginal effect of sustainable finance on ecological resilience is not significant in high-income countries, increases in middle-income countries, and reaches its highest level in low-income countries. The level of financial development and institutional quality constitute key moderating variables. When a country's banking sector depth (M2/GDP) exceeds 80% and its Worldwide Governance Indicators (WGI) score is above 0.5, the positive effect of sustainable finance on ecological resilience is significantly enhanced. The degree of globalization strengthens the spillover effects of sustainable finance: for every 1% increase in cross-border capital flows, the regional ecological resilience index increases by an average of 0.08 units.

4.5.2 | Evolutionary Trend of Geographical Distribution

As shown in Figure 6, from a temporal perspective, research during 2016–2019 was highly concentrated in China and European/North American countries, accounting for 58.3% and 31.2% of the total, respectively. During 2020–2023, the share of research from emerging market countries increased from 12.4% to 22.7%, while cross-country comparative studies grew from 5.1% to 11.8%. This evolution reflects that these emerging market countries are no longer limited to the experiences of developed countries; green finance policies and ecological governance practices suitable for their own regional contexts are advancing rapidly. The doubling of the share of cross-country comparative studies indicates that researchers are increasingly aware that the issues of sustainable finance and regional ecological resilience are, in essence, complex system problems embedded in multi-country institutional, cultural, and ecological differences. Alongside geographical diffusion, there is evidence of cross-country diffusion of research methods. For example, the instrumental variable approach using policy pilots as natural experiments was first extensively applied in studies on China's green finance reform zones; this design has subsequently been adopted by scholars in India and Brazil to evaluate their own national green finance initiatives, indicating a methodological spillover from early-adopting to later-adopting research communities. Single-country case studies struggle to extract universal mechanisms, whereas cross-country comparisons help identify contextual conditions under different political systems, economic structures, and financial regulatory models. This also suggests that future research will pay greater attention to global governance issues of sustainable finance within the frameworks of North-South cooperation and South-South cooperation.

4.6 | Analysis of Inter-Institutional Associations

The layout and association characteristics of the co-authorship network at the country level further reveal the circle structure, linkage patterns, and evolutionary trends of international academic collaboration in the field of sustainable finance and ecological resilience. As shown in Figure 7, we analyze the inter-institutional associations through a visualization map. Each node represents a country, and the node size is positively correlated with the total link strength. From 52 countries, 15 core economies that meet the criteria are selected, forming a complete cross-country co-authorship network. As shown in Figure 7,

each node in the map is labeled with the corresponding country name. The thickness of the connecting lines between nodes represents the intensity of collaboration between countries; a thicker line indicates a higher frequency of co-authorship and closer collaborative ties in the field of sustainable finance and ecological resilience. Node clusters of different colors distinguish relatively independent transnational research collaboration groups, visually presenting the global international collaboration network layout and the spatial distribution characteristics of core research forces in this field.

In terms of publishing institutions, China, as the core contributing entity, forms a dominant cluster, occupying a central position in research on the implementation effects of sustainable finance and ecological resilience. Chinese institutions have published 138 papers, with a total link strength of 52. Most institutions focus on key issues such as sustainable finance, the identification of key factors influencing ecological resilience, and the synergistic relationship between the two, forming highly targeted research directions and a cross-country collaboration system. The core institutional research teams in this field have further promoted theoretical innovation and empirical research progress at the intersection of sustainable finance and ecological resilience, built cross-regional and cross-economy academic collaboration bridges, and expanded the international reach and practical guidance value of research in this field. Other academic institutions are concentrated in economies such as Pakistan, Malaysia, and Turkey, forming secondary core collaboration groups. This distribution pattern reveals a clear characteristic of core country concentration and cross-regional collaboration in the research field of sustainable finance and ecological resilience. Countries such as India, South Korea, France, the United Kingdom, Ghana, and Romania form smaller collaboration branches around the core clusters, with only a few countries forming independent regional linkages.

Each node represents an organization, and the node size is proportional to the total link strength based on citation-weighted co-authorship relationships. Figure 8 reveals a highly concentrated network structure. Chinese institutions—led by the Chinese Academy of Sciences, Tsinghua University, and Renmin University—form a dense domestic collaboration cluster (red group) with strong internal linkage strength. This core Chinese cluster occupies a central position in the network, suggesting its dominance in shaping the research agenda on sustainable finance and ecological resilience. European institutions constitute the second largest cluster, exhibiting numerous cross-continental collaborations with Africa and South Asia; North American institutions, in contrast, are relatively dispersed. A secondary cluster (blue group) comprises institutions from Pakistan, Malaysia, and Turkey, indicating emerging research capacities in South and Southeast Asia. Notably, direct collaboration links between the Chinese core and European or North American institutions (e.g., University of Cambridge, University of California system) appear relatively sparse, with only a few institutions serving as bridging nodes. This pattern hints at the existence of relatively insular “academic schools” or differences in research priorities, even while European institutions maintain strong ties with other regions. In comparison with Figure 7, it is evident that country-level collaboration demonstrates stronger cross-continental linkages, whereas institution-level collaboration is more prominently characterized by regional concentration.

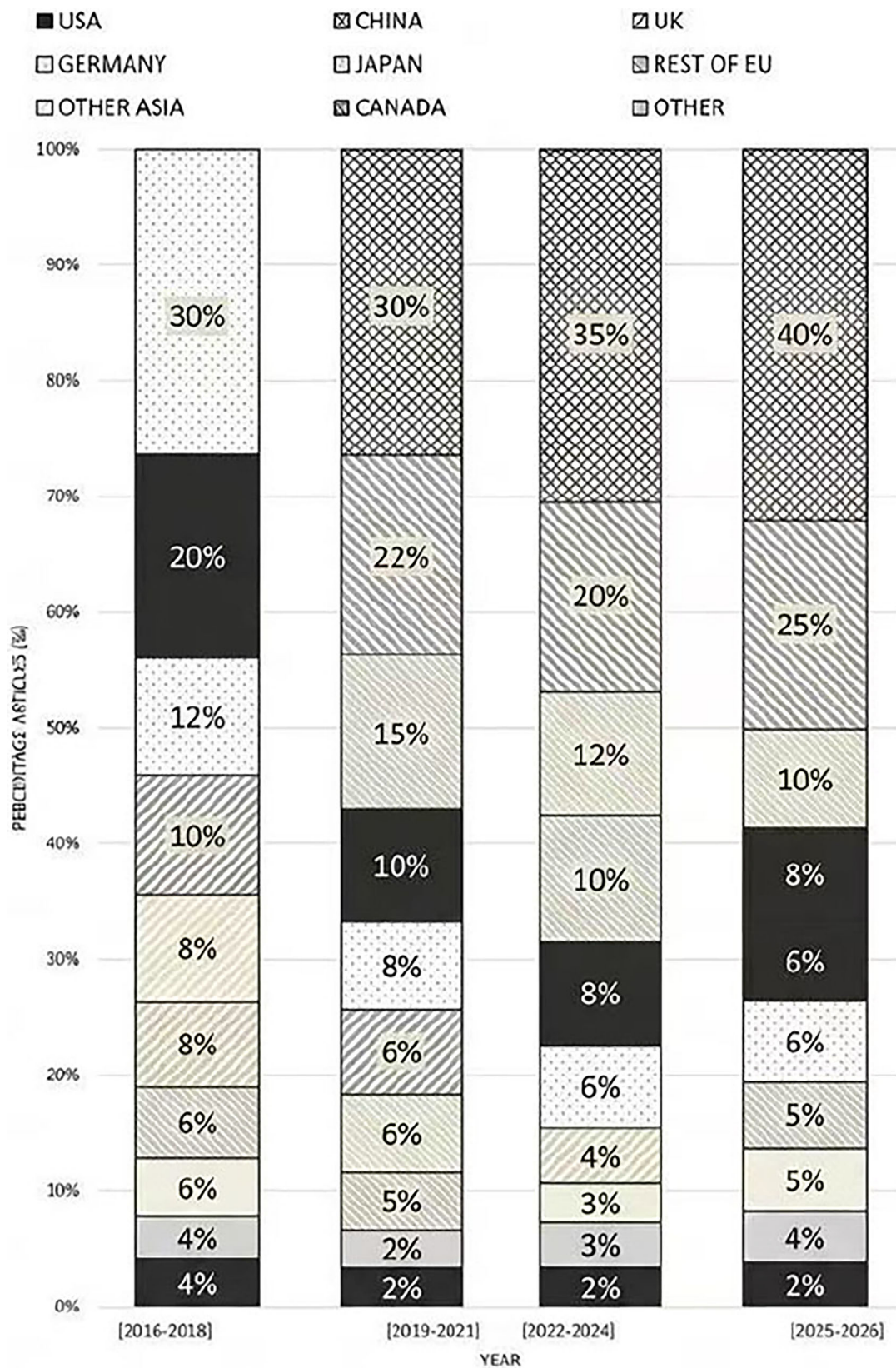


FIGURE 6 | Distribution of relevant papers by country (%). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/joes.70145)]

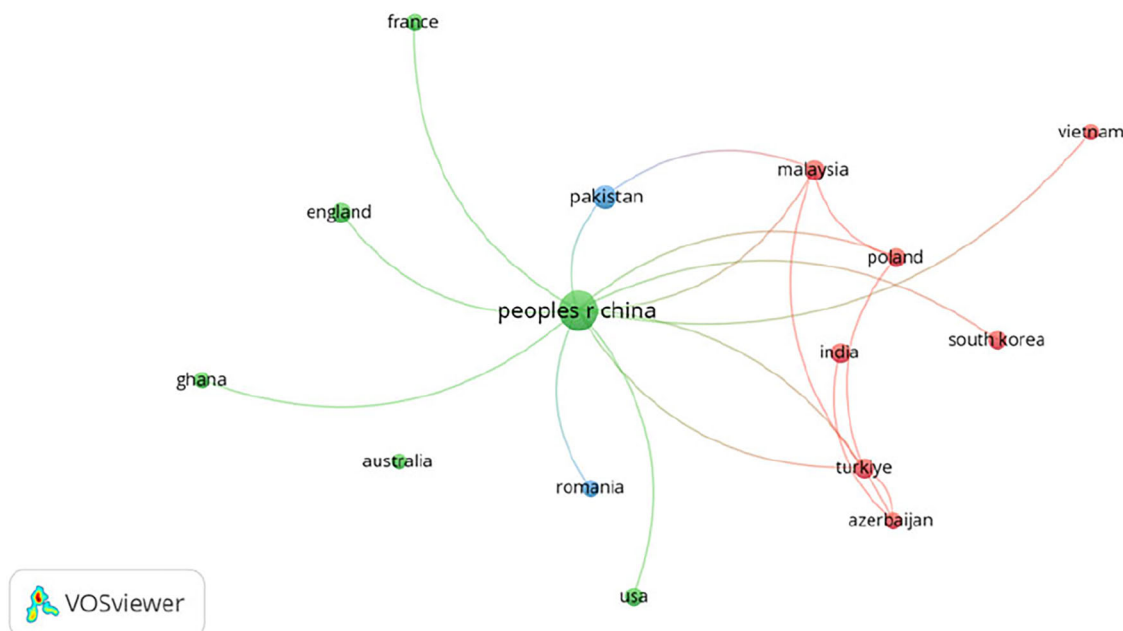


FIGURE 7 | Network diagram of institutional associations across countries. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/joes.20145)]

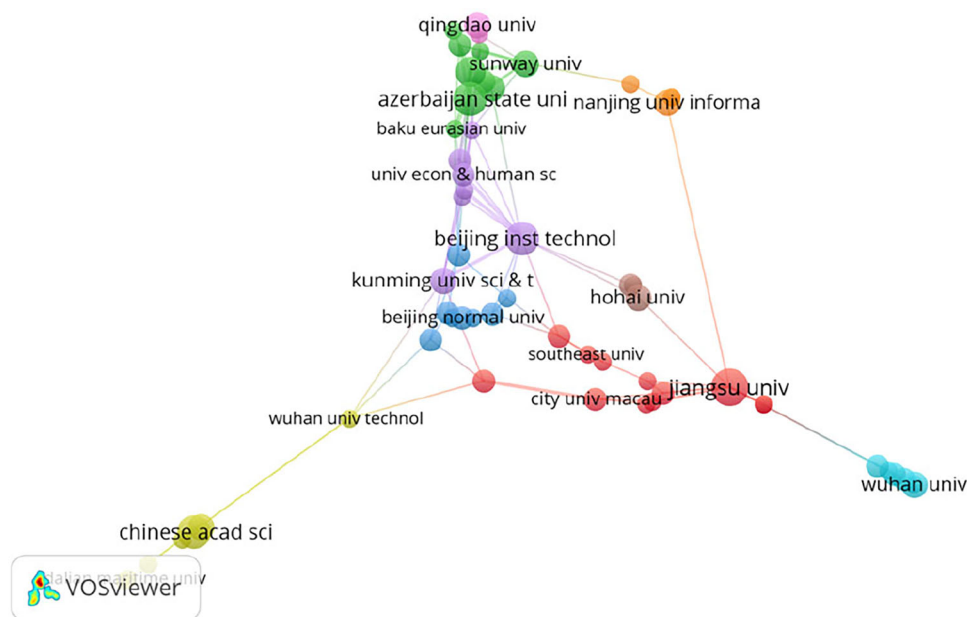


FIGURE 8 | Co-authorship network diagram with organizations as the unit of analysis. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/joes.20145)]

5 | Conclusion

Through a systematic review and bibliometric analysis of nearly ten years of empirical and case literature on sustainable finance and ecological resilience in the Web of Science database, we first cleaned the original dataset, removed duplicate entries and documents not significantly related to the research topic, merged multiple retrieval results, and manually checked and screened each entry one by one. Subsequently, based on six different literature classification methods, we obtained bibliometric results

and drew the following conclusions. From the perspective of publication trends, the annual number of publications on sustainable finance and regional ecological resilience over the past decade first showed a slow decline, then a rapid increase, and has declined again since 2025. The research is mainly concentrated on five major themes: green bonds, ecological compensation, climate adaptation investment, ESG evaluation, and ecological risk governance. Among these, the “coupling mechanism between green credit and ecological restoration” and the “nonlinear impact of financial instruments on regional resilience” are high-frequency co-occurring keywords.

Through the geographical classification of the selected literature, a markedly uneven distribution pattern is observed. China, accounting for 41.1% of the total publications, has become the core research force, focusing mainly on policy practices and multi-scale comparisons in regions such as the Yangtze River Delta and the Pearl River Delta. European and American scholars constitute the second largest cluster (32.6%), emphasizing institutional analysis of the EU Green Deal and U.S. climate finance as well as market mechanisms. Although India, Brazil, and Southeast Asian countries account for only 18.2% of the total, their research grew at an average annual rate of 27.6% between 2020 and 2023, highlighting the coordination of “development-environment” dual goals and the enhancement of ecological resilience under capital constraints. Global or cross-country comparative studies have the smallest share (8.3%), but they find that the marginal effect of sustainable finance on ecological resilience is highest in low-income countries, with financial depth and institutional quality serving as key moderating variables, and that the degree of globalization positively strengthens spillover effects.

In terms of research methods for sustainable finance and regional ecological resilience, from the perspective of methodological evolution, relatively early research was dominated by macro-level statistical regression and single-case description. Panel data linear regression is the most widely used method, identifying the net effect of sustainable finance on ecological resilience by controlling for individual and time effects. The results support a positive promoting effect and exhibit diversified empirical characteristics. Machine learning-assisted narrative identification also overcomes the structural dependence of traditional VAR models, providing a new path for the robustness of causal identification. The above conclusions point the way for the subsequent construction of an integrated analytical framework of “sustainable finance–ecological resilience” and for conducting differentiated regional policy simulations. Based on the command of the entire literature corpus, the most pressing theoretical puzzle that the field currently needs to resolve is how to integrate the context-dependent nature of ecological resilience—where thresholds and recovery capacities vary dramatically across ecosystems—with the standardized, portfolio-level logic of sustainable finance instruments. The most persistent methodological challenge remains the identification of credible exogenous variation: while instrumental variable and quasi-natural experimental designs have advanced, many studies still struggle to rule out unobserved confounding from simultaneous environmental and economic shocks. In addition, the case study method plays a complementary role in revealing internal mechanisms and institutional conditions. In recent years, some studies have further combined empirical analysis with case study methods, using quantitative approaches to establish overall effects and general trends, and qualitative approaches to uncover condition combinations and causal chains. This effectively compensates for the limitation of single regression methods in handling the complexity of condition combinations, and represents an important direction for future methodological development in this field. This indicates that many scholars are intentionally addressing the issues of condition combination complexity and multi-causal equivalent pathways.

Finally, several methodological limitations of this review should be acknowledged. First, the reliance solely on the Web of Sci-

ence Core Collection, while ensuring quality control, inevitably excludes relevant publications from regional journals, books, or grey literature. Second, the inclusion criteria were restricted to English-language publications, potentially omitting important non-English contributions, particularly from non-OECD countries. Third, the temporal window ends in March 2026, meaning that very recent publications (after this date) are not captured. These limitations imply that the findings are most representative of the internationally visible, English-language academic discourse up to early 2026.

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Author Contributions

Yuanhao Zhang: Conceptualization, Software, Writing – original draft; Chaoran Zhou: Methodology, Data curation; Xuanjun Wang: Conceptualization, Data curation; Huijuan Xie: Conceptualization, Supervision; Yanan Tang: Conceptualization, Supervision, Writing – review & editing.

Conflicts of Interest

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

Data Availability Statement

No additional data are available.

Endnotes

¹ It is worth noting that landmark policy documents such as the 2015 UN 2030 Agenda for Sustainable Development catalyzed some preliminary conceptual discussions on sustainable finance. However, these early contributions were predominantly theoretical and lacked the empirical or case-study focus required for this review, hence their exclusion from the final sample.

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APPENDIX

Appendix—Sample Literature for Bibliometric Analysis

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