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Bibliometric Analysis of Sustainable Development Goals in the Context of Climate Change

Yağmur Çetintaş Palabıyıkoğlu[1], Fatih Ayhan[2,*], Zaim Reha Yaşar[3]

[1] *Department of Foreign Trade, Istanbul Esenyurt University, Istanbul, Türkiye*

[2] *Department of Economics, Bandırma Onyedi Eylül University, Balıkesir, Türkiye*

[3] *Department of Economics, Kırıkkale University, Kırıkkale, Türkiye,*

ABSTRACT

Combating climate change is not only about mitigating environmental degradation, but also about maintaining economic stability, social welfare, and long-term development prospects. In this broader perspective, the Sustainable Development Goals (SDGs) provide an integrated framework that links environmental sustainability with inclusive growth, financial resilience, and institutional quality. Therefore, the role of the SDGs extends beyond environmental protection to shaping economic and social policies that support a balanced and sustainable development path. The main objective of this study is to systematically map the intellectual structure, research trends, and thematic evolution of academic studies focusing on the SDGs by conducting a bibliometric analysis of the rapidly growing sustainable development literature. Using a bibliometric approach, an analysis was conducted on 14,928 publications retrieved from the Scopus database for the period 2016-2024. VOSviewer software was used to examine citation networks, the co-occurrence of keywords, and collaboration patterns between authors and countries. In general, bibliometric findings show that the sustainable development literature is shaped around energy and the environment, with relatively less focus on the financial and social dimensions.

Keywords: Sustainable Development Goals, Climate Change, Bibliometric Analysis, Environmental Degradation

* Corresponding author. Department of Economics, Bandırma Onyedi Eylül University, Balıkesir, Türkiye
fayhan@bandirma.edu.tr (F. Ayhan)

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1. INTRODUCTION

The consequences of climate change, such as rising sea levels, droughts, biodiversity loss, and extreme weather events, are increasingly disrupting ecological systems while also generating severe economic and social risks. These impacts threaten food security, income stability, public health, and the long-term development prospects of countries. Consequently, climate change has become a critical global challenge that endangers not only the natural environment but also human well-being and economic sustainability. Greenhouse gas emissions, largely driven by fossil-fuel-based production and consumption patterns since the industrial revolution, are widely recognized as the main cause of global warming and climate change. In response, countries are increasingly required to integrate environmental considerations into their development strategies. However, combating climate change is not solely about reducing environmental damage; it also involves ensuring macroeconomic stability, social welfare, and inclusive and sustainable growth. In this broader context, the Sustainable Development Goals (SDGs) provide an integrated framework that combines environmental protection with economic development and social inclusion, making them central to national policy agendas.

Within this multidimensional framework, the energy sector plays a pivotal role, as it remains the largest contributor to global greenhouse gas emissions. Decarbonizing energy systems is therefore essential not only for achieving climate targets but also for supporting long-term economic resilience and social well-being. Green energy, derived from renewable sources, produces minimal carbon emissions and contributes directly to climate mitigation (Alam et al., 2024). At the same time, it supports the Affordable and Clean Energy goal of the SDGs by enhancing energy security, reducing dependence on imported fossil fuels, and promoting more equitable access to energy (Trinh and Chung, 2023). The transition from fossil fuels to renewable energy—commonly referred to as the green transition—thus represents not only an environmental necessity but also a development strategy that stimulates job creation, technological innovation, and inclusive economic growth, accelerating the shift toward a more sustainable and socially balanced green economy (Androniceanu and Sabie, 2022).

The Sustainable Development Goals (SDGs), presented by the United Nations and adopted by 197 countries, comprise 17 main goals. The green transformation is synergistic with many of these goals. The reduction of fossil resource use through the green transformation is directly linked to SDG 3: Healthy Individuals (Dai et al., 2024). This is because reducing fossil fuel-based air pollution leads to healthier lives. The use of clean energy-powered water treatment plants contributes to SDG 6: Clean Water and Sanitation. The promotion and investment of renewable energy projects within the scope of the green transformation is directly related to SDG 13: Climate Action and SDG 12: Responsible Production and Consumption. Renewable energy projects also contribute to SDG 4: Quality Education by encouraging the development of new technical skills and vocational training. In this context, green energy is an indispensable part of a country's sustainable development process. Therefore, the planning, development, and implementation of green transformation strategies are a solution for both combating the climate crisis and other developmental factors (Dai et al., 2024; Koçak, 2023).

While the Sustainable Development Goals (SDGs) provide a comprehensive normative framework for guiding countries toward environmental sustainability, economic prosperity, and social inclusion, evaluating the extent to which these objectives are achieved requires measurable and comparable indicators. In this respect, the Sustainable Development Index offers a quantitative tool that translates the multidimensional structure of the SDGs into observable performance metrics. By aggregating economic, social, and environmental dimensions into a single composite framework, the SDG Index enables cross-country comparisons and empirical assessments of sustainable develop-

ment progress. Therefore, moving from the SDG framework to the SDG Index allows this study to operationalize sustainable development and examine how different policy, economic, and environmental factors are reflected in countries' actual sustainability performance. In the following sections of the research, the SDGs are first evaluated within a conceptual and theoretical framework. Furthermore, the Sustainable Development Index statistics are examined for the group of developed and developing OECD countries, and countries are classified according to their scores. Thus, the distance of these countries from the SDGs is interpreted. Subsequently, the bibliometric analysis methodology and the starting point of the study are stated. Then, the findings of the applied analysis are presented and evaluated. Finally, the conclusions and policy recommendations are presented in the last section of the study.

The aim of this study is to systematically examine the Sustainable Development Goals (SDGs), a rising trend in the literature, within a conceptual and theoretical framework. To this end, a bibliometric analysis of the SDGs was conducted. A systematic and objective map of the relevant literature was obtained using the VOSviewier application. Thus, the themes and trends of influential and dominant research in the SDG literature were identified. In this respect, the study evaluates empirical research from a broader perspective and provides a solid foundation for positioning it.

2. SUSTAINABLE DEVELOPMENT GOALS IN THE CONTEXT OF THE CLIMATE CRISIS

This section statistically supports the Sustainable Development Goals (SDGs), which were theoretically summarized in the first section. To demonstrate the extent to which the theoretical framework outlined in the introduction is reflected in national policies and performance, the OECD group of countries, representing a combination of developed and developing market economies, provides an ideal sample. These countries also bear significant responsibility due to their historical share of greenhouse gas emissions and their possession of the necessary technological and financial infrastructure for a green transition.

Sustainable Development Index (SDG Index)

Agenda 2030, adopted by all member states of the United Nations in 2015, focuses on the sustainability of countries. The 17 SDGs identified within this framework encompass factors such as poverty, health, education, environment, energy, growth, and climate change. According to the Paris Climate Agreement and Agenda 2030, it is believed that these goals must be achieved by 2030 (Sachs at al., 2025). The need to limit global warming to 1.5 degrees Celsius is particularly prominent. The 17 main targets identified within this scope are as follows:

SDG – 1: No Poverty

SDG – 2: Zero Hunger

SDG – 3: Good Health and Well-Being

SDG – 4: Quality Education

SDG – 5: Gender Quality

SDG – 6: Clean Water and Sanitation

SDG – 7: Affordable and Clean Energy

SDG – 8: Decent Work and Economic Growth

SDG – 9: Industry, Innovation and Infrastructure

SDG – 10: Reduced Inequality

SDG – 11: Sustainable Cities and Communities

SDG – 12: Responsible Consumption and Production

SDG – 13: Climate Action

SDG – 14: Life Below Water

SDG – 15: Life on Land

SDG – 16: Peace, Justice and Strong Institutions

SDG – 17: Partnerships for the Goals

An international examination of SDG progress since 2015 reveals that SDG1, SDG2, SDG4, SDG6, SDG8, SDG11, SDG12, SDG13, SDG14, SDG15, SDG16, and SDG17 are stagnating, SDG3, SDG5, SDG7, and SDG9 are moderately improving, and SDG10 is unavailable. The SDG Report 2025 indicates that no progress has been made since 2015. (Sachs et al.,, 2025).

The SDG Index covers 193 United Nations member states and assesses their SDG progress annually. The latest published calculations are based on 126 indicators. The Index records and provides an assessment of each country's SDG progress (Sustainable Development Report, 2025). Table 1 shows the SDG Index scores for OECD countries.

Table 1. *SDG Index Indicators in OECD Countries*

Country	***Score***	***Country***	***Score***
Australia	77.90	Japan	80.70
Austria	83.00	Latvia	81.20
Belgium	80.70	Lithuania	78.80
Canada	79.20	Luxembourg	76.70
Chile	78.10	Mexico	70.80
Colombia	70.50	Netherlands	80.00
Costa Rica	73.40	New Zealand	79.00
Czech Republic	81.90	Norway	82.70
Denmark	85.30	Poland	82.10
Estonia	80.80	Portugal	80.60
Finland	87.00	Slovak Republic	80.80
France	83.10	Slovenia	81.20
Germany	83.70	South Korea	78.10
Greece	79.10	Spain	81.00
Hungary	80.40	Sweden	85.70
Iceland	80.80	Switzerland	79.20
Ireland	78.60	Turkey	70.60
Israel	74.50	United Kingdom	81.90
Italy	80.30	United States	75.20
Sources: Sustainable Development Report, 2025			

It seems possible to evaluate the OECD countries in four main groups according to their indices in Table 1.

Global Leaders (83.00 and Above): This group includes countries that demonstrate the most balanced and successful performance across all dimensions of sustainable development (economic, social, and environmental). Finland (87.00) is clearly at the top, demonstrating progress not only in environmental policies but also in social indicators such as education, health, equality, and well-being. Sweden (85.70) and Denmark (85.30) consistently demonstrate success and rank highly in achieving the Sustainable Development Goals (SDGs). Strong economies from continental Europe, such as Germany (83.70), France (83.10), and Austria (83.00), are also included in this leading group.

High Performers (78.00-82.99): This broad group encompasses countries that have made solid progress towards achieving the sustainable development goals. Norway (82.70), Poland (82.10), the

Czech Republic (81.90), and the United Kingdom (81.90) stand out at the top of this category. Many European countries, such as Slovenia (81.20), Latvia (81.20), Spain (81.00), Estonia (80.80), Slovakia (80.80), and Iceland (80.80), are in this group with very similar scores. Countries such as Japan (80.70), Belgium (80.70), Portugal (80.60), Hungary (80.40), and Italy (80.30) also demonstrate high performance.

Mid-Performers (73.00-77.99): Countries in this group are making progress toward sustainable development but face significant challenges in some areas. The Netherlands (80.00) leads this group with a lower-than-expected score. This may indicate that the country is facing challenges in specific areas, such as the environment (such as the nitrogen crisis) or social equity. Advanced economies such as New Zealand (79.00), Canada (79.20), Switzerland (79.20), Greece (79.10), Australia (77.90), and Ireland (78.60) are in this range. This demonstrates that high economic well-being does not automatically translate to high SDG scores.

Countries Facing Challenges (Below 73.00): This group represents the countries that require the most effort to achieve the sustainable development goals. The inclusion of advanced economies like Israel (74.50) and the United States (75.20) in this group is striking. This points to significant gaps in income inequality, access to healthcare, and climate policy. Costa Rica (73.40), Turkey (70.60), Mexico (70.80), and Colombia (70.50) stand out as countries facing similar socioeconomic challenges. Table 2 compares the OECD country group for the SDG Index.

Table 2. *Comparison of Indicators across OECD Countries*

Country Group	*SDG Index*	*Evaluation*
Scandinavian Countries	Leader	Consistently global leaders in both environmental and socio-economic sustainability.
USA and Canada	Medium	Weak on green economy transition but better (but still low) on general development indicators (SDG). Environmental performance may be dragging down overall SDG scores.
Switzerland	Medium	Switzerland does very well in green economics but performs less well than expected in other areas covered by SDG, such as inequality, responsible consumption or global partnerships.
Poland and Czech Rep.	High	Although they are in the middle of the green economy index, they are quite successful in general sustainable development indicators (education, health, infrastructure).
Türkiye, Mexico, Colombia	Lowest	Both indices show that they face similar challenges, and there is significant potential for improvement in both environmental and socio-economic sustainability.
Japan and South Korea	High/ Medium	Despite their poor performance in the environment, they fare better in the SDG (especially Japan), suggesting that strong infrastructure, health, and education systems offset environmental weaknesses to some extent.

3. MODEL SPECIFICATION AND DATA

3.1 Model Specification

The concept of bibliometrics, developed by Alan Pritchard in 1969, is defined as the application of statistical methods to the development of science in the communication process. The history of these studies dates back to the 1900s. Cole and Eales (1917) were among the first researchers in this field. Bibliometric studies statistically examine data such as citation, subject, and country distribution in the evaluated field. This provides an opportunity to evaluate authors and publications, as well as trends and topics in the literature of the relevant field (Lawani, 1981; Okubo, 1997).

Bibliometric analysis, unlike classical literature reviews, can quantitatively and visually summarize the relevant literature. It can systematically present which studies in the literature are high-impact

and which are low-impact. It can also evaluate pioneering works, topics, authors, countries, years, etc., from a fundamental perspective. Therefore, the method reveals which authors and articles have shaped the literature. In conclusion, the method presents the literature from a multidisciplinary perspective. This research answers the following questions:

- What is the distribution of articles in the Sustainable Development Goals literature by year?
- Which countries have contributed the most to the Sustainable Development Goals literature?
- What is the distribution of keywords in the Sustainable Development Goals literature?
- Who are the most prolific authors in the Sustainable Development Goals literature?

3.2. Data

This study examines 14,928 articles written in the field of sustainable development goals in the context of the climate crisis worldwide and indexed in Scopus, using bibliometric analysis, a qualitative research method, from a multidimensional perspective. Data explanations for the research are presented in Table 3.

Table 3. *Data Explanation*

Category	***Description***
Searched Database	Scopus
Document Type	Article
Search Field	Title, Abstract, Keywords
Frequency	14,928 documents
Data Time Range	2016-2024
Included Indexes	Scopus Index
Keywords	Sustainable Development Goals or SDGs
Publication Language	English

4. EMPIRICAL RESULTS AND DISCUSSION

The scope of this research consists of 14,928 articles on sustainable development goals found in international literature, in line with the research objectives. The studies included in the research were primarily classified according to keyword usage by year, number of citations, most cited studies, countries with the most publications, and authors.

4.1 Keyword Analysis of Authors

Figure 1 shows the statistical distribution of keyword usage to identify trends in the field of sustainable development goals. When the keywords used by the authors were examined with a criterion of at least 10 repetitions, 257 keywords, 13 clusters, and 2694 links were identified. The total link strength is 6804. This data indicates that the relevant literature is beginning to mature. The findings show that the most frequently repeated keyword with high link strength is sustainable development goal. Other core concepts are climate change, renewable energy, circular economy, and environmental sustainability. This result shows that SDG literature is developing in a multidimensional way, not around a single main goal, but with sub-themes such as climate, energy, environment, and circular economy.

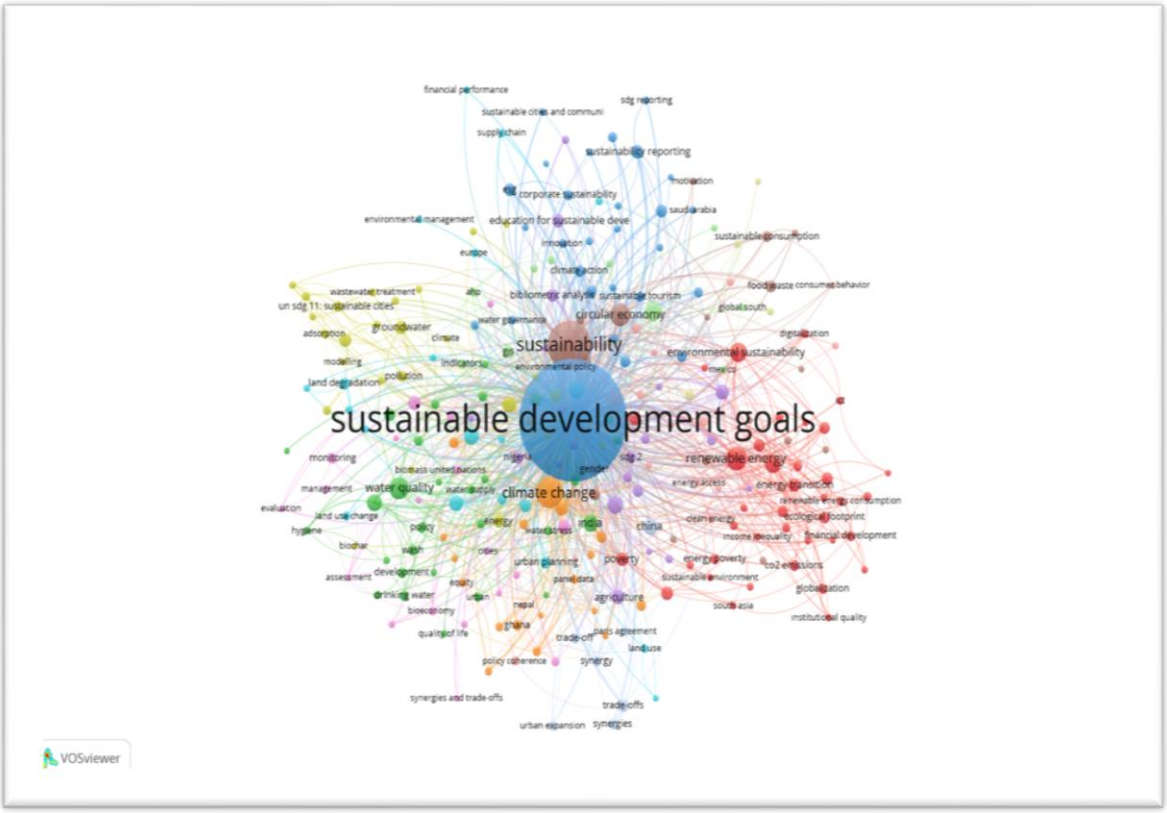

Figure 1: Co-occurence of Author Keywords – Network Visualization

The red clusters on the map focus on the energy, emissions, and economic dimensions of the SDGs. Keywords within this cluster include renewable energy, energy transition, CO2 emissions, ecological footprints, financial development, and environmental policy stringency. This cluster represents initiatives that highlight the economic and financial aspects of SDG 7 (Clean Energy) and SDG 13 (Climate Action).

The blue clusters on the map focus on corporate sustainability and reporting aspects of the SDGs. Keywords in this cluster include sustainability reporting, corporate sustainability, ESG, SDG reporting, and content analysis. This cluster reflects the literature examining the relationship between SDGs and corporate practices and reporting standards.

The green clusters on the map focus on the water, agriculture, and natural resources dimension of the SDGs. The keywords in this cluster are water quality, water supply, agriculture, land use, and biodiversity. This cluster represents the literature focusing on environmental resource management studies centered around SDGs 2, 6, and 15.

The yellow clusters on the map focus on the cities, waste, and infrastructure dimension of the SDGs. The keywords in this cluster are sustainable cities, wastewater, pollution, solid waste, and urban planning. This cluster represents the literature focusing on SDG 11 and infrastructure policies.

The purple clusters on the map focus on the social and inequality dimension of the SDGs. The keywords here are poverty, inequality, gender, education, and health. This cluster focuses on the literature addressing the social inclusion and development dimensions of the SDGs.

In general, the findings from the keyword analysis show that the literature is strongly intercommnected, but the literature is heavily weighted towards the energy-climate axis. This indicates that the literature has matured in the environmental and economic dimensions but is still developing in the social dimension.

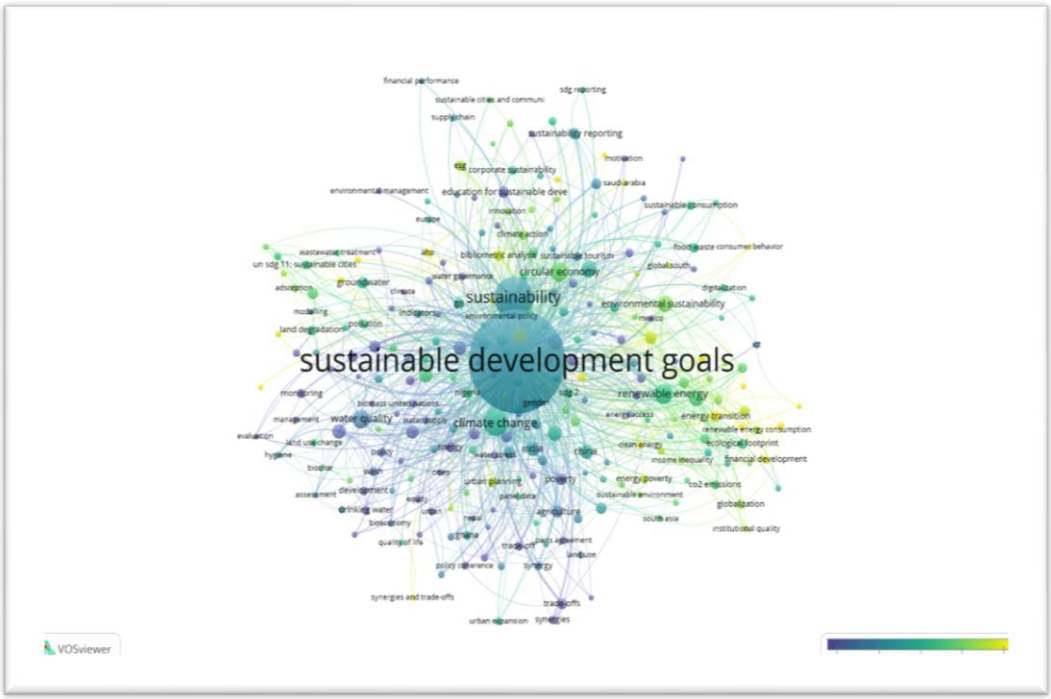

Figure 2: Co-occurence of Author Keywords – Overlay Visualization

Figure 2 shows the temporal evolution of keywords in the SDG literature. The colors of the clusters on the map indicate the distribution according to the average publication year. Blue and purple clusters represent keywords from 2022 and earlier, green clusters represent the mid-term, and yellow clusters represent the most recent keywords, i.e., those from 2023 and 2024.

The blue cluster on the map shows prominent keywords, or topics, such as climate change, poverty, inequality, agriculture, water quality, and sustainable development. This indicates that the literature initially focused on sustainability issues such as climate change, poverty, fundamental development problems, water, and agriculture.

The green cluster on the map characterizes transition themes. Prominent topics in this cluster include circular economy, renewable energy, environmental sustainability, governance, and policy. This period represents a mature stage in literature where SDGs are integrated into sectoral policies and energy transition.

The yellow cluster on the map represents emerging and current topics. The prominent topics in this cluster are carbon neutrality, environmental policy stringency, ecological footprint, digitalization, machine learning, ESG, and SDG interactions/synergies. This indicates that the SDG literature has recently focused more on how to solve the problem rather than identifying it.

Overall, the findings show that SDG literature has evolved from problem-defining studies to measurement and technology-focused studies.

Figure 3 characterizes which keyword is the most dominant and established in the SDG literature. Clusters are classified according to the frequency of keyword repetition and the strength of their association. Yellow areas represent the core of the literature, green areas represent strong but secondary themes in the literature, and blue areas represent areas of development. This analysis focuses on established topics in the literature, not new ones. As seen in the map, sustainable development goals, renewable energy, and climate change are the core areas of the literature. Strong secondary themes in the related literature include CO_2 emissions, energy transition, circular economy, water quality, and poverty. On the other hand, low-intensity but strategic areas include

environmental policy stringency, financial development, machine learning/artificial intelligence, ESG, digitalization, and SDG synergies and trade-offs. The findings indicate that these areas are high-potential new research topics.

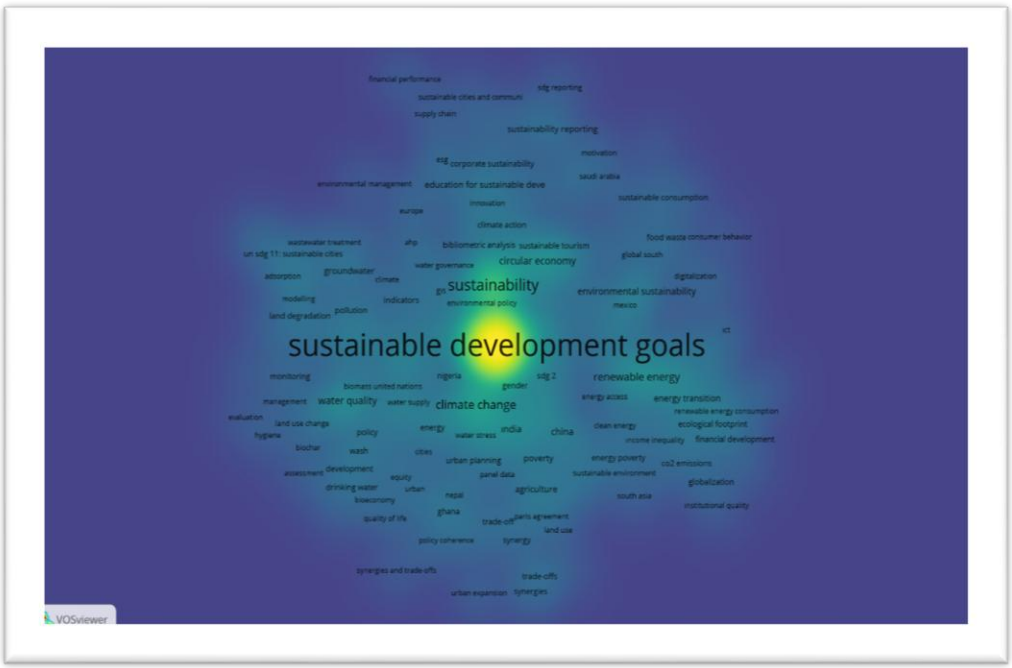

Figure 3: Co-occurence of Author Keywords – Density Visualization

4.2 Distribution by Citation Numbers

Figure 4 shows the citation network of the literature searched in Scopus for sustainable development goals. The citation network consists of 220 items and 220 clusters. This data indicates that the field is growing but is not yet fully integrated theoretically.

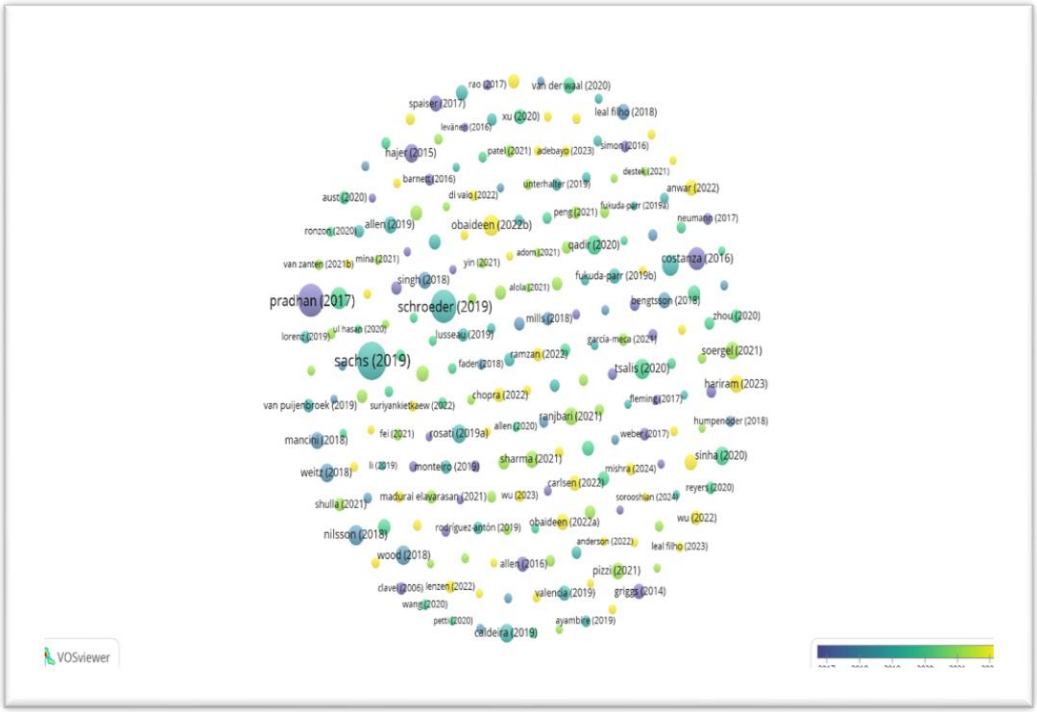

Figure 4: Citation-based Overlay Visualization

Figure 4 describes the citation network of the relevant literature, where the size of the nodes indicates the number of citations and the proximity between nodes indicates the level of proximity in the literature. The findings indicate that the field is dominated by a limited number of pioneering studies such as those by Pradhan (2017), Sachs (2019), Schroeder (2019), Costanza (2016), Nilson (2018), and Weitz (2018). Furthermore, this reveals a centralized citation structure. These pioneering studies form the core of the literature and serve as references for later studies.

After 2019, the number of publications in the relevant literature increased, and citations concentrated around early studies. This indicates that literature has expanded empirically but is based on established concepts. The fragmented structure of the citation pattern shows a rapid increase in studies in the field, but the citation link is relatively weak. This type of citation network points to a dominant and limited structure, but a developing research area. Overall, the findings show that there are relatively smaller nodes in the relevant literature after 2021. This indicates that the citation effect of the studies conducted has not yet been established.

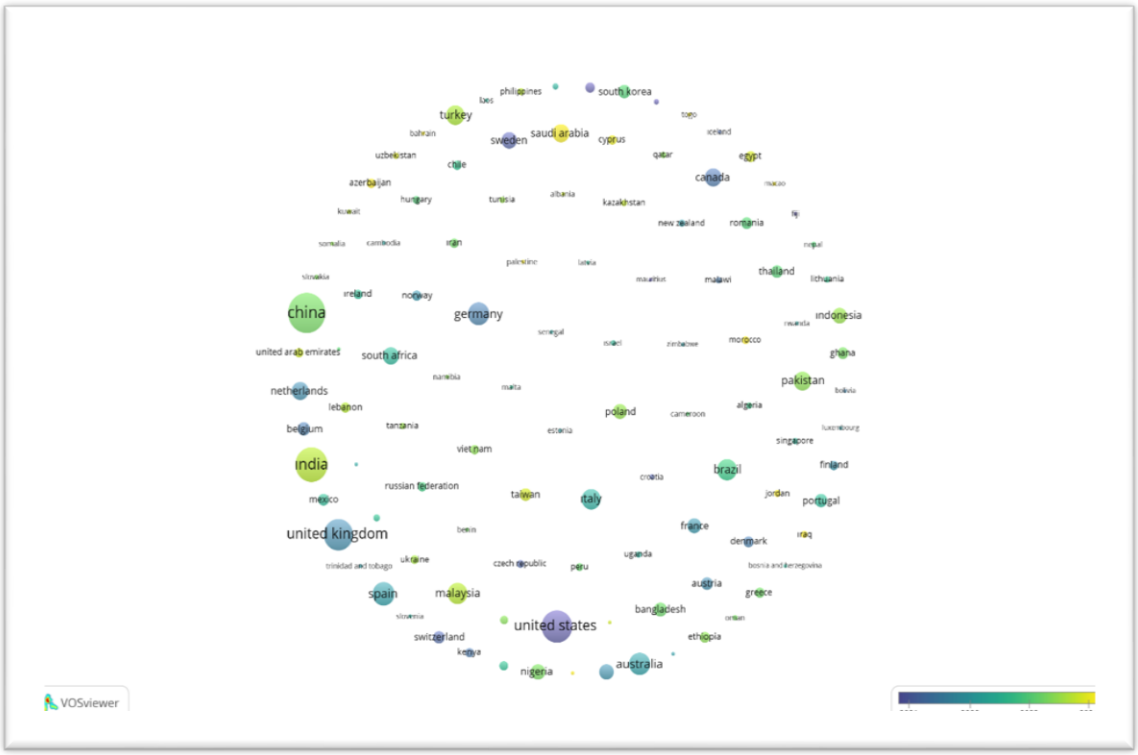

Figure 5: Country-based Citation Overlay Visualization

Figure 5 shows the temporal distribution of publications in the sustainable development literature by country. In other words, it indicates which countries were more active in the relevant literature in which years. As indicated on the map, purple and blue nodes represent the period before 2021. Green nodes represent the mid-period. Yellow nodes show the most recent period, 2023 and 2024. The map performs a temporal productivity analysis.

The large blue/purple nodes on the map were early in the SDG literature and were founding centers of the literature. These countries are: United States, United Kingdom, Germany, France, Italy, Spain. The green nodes on the map have added a quantitative dimension to the literature in terms of implementing the SDGs. These countries are: China, India, Australia, Netherlands, Brazil, South Africa. The yellow nodes on the map are emerging countries that have made the most recent contributions to the SDG literature. These countries are: Pakistan, Indonesia, Bangladesh, Nigeria, Ghana, Ethiopia, Malaysia, Saudi Arabia, Türkiye.

When all the findings are evaluated, it is concluded that the SDG literature is rapidly expanding globally, being examined in all its dimensions, and will maintain its relevance for a long time. Initially, developed countries guided the literature, but later developing countries transformed it into a more inclusive and global structure. In this context, it is seen that sustainable development goals, which have evolved from a qualitative to a quantitative structure, have become an issue of utmost importance for countries.

5. CONCLUSION

Climate change has become a critical global challenge, threatening not only ecosystems but also economic stability and social well-being. The intensive use of fossil fuels has increased greenhouse gas emissions, contributing to global warming and climate-related risks. However, addressing climate change goes beyond reducing environmental damage; it is also closely linked to sustaining economic growth, employment, income distribution, and social resilience. In this broader framework, the Sustainable Development Goals (SDGs) represent an integrated agenda that combines environmental protection, economic development, and social inclusion. Accordingly, green energy policies and climate actions should be evaluated together with their impacts on economic performance and social welfare, making the SDGs a central pillar of countries' development strategies. This study systematically and empirically examines the Sustainable Development Goals (SDGs), a growing trend in the literature, within a conceptual and theoretical framework. To this end, using bibliometric analysis—a qualitative research method—the study examines 14,928 articles written worldwide on the subject of sustainable development goals in the context of the climate crisis and indexed in Scopus, from a multidimensional perspective. Systematic and objective maps of the relevant literature were obtained using the VOSviewier application. Thus, the themes and trends of influential and dominant research in the SDG literature were identified.

According to bibliometric results, the sustainable development literature has an upward trend. However, due to its fragmented structure, despite the increase in publications in the literature, the number of pioneering studies is quite limited. According to the findings obtained from citation maps, Pradhan (2017), Contanza (2016), Sachs (2019), and Schroeder (2019) play a guiding role in the SDG literature. According to the results obtained from keyword maps, the relevant literature focuses heavily on climate change, renewable energy, sustainability, and circular economy, while it focuses less on issues such as environmental taxes, fiscal policies, and financial development. This situation points to gaps in the literature. Country-based analyses show that the SDG literature is concentrated in countries such as the USA, the UK, Germany, and China, but studies from Turkey, Pakistan, Indonesia, African countries, and South Asia have rapidly increased in recent years.

In general, bibliometric findings show that the sustainable development literature is shaped around energy and the environment, with relatively less focus on the financial and social dimensions. The core findings of this study highlight that environmental taxation and financial development play a central role in advancing the sustainable development goals within the context of the climate crisis. The bibliometric evidence reveals that environmental taxes are increasingly framed not only as instruments for reducing emissions but also as tools for mobilizing green investments and correcting market failures associated with environmental externalities. At the same time, financial development emerges as a key enabling factor that facilitates the diffusion of clean technologies, supports green innovation, and improves access to sustainable finance. Together, these mechanisms strengthen countries' capacity to simultaneously pursue environmental protection, economic resilience, and social well-being, thereby reinforcing the multidimensional nature of sustainable development. it is crucial for policymakers to adopt an integrated SDG framework that combines environmental taxation and financial development mechanisms in order to accelerate progress towards the sustainable development goals.

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