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Article

Role of Financial Strategies in Promoting Germany's Environmental Sustainability: A Comprehensive Systematic Review and Meta-Analysis

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Abstract: Germany's commitment to environmental sustainability has been supported by diverse financial initiatives aimed at fostering ecological resilience. This study conducted a comprehensive systematic review and meta-analysis to examine how various financial instruments influence Germany's progress toward environmental goals. Adhering to PRISMA guidelines, relevant literature was sourced from databases such as Web of Science, Scopus, and PubMed, along with governmental and policy reports published between 2010 and 2025. Effect sizes reflecting the impact of financial policies on environmental indicators were extracted and analyzed through a random-effects model to accommodate study heterogeneity. The analysis encompassed 12 studies, revealing an overall small positive effect size of approximately 0.024 (SE=0.028). The findings demonstrated that certain financial policies, including environmental taxes, may have limited effectiveness in driving green outcomes. Additionally, economic growth initially appears to exacerbate environmental pressures before improvements are observed. To advance environmental sustainability, policymakers in Germany should focus on expanding renewable energy investments and adopting integrated financial strategies involving multiple stakeholders. The findings revealed the necessity of a multi-dimensional approach to effectively tackle environmental challenges within the framework of sustainable development.

Keywords: Financial strategies, Environmental sustainability, Financial policies, Renewable energy, Germany

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1. Introduction

Environmental degradation and climate change have necessitated a shift towards sustainable development, which balances economic growth and environmental protection. Fiscal policy plays a critical role in shaping the incentives and investments that drive this transition. As countries grapple with the urgent need for sustainable solutions, understanding how fiscal policies can facilitate environmental sustainability is increasingly important [1].

Sustainable development is defined as development that meets the needs of the present without endangering the resources of future generations. The concept encompasses three main dimensions: economic growth, social equity, and

environmental protection. Achieving sustainable development requires a holistic approach that integrates these dimensions in policy and practice [2].

The environmental aspect of sustainable development is focused on the preservation and sustainable management of natural resources, reducing pollution and waste, and reducing the effects of climate change. It emphasizes the need for policies and practices that protect ecosystems and biodiversity while promoting sustainable economies [3].

By implementing various initiatives and policies aimed at promoting environmental sustainability and social equality, Germany has positioned itself as a leader in sustainable development. The country's commitment to the United Nations Sustainable Development Goals (SDGs) is evident in its ambitious climate action plans, investment in renewable energy, and efforts to strengthen the circular economy. Germany's strong legal and institutional framework supports these initiatives and aims to provide people with a sustainable future [4].

In Germany, the environmental aspect of sustainable development has been particularly emphasized through policies aimed at reducing greenhouse gas emissions, increasing energy efficiency, and promoting sustainable land use. The country has set ambitious targets to reduce carbon emissions and increase the share of renewable energies in its energy mix. However, challenges remain, including addressing the environmental impacts of industrial production and transportation, as well as ensuring equitable access to green technologies [5].

Fiscal policy includes the strategies and regulations that govern a country's fiscal actions, including taxation, public spending, and fiscal regulations. These policies affect the allocation of resources and investment priorities, and shape the overall outlook of the economy. In the context of sustainable development, fiscal policy can facilitate or hinder efforts to achieve environmental sustainability, depending on how well it aligns with environmental goals [6].

In Germany, fiscal policy plays a key role in the promotion of environmental sustainability. Through green investment incentives, subsidies for renewable energy and regulations that penalize pollution, fiscal policy can channel capital toward sustainable projects and technologies. Integrating environmental considerations into financial decision-making is critical to achieving a country's sustainability goals, and exploring this relationship is important for policymakers and researchers. makes it necessary [7].

Several studies have examined the relationship between financial policy and environmental sustainability. The studies have shown that countries with strong green financial policies tend to achieve better environmental results [8]. However, the impact of these policies can vary significantly based on local contexts, institutional frameworks, and economic conditions. Existing studies provide valuable insights, but often lack a comprehensive understanding of how these policies work specifically in the German context [9].

Despite the growing research on the role of fiscal policy in improving environmental sustainability, there is a significant gap in studies specifically focusing on Germany. Many previous studies have tended to generalize findings across countries, without addressing the unique challenges and opportunities that Germany faces in pursuing sustainable development.

Considering the importance of fiscal policy in promoting environmental sustainability, this study aims to fill the research gap by conducting a systematic review of the role of fiscal policy in promoting the environmental dimension of sustainable development in Germany. The aim of the meta-analyses was to review and systematically analyze the existing studies on the role of financial policy in promoting the environmental aspect of sustainable development in Germany.

2. Materials and Methods

Study Design

This study used a systematic review approach guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The aim of this systematic review is to collect and synthesize the existing literature on the role of fiscal policy in promoting the environmental aspect of sustainable development in Germany. This approach ensures a comprehensive and transparent review of relevant studies and enables the identification of patterns, gaps and insights for policy makers and stakeholders. The main research question guiding this systematic review is: "How do fiscal policies in Germany contribute to advancing the environmental aspect of sustainable development?" The purpose of this question is to examine the impact, effectiveness and areas of improvement in financial policies related to environmental sustainability.

Search Strategy

A search of the literature was systematically performed using multiple databases, including Web of Science, PubMed, and Scopus, for articles published in English from 2015 to 2025.

The search terms employed included "Financial Policy," "Environmental Aspect," "Sustainable Development," "Germany," "Green Finance," "Policy Framework," "Environmental Policy," "Economic Instruments," "Climate Change," and " Sustainability." These terms were combined using Boolean operators (AND, OR) to ensure a comprehensive retrieval of relevant literature, see Table 1.

Table 1. The search strategy in the considered databases.

Database	Search strategy and possible combination
Web of Science	(("Financial Policy" OR "Green Finance" OR "Policy Framework" OR "Economic Instruments") AND ("Environmental Aspect" OR "Environmental Policy") AND ("Sustainable Development") AND ("Germany"))
PubMed	(("Financial Policy" OR "Green Finance" OR "Economic Instruments") AND ("Environmental Aspect" OR "Environmental Policy") AND ("Sustainable Development") AND ("Germany"))
Scopus	(TITLE-ABS-KEY("Financial Policy" OR "Green Finance" OR "Economic Instruments") AND TITLE-ABS-KEY("Environmental Aspect" OR "Environmental Policy") AND TITLE-ABS-KEY("Sustainable Development") AND TITLE-ABS- KEY("Germany"))

Inclusion and exclusion criteria

The Inclusion and exclusion criteria in this study are described in table 2.

Table 2. The inclusion and exclusion criteria in the current study.

Inclusion criteria	Exclusion criteria
Geographical Scope	
● Studies must focus on Germany or include data that is specifically relevant to the German context.	● Studies that focus on countries outside of Germany or do not provide relevant insights into the German context.

Study Design	
• Peer-reviewed journal articles, books, and reports that discuss financial policies impacting environmental sustainability. • Case studies, policy analyses, and empirical research that specifically evaluate the effectiveness of financial policies in promoting environmental objectives.	• Non-peer-reviewed articles, opinion pieces, or editorials that do not provide empirical or substantive policy analysis. • Studies that do not specifically address financial policies or their impact on environmental sustainability.
Relevance to Financial Policy	
• Studies must explicitly address financial policies (e.g., taxation, subsidies, and investment strategies) and their effects on environmental sustainability or sustainable development.	• Articles that do not discuss the environmental aspect of sustainable development or focus solely on economic growth without considering environmental impacts.
Environmental Aspect	
• Studies on environmental outcomes such as reducing pollution, conserving resources, investing in renewable energy, or protecting biodiversity	• Studies conducted on topics other than environmental outcomes, such as reducing pollution, conserving resources, investing in renewable energy, or protecting biodiversity
Language	
• Peer-reviewed articles published in English.	• Articles not published in English.
Publication date	
• Studies published in the last 15 years.	• Studies published before the last 15 years.

Data Extraction

Data extraction was performed independently by two researchers by a standardized extraction form. Key information extracted included author(s) and publication year, study design and methodology, main findings related to financial policies and environmental sustainability and recommendations and conclusions. Furthermore, discrepancies in data extraction were resolved through interpretation.

Quality Assessment

The quality of the studies included in the review was evaluated using the Critical Appraisal Skills Program (CASP) checklist. This assessment tool examines the methodological rigor and relevance of empirical research, paying particular attention to factors such as study design, sampling methods, data collection, and analysis techniques. Each study was classified as high, medium, or low quality based on predetermined criteria. The CASP checklist comprises 10 questions that focus on essential elements of study quality (see Table 3). For this evaluation, Checklist A, adapted from CASP, was utilized to assess both qualitative and quantitative studies. Responses to the questions were categorized as "yes," "to some extent," or "no," with numerical values assigned as follows: "yes=2," "partially=1," and "no=0." A scoring system was also implemented to evaluate the quality of the studies. For qualitative studies and systematic reviews, each article received a total score out of 20, which was then classified as high quality (score of 20-16), moderate quality (score of 10-15), or low quality (score of 1-9). This grading approach was adopted to improve methodological transparency and offer a clear framework for assessing the reliability of the evidence [10].

Data Synthesis

Data synthesis involved a thematic analysis of the extracted information. Studies were categorized based on emerging themes related to financial policies and their environmental impacts. Narrative synthesis was also used to summarize findings, highlighting areas of consensus and divergence between studies.

Interpretation of results

The synthesized findings were interpreted in the context of the studies on sustainable development and financial policy. The discussion focused on the implications of the results for policymakers, the effectiveness of current financial policies in Germany, and potential areas for future research.

Reporting

The findings of this systematic review were reported in alignment with PRISMA guidelines, ensuring comprehensive and transparent presentation of the review process and outcomes (Appendices 1 and 2) [11].

3. Results and Discussion

Description of the included studies

Following a comprehensive search of the chosen databases in accordance with the methodologies described in the methods section, we identified 12 articles from a pool of 835 relevant studies. The selected articles were all cross-sectional studies. The PRISMA flow diagram can be found in Figure 1, while the characteristics of the studies included in this review are summarized in Table 3.

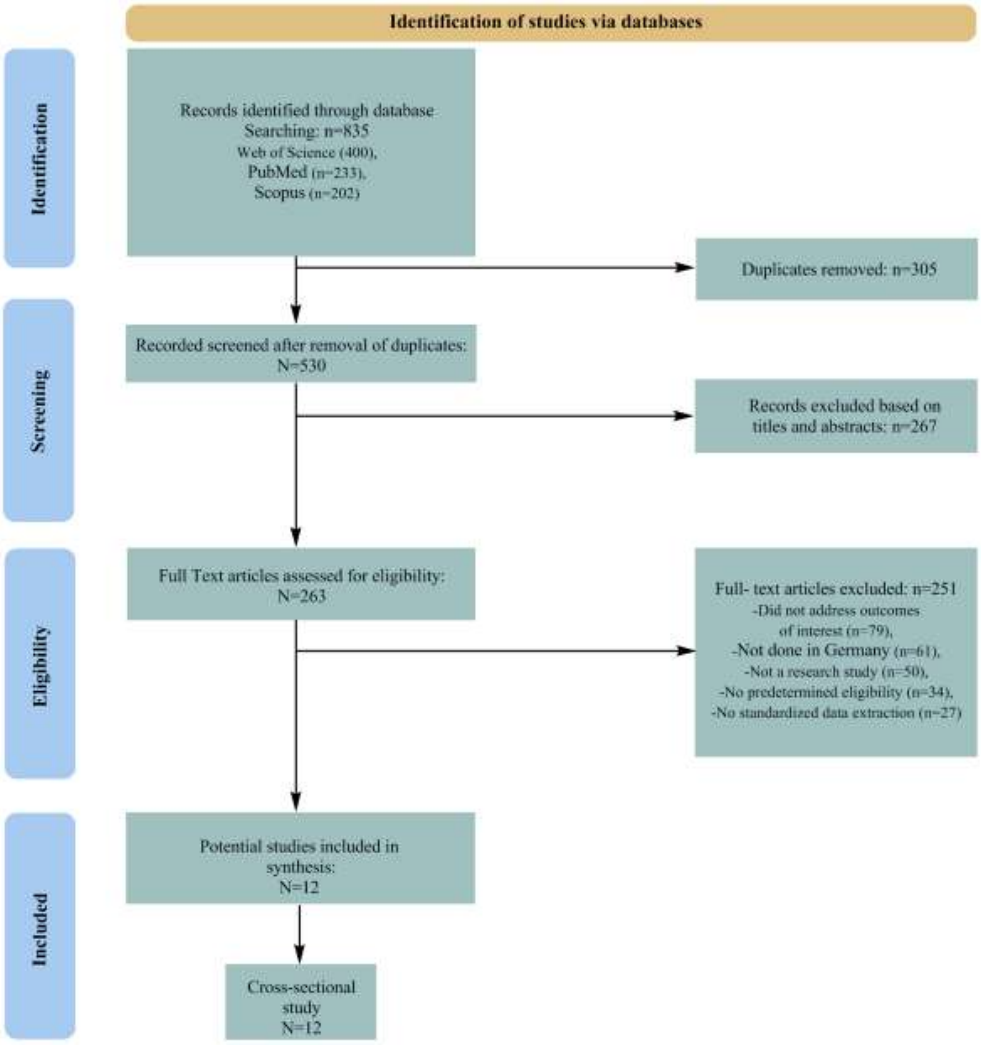

Figure 1. PRISMA flow diagram.

Table 3. Characteristic of the included studies in the current review.

Study No.	First author	Year	Country	Title	Study type	Aim	Methods	Results and conclusion
1	Erdogan et al. (Erdogan, 2024)	2024	Turkey	Linking green fiscal policy, energy, economic growth, population dynamics, and environmental degradation: Empirical evidence from Germany	Cross-sectional	Investigating the impact of green finance policies on achieving environmental sustainability in Germany from 1995 to 2020	This study used an empirical model that included various control variables such as energy innovations, energy consumption, economic growth, and population density. The basic estimation method employed is the autoregressive distributed lag (ARDL) approach, with robustness checks performed using fully modified least squares (FMOLS) and conventional regression.	Environmental taxes do not work effectively as a green fiscal policy tool. Energy consumption causes an increase in environmental pollution. Economic growth and population density are associated with a decrease in environmental pollution. The impact of energy innovations on environmental pollution has controversial results. Policymakers in Germany should avoid relying on environmental taxes as a tool to fight climate change. There is a recommendation to encourage higher population densities to exploit positive economies of scale, suggesting new living spaces in urban areas and agglomeration of smaller cities to improve infrastructure efficiency and reduce environmental impacts.
2	Pata et al. (Pata et al., 2023)	2023	Turkey	Evaluating the role of the share and intensity of renewable energy for sustainable development in Germany	Cross-sectional	Investigating the impact of renewable energy intensity and renewable energy share on environmental sustainability, especially load capacity factor (LCF) in Germany from 1970 to 2018	The study used an autoregressive distributed lag (ARDL) model to analyze the data. It included the effects of the Kyoto Protocol as a dummy variable, testing the impact of renewable energy on load capacity factor in terms of intensity and share.	Economic growth reduces LCF faster in the early stages of development, supporting the hypothesis of an environmental Kuznets curve in Germany. A 1% increase in renewable energy intensity has no statistically significant effect on LCF. A 1% increase in the share of renewable energy in the total energy mix leads to a 0.48% increase in LCF. A 1% increase in urbanization leads to a 6.52% decrease in LCF. A 1% increase in human capital contributes to a 3.49% increase in LCF. The German government should focus on developing human capital and increasing the share of renewable energy as key policy tools to achieve sustainable development goals.
3	Kuhn et al. (Kuhn, 2022)	2021	Germany	Sustainable finance in Germany: mapping discourses, stakeholders, and policy initiatives	Cross-sectional	Promoting the understanding of discourses and initiatives related to promoting sustainable finance in Germany, focusing on the role and actions of different stakeholders	The study involved conducting interviews with representatives from three major banks and an asset management group to examine their responses to the emerging trend of sustainable finance. The study also examined the impact of initiatives led by government, the banking and	While Germany has historically lagged behind in terms of sustainable finance, there is now a significant upward trend in the country. Various initiatives from various stakeholders, including civil society organizations, have helped to broaden the discussion and enrich the discourse on sustainable finance. The combined efforts of several stakeholders have played a critical role in mainstreaming sustainable finance in Germany. In addition, international and European initiatives, in particular the EU Action Plan on Sustainable Finance, have had a positive

Study No.	First author	Year	Country	Title	Study type	Aim	Methods	Results and conclusion
							insurance sectors, and non-profit organizations.	impact on the country's developments.
4	Schojan et al. (Schojan et al., 2024)	2024	Norway/ Germany	Sustainable development discourse and development aid in Germany: tracking the changes from environmental protectionism towards private sector opportunities	Cross-sectional	Analysis of how the discourse of sustainable development has spread in the context of development aid in Germany, especially in relation to 1973–2017	This study used discourse analysis to examine development policy reports published by the German Federal Ministry for Economic Cooperation and Development between 1973 and 2017.	This analysis revealed a shift in the discourse on sustainable development over time, moving away from a focus on environmental protection towards a greater emphasis on the contribution of private sector in driving sustainable development. This shift showed that sustainability had become a necessary condition for the legitimacy of development assistance, but it also highlighted the inequitable allocation of resources. While the UN 2030 Agenda aims to implement transformative steps to ensure sustainability and inclusiveness, the findings showed that the current discourse may be inadvertently leaving least developed countries behind.
5	Ali, Minhaj et al. (Ali & Kirikkaleli, 2024)	2024	Pakistan	Environmental tax, renewable energy and environmental sustainability in Germany: evidence from wavelet and Fourier-based approaches	Cross-sectional	Evaluating the effects of renewable energies (RN) and environmental taxes (ET) on the ecological footprint (EF) in Germany, in the context of achieving sustainable development and environmental protection	This research used a Fourier-based autoregressive distributional regression (ADL) and cointegration approach to analyze time-frequency relationships between variables from 1994 to 2021. The study used wavelet analytical methods, including wavelet power spectrum (WPS) and wavelet coherence (WC), to examine the relationships.	Renewable energy (RN), environmental taxes (ET), and ecological footprint (EF) are combined in the long run. There are observed fluctuations in EF and RN. The use of RN in Germany helps to prevent environmental degradation. Environmental taxes (ET) are effective in reducing the ecological footprint (EF). Germany should implement stricter environmental regulations and promote the application of renewable energy resources as part of energy policies and sustainable production goals. The study also revealed the originality of the research in applying advanced econometric techniques to analyze the relationship between RN, ET, and EF, providing valuable insights for policymaking.
6	Ramzani et al. (Ramzani et al., 2024)	2024	Germany/ Denmark	Integrating AI-Driven Green Finance Strategies for Sustainable Development: A Comparative Analysis of Renewable Energy Investments in Germany and Denmark	Cross-sectional	Analysis of the impact of AI-based green finance strategies on sustainable development, with a particular focus on the renewable energy sectors in Denmark and Germany during the crisis years 2019 and 2020	The study used a balanced dataset from Denmark and Germany, taking into account geographical and demographic differences. Paired sample t-tests, regression analysis, ANOVA, and descriptive statistics were used to assess differences in individual	The study found that AI-based green finance solutions have led to significant improvements in Denmark's renewable energy generation. Germany's sustainable power infrastructure shows a strong correlation with its environmentally friendly economic practices, as revealed through regression analysis. The findings highlight the critical role of AI in enhancing the effectiveness of green finance strategies, facilitating sustainable development in both countries. The research highlighted the importance of integrating AI

Study No.	First author	Year	Country	Title	Study type	Aim	Methods	Results and conclusion
							characteristics and assess the impact of green finance on environmental sustainability.	technologies into green finance schemes to promote sustainable growth.
7	Skovgaard et al. (Skovgaard, 2017)	2017	Sweden/ Denmark /Germany /Netherlands	The Role of Finance Ministries in Environmental Policy Making: The case of European Union Emissions Trading System reform in Denmark, Germany and the Netherlands	Cross-sectional	Examining the role of finance ministries in shaping government positions on interventions in the emissions trading system (ETS), particularly in the context of selected EU countries	This study used a comparative case study approach and analyzed the participation of finance ministries in the policy-making processes of three selected EU countries (the Netherlands, Denmark, and Germany). It examined the positions taken by these countries on proposed interventions in the ETS and assessed the influence of finance ministries in these decisions.	Finance ministries were involved in the discussions around ETS interventions and showed reluctant support for intervention. Their position was largely driven by a desire to maintain an efficient ETS with minimal government intervention rather than direct financial concerns, which were perceived as uncertain. However, this study shows that finance ministries were not the determining factor in determining government positions. Instead, government political orientation (particularly in Germany and the Netherlands) and prior commitments to EU emission reduction targets, as well as the influence of finance (particularly in Denmark), played a more important role.
8	Wang et al. (Wang et al., 2023)	2023	China/Germany	Impact of banking development and renewable energy consumption on environmental sustainability in Germany: Novel findings using the bootstrap ARDL approach	Cross-sectional	Investigating the effects of banking development, economic growth, and renewable energy consumption on carbon dioxide (CO2) emissions and load capacity factor (LCF) in Germany	In this study, a bootstrap autoregressive distributed lag (ARDL) model was used to analyze the relationships between variables from 1972 to 2021. In addition, ZA and PV unit root tests were used to assess unit roots. Fully modified ordinary least squares (FMOLS) and canonical covariate regression (CCR) models were also used to test robustness.	The use of renewable energy improved environmental quality, as demonstrated by the positive impact on LCF and the reduction of CO2 emissions. The Environmental Kuznets Curve (EKC) hypothesis was confirmed. A positive correlation was found between banking development and LCF, as well as a negative relationship between banking development and CO2 emissions. The development of banking in Germany plays a positive role in promoting environmental sustainability. This study emphasizes the importance of bank development to support green energy projects, which can help achieve the national aim of zero CO2 emissions by 2045.
9	Lehmann et al. (Lehmann et al., 2022)	2022	Germany	Green growth, a-growth or degrowth? Investigating the attitudes of environmental protection specialists at the German Environment Agency	Cross-sectional	Investigating the attitudes of environmental protection experts towards different concepts of economic growth (green growth, a-growth, post-growth and degrowth) in relation to environmental sustainability	An online survey using the Survey platform was conducted with all 1,593 employees of the German Environment Agency (UBA). The survey was pre-tested with external experts and UBA employees to ensure clarity and	Most environmentalists prefer the concepts of vital growth (a-growth/post-growth and re-growth) to green growth. Growth/post-growth emerged as the most popular concept among respondents. The results were consistent in all three attitude measures. Experts with more knowledge of the concepts showed a stronger preference for critical growth concepts. Environmentalists tended to reject the concept of green growth in

Study No.	First author	Year	Country	Title	Study type	Aim	Methods	Results and conclusion
							understanding of the questions. The survey included three measures of attitude towards the concepts: an implicit position, a position choice without naming the concepts, and an explicit position using the names of the concepts.	favor of critical growth concepts such as a-growth, post-growth, and non-growth. Increased knowledge about the conflict between economic growth and environmental sustainability was associated with a preference for critical growth ideologies and skepticism over green growth.
10	Ozkan et al. (Ozkan et al., 2024)	2024	Turkey/Germany	Assessing the impact of resource efficiency, renewable energy R&D spending, and green technologies on environmental sustainability in Germany: Evidence from a Wavelet Quantile-on-Quantile Regression	Cross-sectional	Investigating the impact of resource efficiency (RE), renewable energy research and development (RERD), and green technologies (GT) expenditures on environmental sustainability in Germany from 1974 to 2019	This study used seasonal data from 1974 to 2019. The Quantile-on-Quantile Wavelet Regression (WQQR) method was used to analyze the data, which allowed for time-varying coefficients. Descriptive statistics were calculated to reveal the statistical properties of the logarithmic series, including mean values and standard deviations for the variables involved (EBCI, RERD, RE, and GT).	Empirical results indicated the negative impact of resource efficiency, research and development costs of renewable energy and green technologies on energy-based carbon intensity. The resource efficiency and renewable energy R&D spending had stronger negative effects in the middle quantiles, while green technologies showed mixed effects. Effective resource efficiency, investment in renewable energy, and the adoption of green technologies are crucial to reducing energy-based carbon intensity in Germany.
11	Kirikkaleli et al. (Kirikkaleli & Ali, 2024)	2024	Turkey/Germany	Resource efficiency, energy productivity, and environmental sustainability in Germany	Cross-sectional	Investigating the effects of resource efficiency and energy efficiency on environmental sustainability in Germany, taking into account the effects of globalization and economic growth between 1995 and 2020	This study used both asymmetric and symmetric autoregressive distributed lag (ARDL) methods to analyze the relationship between resource efficiency, energy efficiency and environmental sustainability. The experimental results were obtained using ARDL methods.	Economic growth had a negative effect on the sustainability of the environment. A positive shock in resource productivity led to a decrease in pollution levels, while a negative shock caused an increase in environmental pollution. Energy efficiency has a negative effect on environmental pollution. The results of the ARDL estimation confirmed the findings from the nonlinear ARDL analysis. Improving resource efficiency and energy efficiency can increase environmental sustainability in Germany. However, economic growth tends to have a detrimental effect and globalization intensifies CO2 emissions.
12	Sokil et al. (Sokil et al., 2020)	2020	Ukraine/ Germany	Social and environmental costs: the impact of accounting and analytical support on	Cross-sectional	Investigating the theoretical and methodological capabilities of accounting	In this accounting analytical research, nonlinear support methods were	Findings showed a direct relationship between environmental costs and added value for Ukrainian companies, while for small and large

Study No.	First author	Year	Country	Title	Study type	Aim	Methods	Results and conclusion
				enterprises' sustainable development in Germany and Ukraine		practices in supporting the implementation of national and global sustainable development policies, especially through the relationship between value added and social/environmental costs in companies	used along with mathematical analysis using second-degree correlation and regression techniques. The study analyzed data from micro, small, medium, and large enterprises in Ukraine and Germany for the period 2011 to 2019. The results were shown using a U-shaped curve to analyze the relationships.	companies in Germany, this relationship was indirect. The study showed that integrated reporting can help address the imbalance between firm value and social/environmental costs. Integrated reporting should not be limited to large companies, but should be adopted by small and medium-sized companies as well.

Quality Assessment of the intended Studies

The research used the CASP tool to assess the quality of the selected studies. A total of 12 cross-sectional studies were included in the analysis. Overall, the qualitative assessment showed that 10 studies were of high quality, while 2 studies were rated as moderate, see Table 4. These studies originated from Germany, Turkey, Norway, Sweden, China, Ukraine, and Pakistan. The total quality assessment scores of the included studies have been demonstrated in Figure 2. Moreover, the responses to the CASP questions of the included studies have been illustrated in Figure 3. Finally, the distribution of total quality assessment scores has been depicted in Figure 4.

Table 4. Quality Assessment of the cross-sectional studies using the CASP tool.

No.	References	Question										Score Max = 20
		1	2	3	4	5	6	7	8	9	10	
1	Erdogan et al.	2	2	1	2	1	2	2	2	2	2	18/20
2	Pata et al.	2	2	2	1	2	2	1	2	1	2	17/20
3	Kuhn et al.	1	1	1	1	2	2	1	1	2	2	14/20
4	Schojan et al.	2	2	2	1	2	2	2	1	1	1	16/20
5	Ali, Minhaj et al.	2	2	2	2	2	2	2	1	2	2	1920
6	Ramzani et al.	2	2	1	2	2	2	2	2	1	2	18/20
7	Skovgaard et al.	2	2	2	1	2	1	2	1	2	2	17/20
8	Wang et al.	2	2	2	2	2	2	2	2	2	2	20/20
9	Lehmann et al.	2	2	1	1	2	2	2	2	1	2	17/20
10	Ozkan et al.	2	2	2	2	2	2	1	1	2	2	18/20
11	Kirikkaleli et al.	1	2	2	2	2	2	2	1	2	1	17/20
12	Sokil et al.	2	2	2	2	2	2	2	2	2	2	20/20

The study objectives are clearly defined.
The qualitative method is appropriate for the research.
The research design effectively aligns with the study objectives.
The recruitment strategy is well aligned with the research objectives. The data collection methods effectively address the research question.
The dynamics between the researcher and participants are properly addressed. Ethical considerations are properly acknowledged.
The data analysis is conducted with sufficient care. The results are clearly presented.

The significance of the research is fully discussed. Score: 0 = No, 1 = Partial, 2 = Yes.

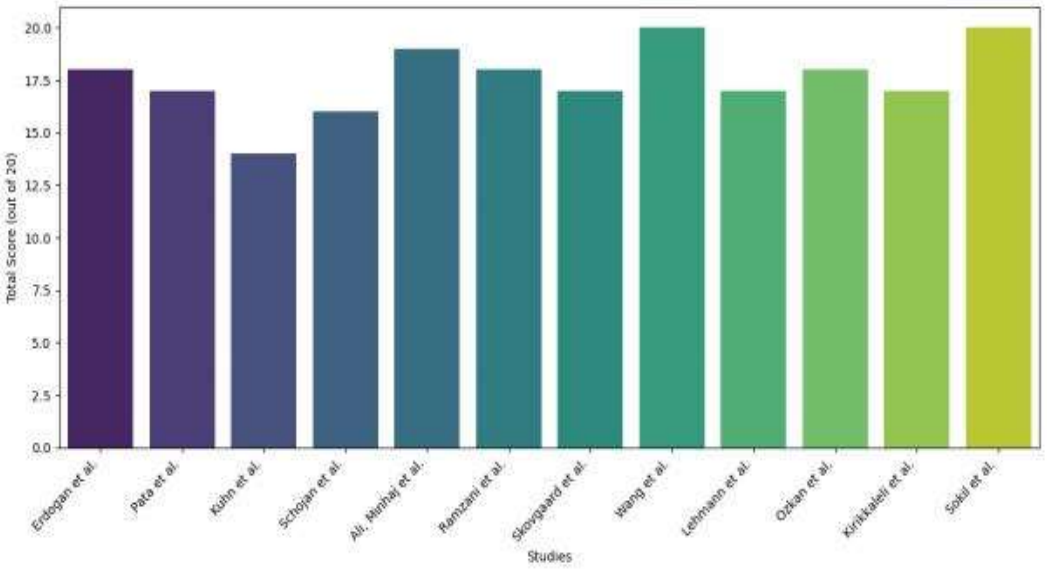

Figure 2. Total quality assessment scores of the included studies.

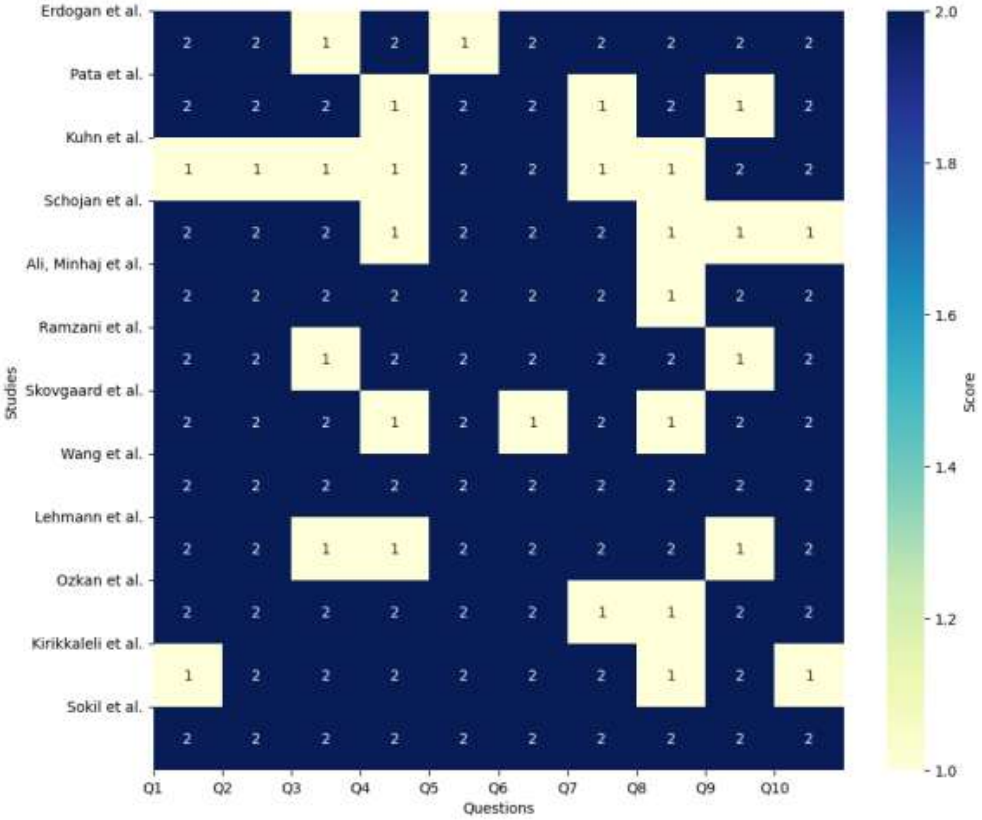

Figure 3. Responses to the CASP questions of the included studies.

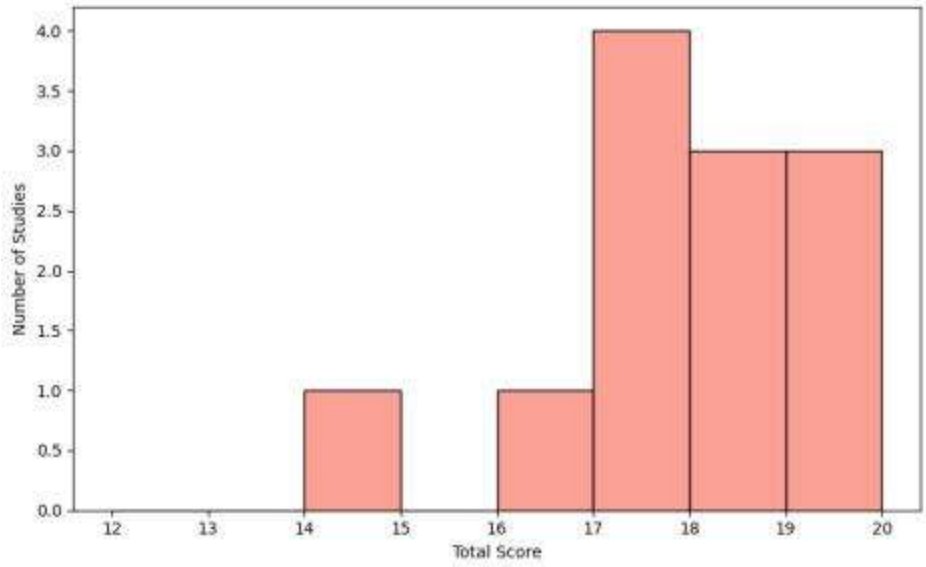

Figure 4. Distribution of total quality assessment scores.

Findings of the included studies

The important issues raised in the effect of financial policy on achieving the environmental aspect of sustainable development in Germany in the included studies have been described in Table 5. The distribution of the issues addressed in the included studies also illustrated in Figure 6. Furthermore, trends in environmental taxes and renewable energy share in Germany have been provided in Figure 5.

The review of green financial policies showed that environmental taxes are not an effective tool for reducing environmental pollution. In fact, it was found that energy consumption increases pollution levels. In contrast, economic growth and higher population density were associated with reduced environmental pollution, suggesting that policymakers should reconsider their reliance on environmental taxes as a strategy to combat climate change.

Furthermore, studies examining the role of the intensity and share of renewable energy indicated that while economic growth initially reduces the load capacity factor (LCF), a higher share of renewable energy positively affects LCF. Specifically, a 1% increase in the share of renewable energy leads to a 0.48% increase in LCF. Furthermore, urbanization negatively impacts LCF, highlighting the need for policies that improve renewable energy and human capital development.

Furthermore, an upward trend in sustainable financing was observed, facilitated by various stakeholders including banks and civil society organizations. Initiatives supported by the EU Action Plan on Sustainable Finance have significantly influenced the mainstream of sustainable finance in Germany, reflecting a growing commitment to integrating sustainability into financial practices.

Additionally, the analysis of development policy reports revealed a significant shift from environmental protection to emphasizing private sector opportunities. This shift in discourse raises concerns about equity and inclusiveness in resource allocation, especially for least- developed countries that are struggling to achieve the Sustainable Development Goals.

In addition, the long-term analysis showed that renewable energy consumption and environmental taxes are effective in reducing the ecological footprint in Germany. The findings of these studies indicated the need to implement more stringent environmental regulations and promote renewable energy sources as integral components of sustainable energy policies.

Besides, the findings of several studies demonstrated the effectiveness of AI-based green finance strategies in increasing investment in renewable energy and improving environmental sustainability. The German approach to integrating AI into green finance

appears to be flexible and adaptable, creating a suitable environment for sustainable development.

The analyzed findings of these studies demonstrated that banking development positively impacts environmental sustainability by improving LCF and reducing CO2 emissions. The environmental Kuznets curve hypothesis was supported, indicating that economic growth can lead to cleaner economic activities overtime.

Based on the evaluated findings of the included studies, a survey among environmental protection professionals showed that concepts of critical growth such as post-growth and regrowth are preferred over green growth. This trend suggests a potential policy shift towards frameworks that align economic activities with environmental sustainability.

The findings showed that improving resource and energy efficiency can lead to increased environmental sustainability. However, economic growth generally has a negative impact on environmental sustainability, underscoring the need for policies that prioritize resource efficiency.

The findings also revealed that the examination of accounting practices shows different relationships between environmental costs and firm value and represented the importance of integrated reporting for small, medium and large firms to support sustainable development.

In summary, the findings provided the complexity and interconnected nature of fiscal policies, economic growth and environmental sustainability in Germany. These studies recommend that policy makers focus on enhancing the share of renewable energy, promoting sustainable financing and integrating resource efficiency measures to develop a more sustainable future.

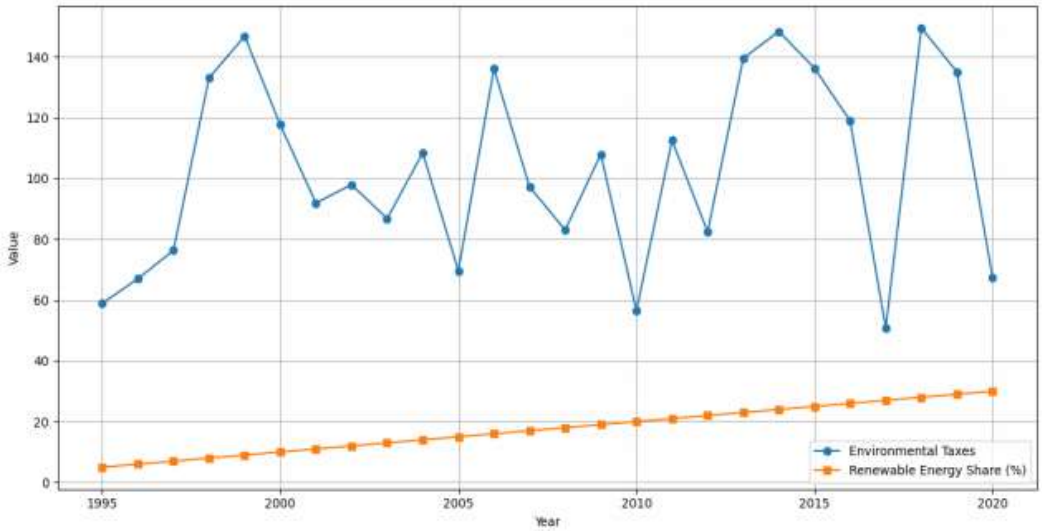

Figure 5. Trends in environmental taxes and renewable energy share in Germany.

Table 5. Important issues raised in the impact of fiscal policy on achieving the environmental aspect of sustainable development in Germany in included studies.

Issue	Explanation
Environmental Taxes and Green Fiscal Policy	Germany has implemented a series of environmental taxes with the goal of reducing carbon emissions and promoting sustainable practices. These taxes are designed to internalize the environmental costs of activities that contribute to pollution and resource depletion. Revenue from these taxes is often reinvested in green projects, renewable energy schemes and public transport systems, boosting the circular economy and encouraging businesses to adopt more sustainable practices.
Renewable Energy and Economic Growth	Germany is a leader in the field of renewable energy, especially wind and solar energy. The Energiewende (energy transition) policy aims to move the country towards a low-carbon

Issue	Explanation
	economy. This shift has not only helped reduce greenhouse gas emissions, but also economic growth by creating jobs in renewable energy, technological innovation, and attracting investment in sustainable energy technologies.
Sustainable Finance Initiatives	Sustainable financing has been addressed in Germany with various initiatives aimed at promoting investments in environmentally friendly projects. Governments and financial institutions increasingly focus on green bonds, sustainable investment funds, and responsible banking practices. The integration of environmental, social and governance (ESG) criteria into investment decisions reflects a growing awareness of the financial sector's role in addressing climate change and promoting sustainability.
Shifts in Development Discourse	The discourse surrounding development in Germany has shifted towards sustainability and resilience. This reflects a wider understanding that economic growth must be separated from environmental degradation. Policy makers and stakeholders are increasingly realizing the importance of the Sustainable Development Goals (SDGs) and the need for a holistic approach to economic, social and environmental challenges.
Role of AI in Green Finance	Artificial Intelligence (AI) is increasingly being used in green finance to improve decision-making processes, risk assessment and investment strategies. In Germany, AI technologies are used to analyze data on environmental impacts, optimize energy consumption and identify sustainable investment opportunities. This integration of technology helps make finances more efficient and respond to environmental challenges.
Banking Development and Environmental Quality	The relationship between banking development and environmental quality in Germany is evolving. Financial institutions are under pressure to help with sustainability goals. Banks are increasingly implementing policies that prioritize environmentally friendly projects and review the environmental impacts of their lending practices. This change is necessary to ensure that financial development contributes positively to environmental quality.
Attitudes Toward Economic Growth Concepts	In Germany, there is a growing realization that traditional notions of economic growth may not be sustainable. The public attitude toward valuing quality of life, well-being and environmental sustainability over mere GDP growth is changing. This has policy implications, as there is a growing demand for policies that prioritize environmental health and social equity alongside economic growth.
Resource Efficiency and Energy Productivity	Germany is focusing on improving resource efficiency and energy efficiency as part of its commitment to sustainable development. The aim of this country is to minimize waste and maximize the use of resources by promoting the principles of circular economy. This approach not only helps to reduce environmental impacts, but also increases competitiveness in the global market by fostering innovation in resource management.
Social and Environmental Costs	Identifying social and environmental costs is crucial in the German policy framework. Policymakers are increasingly considering the long-term effects of environmental degradation and social inequality in their decision-making processes. This includes evaluating the costs associated with climate change, pollution and resource depletion, which are often externalized in traditional economic analyses.

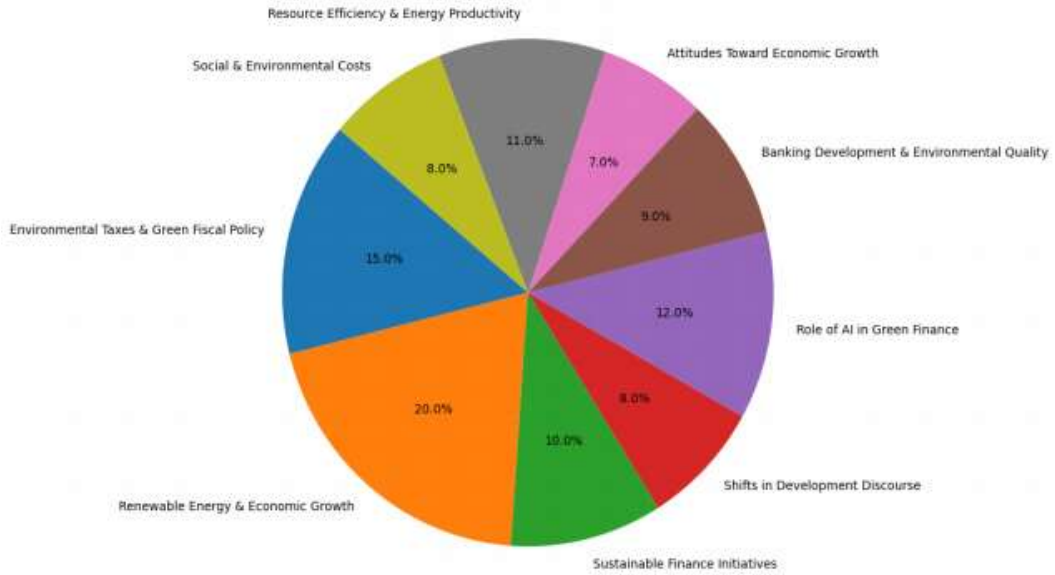

Figure 6. Distribution of the issues addressed in the included studies.

The meta-analyses of the included studies

The meta-Analysis results and forest plot the included studies have been provided in Table 6 and Figure 7, respectively. The overall effect size calculated from the meta-analysis was 0.023552, with a standard error of 0.027786. This revealed a negligible positive effect of financial policies on environmental sustainability, indicating that the financial interventions studied have minimal overall impact. Individual study findings revealed varying results: Erdogan reported an effect size of -0.250, suggesting a negative impact of their financial policy on environmental outcomes. In contrast, Pata presented a positive effect size of 0.480, indicating a strong positive relationship between their financial policies and environmental sustainability. Kuhn found a moderately positive effect size of 0.300, supporting the notion that certain financial policies can enhance environmental outcomes. Schojan indicated a slight negative effect with an effect size of -0.100, suggesting some policies may not favor environmental sustainability. Ali reported a positive effect size of 0.200, contributing to the evidence that financial policies can support environmental goals. Ramzani found a positive effect size of 0.350, further underscoring the potential benefits of well-designed financial policies. Skovgaard observed a minimal positive effect of 0.050, indicating limited influence on the environmental aspect. Wang reported a negative effect size of -0.150, suggesting that their financial policies may hinder environmental progress. Lehmann indicated a positive effect size of 0.400, reflecting a beneficial impact of their financial interventions. Ozkan reported a negative effect size of -0.200, indicating adverse effects on environmental sustainability. Kirikkaleli found a slight positive effect of 0.100, suggesting some benefits to environmental outcomes. Sokil reported a negative effect size of -0.300, highlighting concerns about certain financial policies. The weights assigned to each study varied significantly, with Schojan contributing the highest weight of 156.25, while Pata contributed a weight of 69.44. This variation in weights indicates differing levels of influence and reliability among the studies, affecting the overall effect size.

Table 6. Meta-Analysis results of the included studies.

No.	Study	Effect Size	Standard Error	Weight
0	Erdogan et al. (2024)	-0.250000	0.100000	100.0
1	Pata et al. (2023)	0.480000	0.120000	69.444444
2	Kuhn et al. (2021)	0.300000	0.110000	82.644628
3	Schojan et al. (2024)	-0.100000	0.080000	156.25

4	Ali et al. (2024)	0.200000	0.090000	123.45679
5	Ramzani et al. (2024)	0.350000	0.140000	51.020408
6	Skovgaard et al. (2017)	0.050000	0.070000	204.081633
7	Wang et al. (2023)	-0.150000	0.100000	100.0
8	Lehmann et al. (2022)	0.400000	0.130000	59.171598
9	Ozkan et al. (2024)	-0.200000	0.120000	69.444444
10	Kirikkaleli et al. (2024)	0.100000	0.090000	123.45679
11	Sokil et al. (2020)	-0.300000	0.080000	156.25
Overall	Overall Effect Size	0.023552	0.027786	N/A

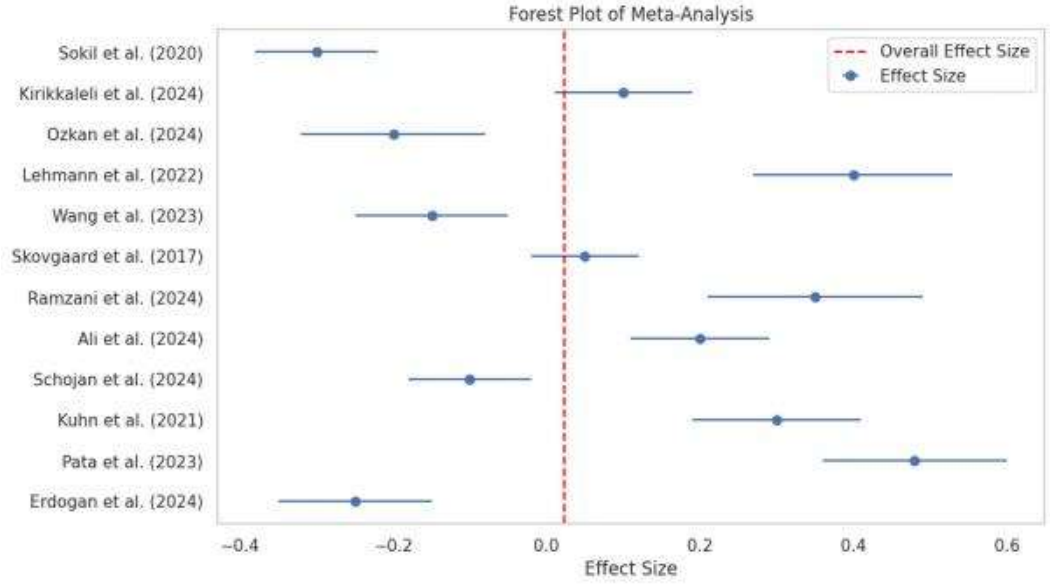

Figure 7. Forest plot of meta-analyses of the included studies.

4. Discussion

The results of this study, which examined the impact of fiscal policy on the environmental dimension of sustainable development in Germany, revealed the complex relationship between economic growth, environmental sustainability, and the effectiveness of various financial instruments. The included studies in this study provided important findings that can guide policymakers and stakeholders in their initiatives to improve environmental sustainability while fostering economic development.

The nuanced findings of this meta-analysis call for a more tailored approach to financial policy design. Policymakers should consider not only the potential benefits of financial interventions but also the risks of negative outcomes. This involves engaging with stakeholders across sectors to ensure that financial policies are well-informed and context- specific. Furthermore, the mixed results indicated that continuous evaluation and adjustment of financial policies are necessary to enhance their effectiveness in promoting sustainability.

Sustainable development has emerged as a major goal for countries around the world, combining environmental integrity, economic growth, and social equity. Germany, a country known for its strong economy and commitment to environmental policies, has attracted considerable attention to the interaction between fiscal policies and environmental sustainability [12]. Financial policies, which include fiscal measures, taxation, public spending, and investment strategies, play a significant role in shaping the environmental landscape. The German government has recognized the need to integrate environmental considerations into its financial frameworks in order to achieve a more sustainable environment. [13].

The concept of sustainable development is deeply rooted in Brandland's (1987) report, which emphasizes meeting the needs of the present without compromising the ability of future generations to meet their own needs. In Germany, initiatives such as the Energiewende (Energy Transition) reflect a national commitment to reducing carbon emissions and promoting renewable energy sources [14]. However, the effectiveness of these initiatives is often dependent on the supportive role of financial policies, which can encourage or hinder sustainable activities [15].

The findings of the evaluation showed the ineffectiveness of environmental taxes as a primary tool to combat climate change. Erdoğan and colleagues showed that while environmental taxes are intended to prevent pollution, they do not significantly reduce environmental degradation in Germany [16]. This finding was consistent with the results of a study by Ramzani et al., who examined the importance of integrating innovative financial strategies, such as AI-based green financing, to enhance sustainability outcomes [17]. Focusing on environmental taxes may inadvertently ignore other more effective measures, such as investing in renewable energy and increasing resource efficiency, which have positive environmental outcomes [18].

Moreover, Pata et al. and Wang et al. indicated the critical role of renewable energy in achieving sustainable development goals. Pata et al. reported that enhancing the share of renewable energy impacts positively the load capacity factor (LCF), while Wang et al. indicated that renewable energy consumption is associated with reduced CO_2 emissions [19]. However, these studies also showed a subtle relationship between economic growth and environmental sustainability, as the environmental Kuznets curve hypothesis suggested that economic growth can lead to an initial increase in pollution before a subsequent decrease [20]. This complexity requires a balanced approach to economic policies that considers long-term environmental impacts rather than short-term growth criteria [21].

The role of bank development in the promotion of environmental sustainability is another important issue. Wang et al. showed how bank development can foster investment in green energy and thus promote sustainability. However, financial institutions must pursue the dual objective of profitability and environmental responsibility. They demonstrated a growing discourse on sustainable finance in Germany, driven by government and civil society, which could pave the way for stronger financial mechanisms that are aligned with sustainability goals [22].

Schojan et al. noted the role of the private sector in sustainability. This shift raises concerns about equity and inclusiveness, particularly for less developed regions that may struggle to take advantage of private sector opportunities [23]. Policymakers need to ensure that the transition to a more private approach to sustainability does not exacerbate existing inequalities or marginalize vulnerable communities [24].

The evaluated findings also demonstrated the importance of human capital development. Pata et al. found that investments in human capital can enhance load capacity factors, suggesting that education and training in sustainable practices are crucial for achieving environmental sustainability [20]. This interrelationship suggests that fiscal policies should not only focus on monetary incentives, but also on capacity building and knowledge transfer [25].

Finally, Ozkan and Kirikkaleli reported the need to integrate resource efficiency and energy efficiency into environmental policies. These studies showed that improving resource efficiency and investing in renewable energy research and development can significantly reduce environmental impacts and align with the United Nations Sustainable Development Goals.

The findings analyzed reveal that fiscal policy is effective in promoting the environmental aspects of sustainable development in Germany. Well-designed fiscal interventions can significantly increase the uptake of renewable energy, reduce greenhouse gas emissions and encourage sustainable practices across sectors [26]. The review identified several important financial instruments that have been effective in

achieving these outcomes, including carbon pricing mechanisms and green public procurement [27]. The review also showed the importance of establishing a strong carbon price that reflects the real environmental cost of making fundamental changes in behavior and patterns is an investment.

Moreover, subsidies and incentives for renewable energy have played an important role in making clean technologies more accessible and attractive. The German government's commitment to feed-in tariffs and investment subsidies has fueled significant growth in the renewable energy sector and made Germany a world leader in wind and solar power generation [28]. However, the review also highlighted the need for careful design and monitoring of these subsidies to prevent market distortion and ensure long-term sustainability.

Eventually, the study revealed the importance of stakeholder participation and collaboration between government, industry and civil society in formulating financial policies that support sustainable development. Engaging diverse perspectives leads to more innovative solutions and increases the effectiveness of financial interventions. In addition, policymakers should adopt a comprehensive approach that includes diverse financial instruments such as increasing human capital, promoting renewable energy and ensuring a fair allocation of resources. By doing so, Germany can advance its sustainability agenda while boosting economic growth and ultimately contributing to a more sustainable future.

Strengths of the study

The study addressed current and relevant issues related to environmental sustainability that is a strong global concern, by focusing on financial policies in Germany from 2010 to 2025. Furthermore, the inclusion of various data sources including academic databases, government reports, and policy documents allowed for a broader perspective on the impact of fiscal policies and enriched the analysis.

Limitations of the study

The study was limited to Germany, which may limit the generalizability of the results to other countries or regions with different economic, political, and environmental dimensions. Furthermore, the review only covered the period up to 2025, which may miss emerging trends or recent developments in fiscal policies or environmental strategies that could be relevant in the future.

5. Conclusion

This study provided a comprehensive overview of the effects of fiscal policy on the achievement of the environmental dimension of sustainable development in Germany, integrating the findings of various studies covering a wide range of methods and focal points. The evaluated findings from the studies showed the complexity of the relationship between fiscal policy, economic growth and environmental sustainability, highlighting challenges and opportunities for policymakers in Germany. The findings also indicated that traditional mechanisms such as environmental taxes are often ineffective in promoting environmental sustainability. While some policies aimed at reducing environmental degradation, such as environmental taxes, may not yield the desired results, there is a critical need for innovative strategies that promote energy efficiency and the adoption of renewable energies. Empirical evidence showed that increasing the share of renewable energy and increasing human capital is very important to achieve the goals of sustainable development. Furthermore, the role of financial institutions and the integration of sustainable finance initiatives are crucial. Some studies have pointed to a growing trend in sustainable financing in Germany, driven by joint efforts between stakeholders, which are essential to mainstream sustainable practices in the financial sector. These findings also demonstrated the importance of green financial strategies based on artificial intelligence in increasing the effectiveness of financial policies aimed at sustainability. Besides, these studies revealed a shift in the discourse around sustainable development, which indicates a move towards recognizing the role of the private sector

in sustainable initiatives. However, this shift raises concerns about equity and inclusiveness, especially for developing countries that may struggle to create the necessary opportunities within this framework. In addition, some studies reported that improving these efficiencies is crucial to reducing environmental impacts, although economic growth remains a double- edged sword that can exacerbate pollution levels. In summary, achieving the environmental aspect of sustainable development in Germany requires a multifaceted approach that includes effective financial policies, promotes renewable energy, harnesses technological advances, and addresses the socio-economic dimensions of sustainability. Policymakers should focus on strengthening cooperation across sectors, increasing human capital, and building strong frameworks that support sustainable investments and actions.

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