Mapping the Research Landscape of Emission Trading System, Carbon Emission, and Economic Growth: A Bibliometric Analysis

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Abstract

The growing adoption of the Emission Trading System (ETS) as a market-oriented policy tool has garnered increasing interest due to its effectiveness in lowering carbon emissions while fostering sustainable economic development. Nevertheless, the swift rise in publications has not led to a thorough comprehension of the intellectual framework and research trends within this domain. Consequently, this study seeks to chart the progression of research concerning the Emission Trading System, carbon emissions, and economic growth through a bibliometric lens. The research utilized metadata sourced from the Crossref database via Publish or Perish, encompassing publications released between 2021 and 2026. A bibliometric analysis was performed using VOSviewer 1.6.20 and Biblioshiny to investigate publication trends, keyword co-occurrence, and thematic connections. The analysis revealed 334 keywords categorized into 11 clusters, suggesting that the literature has developed into multiple interrelated research themes. The primary themes concentrate on emission trading policies, economic growth alongside energy consumption, carbon emission reduction coupled with industrial decarbonization, and the governance of emission trading systems. Additionally, the findings indicate a transition in research focus from assessing carbon trading mechanisms to exploring technological innovation, carbon pricing, and the transformation of industries towards low-carbon practices. This study concludes that while research on ETS has significantly expanded, there is still a scarcity of studies that integrate emission trading systems with sustainability governance and policy implementation in developing nations. These insights are crucial for guiding future research and aiding the formulation of effective carbon market policies aimed at achieving a sustainable economic transition.

Keywords: Emission Trading System, Carbon Emission, Economic Growth, Bibliometric Analysis, VOSviewer.

INTRODUCTION

Climate change has emerged as one of the most significant challenges to global development, as the rise in greenhouse gas (GHG) emissions continues to accelerate global warming and threatens environmental sustainability as well as economic activities. This situation undrscores the urgent need for a transformation in development system towards a low-carbon economy that can balance economic growth with environmental protection (Fu et al., 2023). In line with international commitments through the Paris Agreement, various countries are beginning to formulate policies focused on decarbonization, energy efficiency, and increased green investments to achieve carbon neutrality and net-zero emissions. In this process, market-based economic mechanisms are gaining attention as they are considered more efficient in reducing carbon emissions compared to conventional regulatory approaches (Mashari et al., 2023).

Green finance has emerged as a key instrument in supporting sustainable development by mobilizing investments in renewable energy, green infrastructure, energy efficiency, and low-carbon technologies. It is also viewed as a mechanism capable of accelerating the achievement of carbon emission reduction targets by directing capital flows towards economic activities that have a positive environmental impact (Numan et al., 2023). Empirical evidence indicates that

an increase in green finance contributes to a reduction in carbon emissions and an improvement in environmental quality, particularly when supported by strong environmental regulations and the development of renewable energy. Furthermore, green finance, environmental regulations, and carbon finance have been shown to simultaneously enhance environmental sustainability across various groups of countries, making the integration of these three instruments increasingly regarded as a vital strategy for achieving sustainable development (Tariq & Hassan, 2023). Thus, the relationship between carbon trading, green finance, and environmental sustainability has evolved into a strategic issue in the literature on environmental economics and public policy, as all three complement each other in supporting the transition to a low-carbon economy.

The development of carbon trading has significantly grown alongside the implementation of carbon pricing policies as a climate change mitigation tool in various countries. The Emissions Trading System (ETS) is seen as capable of creating economic incentives for businesses to reduce greenhouse gas emissions through market mechanisms, making it one of the most widely adopted climate policy instruments in recent decades (Köppl & Schratzenstaller, 2023). Additionally, the voluntary carbon market has rapidly expanded as more companies incorporate carbon credit trading into their decarbonization strategies and net-zero emissions targets (Lou et al., 2023). Furthermore, advancements in digital technology, particularly blockchain, are enhancing the transparency, accountability, and traceability of carbon transactions, thereby strengthening the integrity of the global carbon market (Vilkov & Tian, 2023). The evolution of carbon trading is viewed as both an economic tool for reducing emissions and a crucial component of the transition towards a greener, more efficient, and sustainable development system.

The increased focus on the transition to a green economy has spurred research examining the relationships between carbon trading, green finance, and environmental sustainability. Studies have demonstrated that carbon trading policies can reduce the intensity of corporate carbon emissions through enhanced green innovation and strengthened Environmental, Social, and Governance (ESG) practices, thereby promoting improved environmental performance (Han et al., 2024). Green finance has proven effective in lowering carbon emission intensity and improving emission efficiency through mechanisms such as green innovation, increased productivity of green factors, and industrial structure transformation (Liu & Zhu, 2024).

The effectiveness of this role is enhanced when it is backed by strong environmental regulations, as the synergy between green financial policies and regulatory instruments can expedite the realization of decarbonization goals and the advancement of high-quality development (Guo et al., 2024). The progression of carbon finance is increasingly recognized as a strategic tool that merges carbon market mechanisms with sustainable financing, which not only aids in emission reduction but also boosts green economic efficiency through investments in low-carbon technologies and sustainable initiatives (Chen & Ma, 2024). The advancement of carbon finance and various climate financing frameworks has emerged as a vital element in reinforcing the execution of carbon pricing policies and broadening investments in solutions for climate change mitigation (Zhou et al., 2024). A significant portion of the research continues to concentrate on examining causal relationships among variables through panel data or case studies in specific nations, thereby not providing a holistic view of the evolution of research themes and the directions of research that are developing within the international literature. This situation highlights the necessity for

comprehensive literature mapping to identify research trends and potential future research agendas.

Despite the ongoing development of bibliometric studies on green finance, carbon finance, and sustainable development, research that integrates carbon trading, green finance, and environmental sustainability within a single analytical framework remains relatively scarce. Mashari et al. (2023) chart the relationship between green finance and carbon trading, yet their focus is primarily on identifying research clusters and collaboration networks without addressing its connection to environmental sustainability. Wang et al., (2025) indicate that research on green finance has evolved from the issue of carbon finance towards sustainable development, green technology, and carbon emissions, but has not specifically integrated the advancements in carbon trading research. Furthermore, Sharma & Jain. (2025) concentrate their analysis on the relationship between green finance and environmental sustainability, while Jaishree and Dogga (2025) map the development of green finance and sustainable development literature without exploring the role of carbon market mechanisms. On the other hand, (Roshid et al., 2025) review the evolution of carbon finance from the perspective of sustainable financial innovation, yet fail to connect it comprehensively with the developments in green finance or environmental sustainability. These differing focuses illustrate that, to date, there has been no bibliometric study that simultaneously maps the interconnections between carbon trading, green finance, and environmental sustainability within a unified analytical framework. Therefore, this research aims to bridge this gap through a bibliometric analysis that maps the intellectual structure, scientific collaboration, publication trends, and the evolution of research themes, thereby providing direction for future research development and recommendations for green economic policy-making.

Considering the research gaps identified, the innovation of this study is rooted in the formulation of a bibliometric mapping that consolidates carbon trading, green finance, and environmental sustainability into a cohesive analytical framework. This research not only delineates the progression of publications and scientific collaboration networks but also uncovers the intellectual structure, the evolution of research themes, and the emerging research trends, providing a more holistic view of the research trajectory in green economics and public policy. In light of this innovation, the objective of this study is to analyze the evolution of research related to carbon trading, green finance, and environmental sustainability through a bibliometric lens. More specifically, this research aims to identify publication trends, collaborations among authors and countries, intellectual structures, co-occurrence relationships among keywords, and research themes that may serve as future research agendas.

This research aims to explore the evolution of literature concerning the Emission Trading System, carbon emissions, and economic growth through bibliometric analysis. Specifically, the study identifies publication trends, the structure of keyword networks, dominant research themes, and areas of research that still present opportunities for future development.

RESEARCH METHODOLOGY

This study employs a quantitative approach utilizing bibliometric analysis to map the development of research on carbon trading, green finance, and environmental sustainability. Bibliometric analysis is chosen for its ability to identify trends in scientific publications, intellectual structures, researcher collaboration patterns, and the evolution of research themes based on publication metadata (Donthu et al., 2021).

The research data is obtained through the Publish or Perish (PoP) application, leveraging the Crossref database as a source of scientific publication metadata. Publish or

Perish is selected for its efficiency in gathering metadata from various scientific publishers and its widespread use in bibliometric research. The search process was conducted in June 2026 using a combination of keywords including carbon trading, emissions trading, green finance, and environmental sustainability. The initial search yielded 1,000 publications relevant to the research topic.

The screening phase is conducted by establishing several inclusion criteria, which are: (1) articles published between 2021 and 2026; (2) written in English; (3) categorized as either articles or reviews; and (4) relevant to the topics of emission trading systems, carbon emissions, and economic growth. Conversely, documents such as conference papers, book chapters, editorials, notes, duplicate data, and publications deemed irrelevant are excluded from the analysis process. The metadata of the publications that meet the criteria is then exported in RIS formats for the bibliometric analysis phase.

The bibliometric analysis was conducted using VOSviewer version 1.6.20 to visualize the networks of author collaboration (co-authorship), relationships between keywords (co-occurrence), citation analysis, bibliographic coupling, and co-citation analysis (van Eck & Waltman, 2009). Additionally, Biblioshiny, which serves as an interface for the Bibliometrix package in R software, was employed to analyze publication trends, author productivity, publication sources, country distribution, thematic maps, thematic evolution, and other bibliometric indicators (Aria & Cuccurullo, 2017). The results of the analysis were subsequently interpreted to identify research developments, intellectual structure, dominant themes, and future research opportunities related to emission trading systems, carbon emissions, and economic growth.

RESULTS AND DISCUSSION

Based on the co-occurrence visualization using VOSviewer (Figure 1), research on emission trading systems, carbon emissions, and economic growth forms several interconnected main clusters. The size of the nodes indicates the frequency of keyword occurrences, while the connecting lines (links) represent the degree of relationship between topics in the analyzed publications (van Eck & Waltman, 2009).

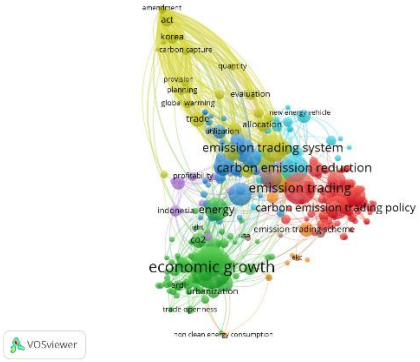


Figure 1 co-occurrence visualization using VOSviewer
Source: VOSviewer, 2026

The visualization indicates that research on emission trading systems, carbon emissions, and economic growth is evolving in a multidisciplinary manner, forming 11 primary clusters that reflect various research directions. Among the total of 334 keywords, several keywords exhibit the highest frequency of occurrence and connectivity, namely economic growth, emission trading system, emission trading, carbon emission reduction, carbon emission, and energy. This suggests that the primary focus of the research continues to be dominated by discussions regarding the relationship between economic growth, carbon emission reduction, and the implementation of emission trading policies as instruments for climate change mitigation.

Each cluster represents a distinct research theme. Some clusters concentrate on the implementation of the Emission Trading System (ETS) and carbon trading policies, while others emphasize the relationship between economic growth, energy consumption, urbanization, trade openness, and low-carbon technological innovation. The

diversity of these clusters indicates that research on emissions trading has evolved from merely being an instrument for emission control to a study that integrates economic, energy, public policy, and sustainable development aspects.

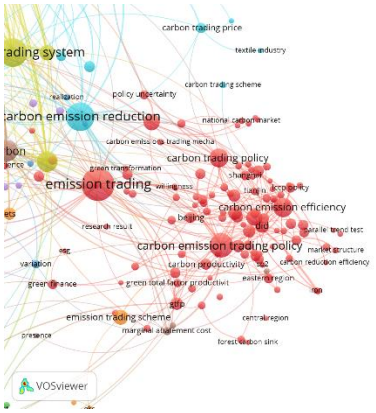


Figure 2 Cluster 1 (Red): Emission Trading Policy and Carbon Emission Efficiency
Source: VOSviewer, 2026

The red cluster (Fig.2) is one of the largest clusters within the co-occurrence network, concentrating on the theme of Emission Trading Policy. This cluster is characterized by prominent keywords such as emission trading, carbon emission trading policy, carbon trading policy, carbon emission efficiency, and carbon emissions trading mechanism, all of which possess relatively large node sizes and high link strength. This situation indicates that research on the Emission Trading System (ETS) extends beyond the mechanisms of carbon trading, also addressing the effectiveness of policies aimed at enhancing carbon emission efficiency and promoting the transition to a low-carbon economy.

In addition to the primary keywords, there are supporting keywords such as national carbon market, carbon trading scheme, carbon productivity, green total factor productivity (GTFP), policy uncertainty, market structure, marginal abatement cost, and forest carbon sink. These keywords indicate that research on the Emission Trading System (ETS) is beginning to explore carbon market design, cost efficiency in emission reduction, green productivity, and the policy uncertainties that affect the effectiveness of emission trading.

This cluster is also strongly linked to the keywords carbon emission reduction and emission trading system, suggesting that emission trading is positioned as a key instrument for carbon emission reduction through market-based mechanisms. The connection to green transformation and green finance further indicates that the ETS is increasingly viewed as part of the transition towards low-carbon development supported by green financing. These findings align with Han et al. (2024), who assert that the implementation of the ETS can enhance green innovation and reduce corporate emission intensity, as well as (Roshid et al., 2025), who demonstrate that the development of carbon trading research is increasingly directed towards the integration of climate policy, sustainable financial innovation, and green economic transformation.

The keywords Shanghai, Beijing, Tianjin, and National Carbon Market appear in the red cluster, indicating that research on ETS is still predominantly focused on its implementation in China. This reflects China's position as the most active country in developing a national carbon market, while also serving as a primary laboratory for evaluating emissions trading policies. This dominance also highlights the limited research on ETS in other developing countries, thereby creating opportunities for comparative studies in other regions, including ASEAN countries.

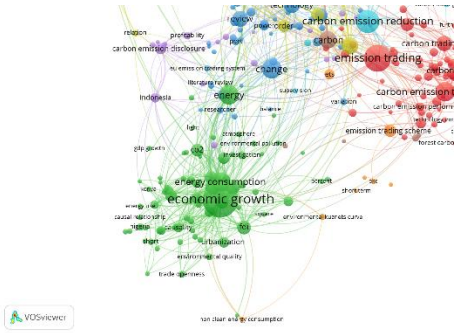


Figure 3 Cluster 2 (Green): Economic Growth and Energy Consumption
Source: VOSviewer, 2026

The green cluster (Fig. 3) illustrates a research theme centered on the relationship between economic growth, energy consumption, and environmental sustainability. This cluster is primarily characterized by the keyword economic growth as the largest node, which is strongly interconnected with energy consumption, energy, CO_2, FDI, urbanization, trade openness, environmental quality, and causality. The prominence of this keyword indicates that a significant portion of the research examines how economic activities influence energy consumption and carbon emissions, while also assessing their implications for environmental quality. The central position of economic growth within the cluster signifies that it serves as the main theme linking energy aspects, international trade, investment, and sustainable development.

The green cluster also demonstrates a connection with the keywords environmental Kuznets curve (EKC), non-clean energy consumption, and energy use, indicating that research is progressing towards testing the Environmental Kuznets Curve (EKC) hypothesis to elucidate the relationship between economic growth and environmental degradation. The emergence of the keywords causal relationship and causality suggests that numerous studies are employing econometric approaches to identify the cause-and-effect relationships among energy consumption, economic growth, and carbon emissions. The focus of research within this cluster aims not only to clarify the interconnections among variables but also to assess the effectiveness of economic and energy policies in promoting sustainable development.

The green cluster has numerous connections with the red cluster through the keywords emission trading, carbon emission reduction, and emission trading scheme. This interconnection indicates that research on economic growth is no longer viewed in isolation from emission trading policies instead, it is evolving towards studies that integrate carbon market instruments as mechanisms to reduce emissions without hindering economic growth. This indicates a shift in research focus from the trade-off between economic growth and environmental protection to the pursuit of balance through policies aimed at transitioning to a low-carbon economy.

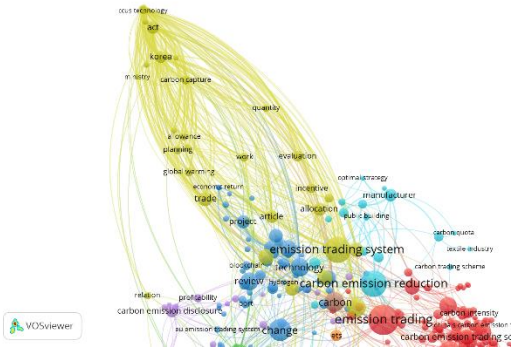


Figure 4 Cluster 3 (Yellow): Emission Trading System Design
Source: VOSviewer, 2026

The yellow cluster (Fig. 4) illustrates a research theme centered on the design, implementation, and governance of the Emission Trading System (ETS) as a market-based instrument for reducing carbon emissions. The keyword emission trading system serves as the primary node in this cluster and is strongly linked to allocation, trade, evaluation, planning, allowance, incentive, carbon capture, CCUS technology, and global warming. This pattern indicates that the research not only addresses the existence of the emission trading system but also assesses how policy design, emission quota allocation mechanisms, and incentive provision can enhance the effectiveness of ETS implementation in supporting decarbonization.

The yellow cluster has a strong connection with the red cluster through the keywords emission trading, carbon emission reduction, and carbon trading scheme, indicating that the design of the ETS is inherently linked to the overall carbon trading policy. This relationship suggests that research has shifted from discussions about carbon market mechanisms to evaluating the

effectiveness of institutional design, market governance, and technological innovation in facilitating the transition to a low-carbon economy.

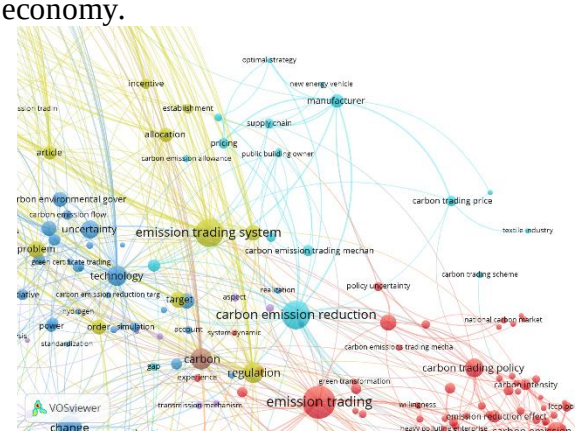


Figure 5 Cluster 4 (Blue): Carbon Emission Reduction and Manufacturer
Source: VOSviewer, 2026

The blue cluster (Fig.5) represents a research theme centered on carbon emission reduction strategies as the primary goal of implementing the Emission Trading System (ETS). This is evidenced by the prevalence of the keyword carbon emission reduction, which is strongly linked to terms such as manufacturer, carbon trading price, pricing, supply chain, new energy vehicle, technology, change, and carbon emission trading mechanism. This pattern indicates that the research not only assesses the effectiveness of ETS in reducing carbon emissions but also explores various strategies that can accelerate the decarbonization of the industrial sector through technological innovation, production efficiency, and carbon market mechanisms. Research by Yang et al. (2022) demonstrates that the implementation of ETS significantly enhances the efficiency of carbon emission reduction in the industrial sector, particularly through advancements in technology and energy efficiency. Furthermore, (Colmer et al., 2025) found that the carbon pricing policy within the European Union Emission Trading System (EU ETS) successfully encourages companies to reduce emission intensity while simultaneously increasing investments in low-carbon technologies.

The emergence of keywords such as manufacturer, supply chain, new energy vehicle, and technology indicates that research focus has shifted towards the implementation of emission reduction at both the corporate and industrial supply chain levels. Literature suggests that the manufacturing sector is the most affected by emission trading policies, necessitating improvements in energy efficiency, the development of environmentally friendly technologies, and the adoption of new energy vehicles to reduce carbon emissions. The relationship between carbon emission reduction and manufacturers suggests that research is increasingly examining corporate responses to ETS policies in promoting industrial transformation towards a low-carbon economy. Furthermore, the integration of hydrogen technology and electric vehicles is viewed as a crucial strategy in supporting the achievement of net-zero emissions targets.

Overall, the visualization results indicate that research on the Emission Trading System has evolved from discussions about emission trading mechanisms to a more comprehensive study that integrates aspects of public policy, economic growth, technological innovation, and decarbonization strategies. However, topics such as green finance, ESG, carbon disclosure, and the implementation of carbon markets in developing countries, particularly in the ASEAN region, still appear relatively infrequently within the keyword network. This situation highlights the potential for further research that combines emission trading with green financial instruments and sustainability governance.

CONCLUSION

This research aims to map the development of scientific publications concerning the Emission Trading System (ETS), carbon emissions, and economic growth through a bibliometric approach. The

analysis results indicate that research in this field has experienced significant growth and has established a multidisciplinary research structure. The co-occurrence analysis produced 334 keywords grouped into 11 clusters, with key themes including emission trading policy, economic growth, carbon emission reduction, technological innovation, and governance of the emission trading system. These findings suggest that research on ETS has evolved from discussions on carbon market mechanisms to a more comprehensive study that integrates economic aspects, public policy, technology, and sustainable development

The mapping results also indicate that certain topics still exhibit relatively low research intensity, particularly those related to the integration of the Emission Trading System with green finance, sustainability governance, and the implementation of carbon markets in developing countries, including the ASEAN region. This situation suggests that there are research opportunities in the future to develop studies that link emission trading instruments with green financing, public policy innovation, and strategies for transitioning to a low-carbon economy. The findings of this research are expected to serve as a reference for academics and policymakers in understanding the direction of literature development and identifying research agendas that support the achievement of sustainable development targets and economic decarbonization.

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