

## Challenges and trends in green finance and environmental policy in East African countries: A bibliometric and policy analysis

 Elmi Hassan Samatar<sup>1\*</sup>

<sup>1</sup>Tropical Consult, Mogadishu, Somalia; elmi.samatar@outlook.com (E.H.S.).

**Abstract:** This study examines the challenges and trends in green finance and environmental policy in East African countries (EAC), focusing on how green finance contributes to carbon emission reduction, renewable energy adoption, and sustainable land use. Using a bibliometric and policy analysis approach, the study draws on 147 peer-reviewed articles published between 2017 and 2024 and indexed in the Scopus database. VOSviewer was applied to map authorship patterns, co-citation networks, keyword occurrences, publication trends by year, and the geographical distribution of research influence. The findings reveal limited regional research output, with only 523 authors contributing to the domain, highlighting a substantial research gap compared to global trends. Three core thematic clusters emerged from the analysis: green financial instruments (e.g., bonds and fintech), policy and sustainability frameworks, and methodological innovations in econometrics. Interest peaked in 2022 but has since declined, indicating saturation in broader themes and a need for localized studies. There are disparities in regional publications, particularly with influential countries like China, the USA, and the UK. Contributions from African nations, especially the EAC, reveal institutional and capacity gaps. Challenges include a lack of standardized definitions for green financing, poor policy integration, and limited collaboration. This paper recommends enhanced regional research on green finance, policy alignment, institutional strengthening, and international cooperation to optimize green finance for sustainable development in the EAC. Future research should focus on context-driven financial models, regional public-private partnerships, and targeted capacity-building efforts to address gaps and enhance environmental sustainability in the region.

**Keywords:** *Bibliometric, Carbon emissions, Climate finance, East African community (EAC), Environmental policy, Green finance, Renewable energy adoption.*

### 1. Introduction

The East African Community (EAC) faces significant environmental challenges, prompting research into sustainable economic development and green finance initiatives. Studies have examined the relationship between economic growth and ecological degradation in EAC countries, finding a bell-shaped curve that suggests economic activities do not necessarily lead to increased CO<sub>2</sub> emissions [1, 2]. EACs' recent publications indicated that CO<sub>2</sub> is reduced by the consumption of renewable energy, while it is increased by population and economic growth [3]. Furthermore, according to Chambile et al. [4] despite infrastructure and financial barriers, integrating traditional knowledge with modern technologies of renewable energy can augment energy security. When coupled with environmental sustainability policies, foreign direct investment can improve environmental quality in the long term [5]. The EAC has recognized the importance of green public procurement strategies in harmonizing public financial management across member states [6]. Additionally, developing countries, including those in Central Africa, are particularly vulnerable to international financial fluctuations and require strategies to enhance green financing alternatives [7]. These studies highlight the need for

environmental conservation policies, technological advancements, and innovative financial products to support sustainable development in East African countries.

As discussed by Ngepah et al. [8] the EAC has made noteworthy progress in aligning its climate policies with global sectoral frameworks, including the Intergovernmental Panel on Climate Change (IPCC) recommendations. Adopting EAC climate change policies promotes adaptation and mitigation strategies and sustainable development across the EAC member states. In Kenya, green finance has been instrumental in supporting large-scale renewable energy initiatives, remarkably the Lake Turkana Wind Power Project, which has improved energy security while reducing carbon emissions [9]. Like Kenya, Tanzania has leveraged green bonds and ecosystem payment mechanisms such as the Simanjiro Conversation Easement. This promotes forest conversation and offers financial incentives as well as sustainable land use [10]. Moreover, according to Kumar et al. [11] agroforestry initiatives like “Trees for the Future” show how community-based green finance enhances biodiversity, soil fertility, and carbon sequestration in East Africa. These initiatives align with broader climate adaptation objectives Datta, et al. [12] and green finance in EAC not only encourages investment toward sustainable energy and reforestation but also encourages the integration of resilience strategies consistent with IPCC guidelines [13].

Geospatial and climate change data have recently enhanced how financial policies impact environmental outcomes in EAC. According to Nzabarinda et al. [14], green finance initiatives targeting watershed and reforestation protection have been linked to measurable reductions. This has improved water availability, as confirmed through GIS examination and remote sensing. Similarly, Sun et al. [15] confirmed that climate data revealed regions with targeted green investments have experienced slower growth rates in terms of carbon emissions compared to areas without similar interventions. According to Hu [16], governments enhanced financial policies to maximize ecological benefits by incorporating satellite data and environmental modeling into their strategies. Furthermore, mechanisms of green finance are important in enhancing natural resource governance in EAC [17]. Additionally, according to Agrawal et al. [18], adopting innovation initiatives and green finance has been instrumental in achieving sustainable initiatives, particularly in the context of the environmental conversation and renewable energy [19]. These initiatives not only support forest conversation efforts but also facilitate the transition to clean energy, contributing to the EAC’s sustainability of the environment.

Green finance has emerged as a crucial tool for addressing climate change and promoting sustainable development. Research in this field has grown significantly, focusing on various aspects such as green bonds, green credit, carbon markets, and climate finance policies [20, 21]. Despite its potential to make a substantial environmental impact, green finance faces challenges, including a lack of awareness, inconsistent definitions, and policy coordination issues [22]. The BRICS countries have integrated green finance into their national strategies, with China leading in developing regulatory frameworks and increasing green investments [23]. However, implementation often lags behind policy development in some countries. To advance green finance research and practice, scholars recommend focusing on economic and financial perspectives using quantitative approaches [21]. Addressing these challenges and promoting collaborative efforts among stakeholders can help realize the full potential of green finance in mitigating climate change.

Green finance has emerged as a crucial tool for promoting environmental sustainability and addressing climate change. Studies show that green finance development, including investments in renewable energy and R&D for eco-friendly projects, can significantly reduce CO<sub>2</sub> emissions and improve energy efficiency [24, 25]. Green finance policies have been found to enhance corporate environmental, social, and governance performance [26]. However, challenges such as lack of awareness, inconsistent definitions, and policy coordination hinder its widespread adoption [22]. Green bonds, in particular, have been shown to effectively promote green energy projects and reduce emissions [27]. While green finance generally improves environmental sustainability, its effects may vary across regions and timeframes [5, 28].

Jian & Afshan [29] extended the scope of research to G10 economies, examining the role of green financing and green technologies in achieving carbon neutrality from 2000 to 2018. Their findings corroborated the positive impact of green finance on environmental sustainability. The study revealed that green financing contributes to carbon neutrality by 0.319% in the long run. Additionally, the research emphasized the role of green technology innovation, which was found to promote carbon neutrality by 0.189% in the long run. The study also validated the Environmental Kuznets Curve hypothesis, suggesting that economic growth beyond a certain threshold can lead to environmental improvements.

Lee [30] focused on the case of China, providing insights into the country's green finance initiatives and challenges. The research highlighted China's emergence as a global leader in green bond issuance, with the market reaching approximately USD43 billion in 2018. The study outlined various policy measures implemented by the Chinese government to promote green finance, including the establishment of pilot green finance zones. However, Lee also identified several challenges in developing green finance in China, such as the lack of consensus on green definitions, insufficient environmental data disclosure, and inadequate risk management.

The literature collectively emphasizes the growing importance of green finance in addressing environmental concerns and promoting sustainable development. Nguyen & Khominich [31] and Jian & Afshan [29] provide quantitative evidence of green investment and technologies' positive impact on environmental outcomes. Lee [30] complements these findings with a qualitative analysis of policy initiatives and challenges in implementing green finance, particularly in the context of China. All three studies underscore the need for supportive policies, standardization of green definitions, and increased collaboration between the public and private sectors to advance green finance initiatives.

Green finance has emerged as a crucial instrument for fostering environmental sustainability globally, with significant regional variations in its implementation and impact. Zakari & Khan [28] and Areche et al. [27] both emphasize the potential of green finance to combat environmental degradation through investments in renewable energy and green bonds. Zakari & Khan [28] focus on a global perspective, applying panel-corrected standard errors and feasible generalized least squares models to highlight the role of green finance in enhancing sustainability despite challenges posed by urbanization and energy consumption. Similarly, Areche et al. [27] underline the effectiveness of green bonds in reducing CO<sub>2</sub> emissions in ASEAN countries, employing econometric models like the STIRPAT and GMM. Both studies agree on the importance of integrating green finance with long-term policies to achieve meaningful environmental outcomes but differ in geographical scope and methodological emphasis.

Focusing on regional disparities and policy implications, Khan et al. [32] and Peng & Zheng [25] investigate the dynamics of green finance in Asia. Khan et al. [32] provide a multi-regional analysis, using panel data to underline the importance of R&D, renewable energy investments, and public-private partnerships in achieving environmental sustainability. Their findings suggest that geographical clusters significantly influence the success of green finance. On the other hand, Peng & Zheng [25] analyze the Chinese context, highlighting how green finance boosts energy efficiency through green technology innovations, particularly in resource-rich provinces. Both studies underscore the pivotal role of targeted policies and technological advancements but diverge in their focus on regional versus national impacts.

On a global scale, Ozili [22] and Muchiri et al. [21] review the broader literature on green finance, identifying common challenges such as inconsistent policies, limited investor incentives, and the need for increased awareness. Ozili [22] emphasizes the role of regulatory frameworks in addressing these gaps, while Muchiri et al. [21] focus on post-Paris Agreement trends, advocating for more quantitative studies to guide policymakers in regions like East Africa. Their work aligns with the transformative potential of green finance but differs in methodological approaches, with Ozili [22] taking a thematic review and Muchiri et al. [21] using bibliometric analysis.

Lastly, studies like Debrah et al. [20] and Choi et al. [23] delve into specific aspects of green finance, such as green bonds and green banking. Debrah et al. [20] employ a mixed-methods approach to map research trends, identifying green bonds and fintech as critical tools for advancing green finance. Focusing on China, Choi et al. [23] highlight the superior performance of green credit portfolios compared to traditional loans and advocate for replicating successful policy frameworks in other regions. Both studies emphasize innovation and policy as drivers of green finance but differ in their thematic focus and geographical applications.

These studies demonstrate the diverse dimensions of green finance and its potential to address global environmental challenges. However, significant gaps remain, particularly in harmonizing green finance definitions, fostering cross-border collaboration, and tailoring strategies to regional contexts like East Africa. Addressing these gaps requires integrated approaches combining policy innovation, stakeholder engagement, and technological advancements.

### *1.1. Literature Gaps in Green Finance and Environmental Policy in East African Countries (EAC)*

Despite the increasing global emphasis on green finance as a mechanism for achieving sustainable development, substantial gaps remain in its application and impact assessment within East African Countries (EAC). Studies like Renyong & Sedik [5] and Nur [33] emphasize the role of institutional and policy frameworks in enhancing environmental sustainability through foreign direct investment (FDI) but largely focus on macroeconomic variables without addressing the integration of local green finance initiatives. Similarly, Beyene & Kotos [2] validate the Environmental Kuznets Curve (EKC) hypothesis for EAC, showing the environmental effects of economic activities, yet fail to connect these findings with developing and implementing specific green finance instruments. These omissions highlight the lack of comprehensive research examining the interplay between local environmental policies and the broader objectives of green finance in fostering sustainability in the region.

Moreover, existing research predominantly adopts a global or regional perspective, such as Jian & Afshan's [29] insights into green financing and carbon neutrality in G10 countries, which do not fully consider East African countries' unique socio-economic challenges and institutional weaknesses. Works like Nguyen & Khominich [31] which explore spatial and spillover effects of green investment, provide valuable insights but fail to contextualize these dynamics within the fragmented energy markets and uneven financial access characteristic of the EAC region. These gaps underscore the urgent need for localized studies that investigate how green finance mechanisms can be tailored to address the specific environmental, economic, and institutional challenges of East Africa while leveraging its opportunities for green economic growth.

According to Ngepah et al. [8] earth system processes in East Africa are hugely influenced by green finance, especially in soil conservation, sustainable mining, and managing water resources. Similar to Ngepah, et al. [8] and Coulibaly [34] believes investments in hydrological projects have improved the availability and quality of water, contributing to agricultural productivity and ecosystem resilience. In the mining sector, initiatives for green financing have simplified the implementation of environmentally friendly practices, reducing the negative effects of extractive activities on water resources and soil [8, 34].

The primary objective of this paper is to perform a bibliometric analysis of 147 studies conducted from 2017 to 2024 to evaluate the development, prevailing trends, key themes, and knowledge gaps in green finance and environmental policy in East African Countries (EAC). The paper further examines how green finance can mitigate drought, energy poverty, and deforestation in East Africa. The study provides insights into how green finance aligns with environmental policies to address pressing sustainability challenges. By synthesizing the academic discourse and using the bibliometric VOSviewer tool, the study aims to uncover the evolution of research themes, collaborations, and methodologies employed in this field. This analysis will provide a nuanced understanding of the integration of green finance into regional environmental policies, highlighting critical enablers and barriers to achieving sustainable development within the EAC context. Furthermore, the study seeks to identify actionable

recommendations for advancing research and practical applications in this domain. To achieve this, the study explores critical questions regarding the evolution of scholarly output, the efficacy of green finance mechanisms, the barriers to their adoption, and the integration of global trends into regional contexts, ultimately offering a roadmap for future research and policy innovation.

Accordingly, this study will address the following research questions.

RQ1: What are the key themes and trends in the literature on green finance and environmental policy in East African Countries (EAC) from 2017 to 2024?

RQ2: What are the primary challenges and barriers to implementing green finance initiatives in the EAC region?

RQ3: How have scholarly collaborations, authorship patterns, and publication trends evolved in the field of green finance and environmental policy in the EAC?

RQ4: Which green finance instruments, such as green bonds or public-private partnerships, have been most emphasized in addressing environmental challenges in the EAC?

RQ5: What gaps exist in the current research on green finance and environmental policy in the EAC, and how can future studies address these gaps?

## 2. Materials and Methods

This study employs a comprehensive bibliometric analysis to examine the landscape of green finance and environmental policy research in East African Countries (EAC) from 2017 to 2024. The methodology follows established practices in bibliometric studies, adapting them to the specific context of this research [1, 21, 35].

### 2.1. Data Collection and Preprocessing

The Scopus database was utilized for data collection, given its extensive coverage of academic literature and its advantage over the Web of Science in terms of journal coverage [1]. On March 25, 2024, a query was conducted using the following search string in the Article title, Abstract, and Keyword fields [1]: ("green finance" OR "carbon sequestration" OR "renewable energy" OR "sustainable finance" OR "climate finance" OR "biodiversity conservation" OR "environmental finance") AND ("environmental policy" OR "climate policy") AND ("East Africa" OR "Kenya" OR "Uganda" OR "Tanzania" OR "Rwanda" OR "Burundi" OR "South Sudan") OR "Somalia") OR "Democratic Republic of the Congo".

This search initially yielded 1013 documents. The dataset was then refined based on three primary exclusion criteria: language (English only), document type (peer-reviewed articles and journal papers), and publication timeframe (2017-2024). After applying these criteria, a final sample of 147 documents was selected for analysis.

### 2.2. Data Analysis

The bibliometric analysis was performed using VOSviewer software, a widely utilized tool for visualizing and analyzing bibliometric networks [1, 35]. The study focused on three key aspects: descriptive analysis, which provided insights into publication trends and the temporal distribution of research output Muchiri et al.[21]; citation analysis, which evaluated the impact of publications, authors, sources, countries, and organizations in the field Krastev and Krasteva-Hristova [1] and structural analysis, which explored the conceptual, intellectual, and social frameworks shaping the research landscape [35].

### 2.3. Analytical Approaches

The study utilized multiple analytical techniques to gain a detailed understanding of the research landscape. Co-authorship analysis assessed collaboration patterns among researchers, institutions, and countries. Co-citation analysis identified influential publications and key research themes by examining how frequently papers were cited together. Bibliographic coupling explored the connections between

publications based on shared references. Additionally, the keyword co-occurrence analysis provided insights into prominent research themes and their progression over time by analyzing the frequency of keywords appearing together in the literature.

#### 2.4. Visualization

VOSviewer was utilized to create visual representations of the bibliometric data [35]. These visualizations included network maps of co-authorship, country collaborations, keyword co-occurrences, and density visualizations to highlight prominent topics and clusters in the field.

#### 2.5. Performance Analysis

The study evaluated the impact and productivity of researchers, institutions, and countries using a range of performance metrics. These included publication metrics, such as the total number of publications, single-authored works, and collaborative publications. Citation metrics were used to measure influence and academic reach, including total citations, average citations per publication, and the h-index, as shown in Table 2. Additionally, combined metrics like the Collaboration Index and Degree of Collaboration were employed to assess the extent and quality of cooperative efforts within the research community.

#### 2.6. Interpretation and Reporting

The final stage involved interpreting the bibliometric analysis results in the context of green finance and environmental policy in East African Countries [36]. This interpretation focused on identifying key trends, research gaps, and potential future directions for research in this field.

By employing this comprehensive bibliometric approach, this study aims to provide a thorough overview of the current state of research on green finance and environmental policy in East African Countries. It highlights the most influential works, authors, and emerging trends in this important field [37]. The analysis seeks to contribute to the understanding of how this research area has developed from 2017 to 2024, identifying key themes and knowledge gaps to guide future research efforts [38].

This methodology allows for a systematic exploration of the literature, providing insights into the intellectual structure of the field, collaboration patterns, and the evolution of research themes over time [37]. By combining quantitative bibliometric techniques with qualitative interpretation, this study aims to offer a nuanced understanding of East African countries' green finance and environmental policy landscape [37].

The use of multiple analytical approaches and visualization techniques ensures a comprehensive examination of the research field, allowing for the identification of both established and emerging trends [38]. This multifaceted approach provides a robust foundation for understanding the current state of research and identifying promising avenues for future investigation in the realm of green finance and environmental policy in East African countries [38].

### 3. Results

In the context of this bibliometric analysis of green finance and environmental policy in East African Countries (EAC), the results section evaluates the influence of sources, publications, and authors through citation analysis. Citation analysis serves as a measure of the impact and relevance of journals, publications, or authors by examining the total number of times their work has been cited in other scholarly studies. This metric highlights the contribution of a publication or author to the broader academic community and its utility to other researchers [39].

Citations also signify the extent to which a publication incorporates the ideas, findings, or methodologies from prior works, making the citation count a key indicator of a study's influence [40]. Tools such as Bibliometric and VOSviewer have been utilized to profile citation analysis across various dimensions, including by source, publication, author, country, and institution. This analysis provides

insights into the foundational works and contributors shaping the discourse on green finance and environmental policy within the EAC region.

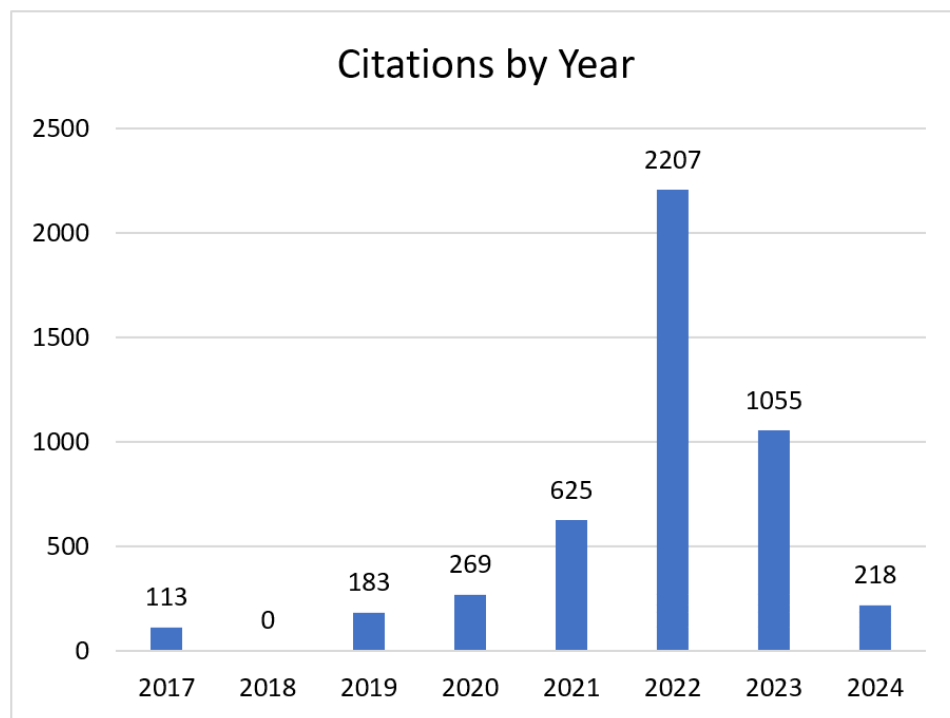
### 3.1. Descriptive Analysis

The sample includes 147 scientific articles written by 523 authors across 31 Scopus journals. Among these articles, 9 are by single authors, and 138 are co-authored. The study covers a period of eight years, from 2017 to 2024. The average number of published articles per year is approximately 18 (precisely 18.375). In general, the subject of the study, which is the challenges and trends in green finance and environmental policy in East African Countries (EAC), is not written much, as can be seen in the number of articles that have been written in the sector for around 8 years.

### 3.2. Citation Analysis

#### 3.2.1. Citation by Years

The citation trend of the 'Green Finance and Environmental Policy in East African Countries (EAC)' from 2017 to 2024 uncovers noteworthy insights into the evolution and impact of this research area. As indicated in Figure 1, the number of citations has experienced significant fluctuations over the years. In 2017, the field recorded 113 citations, marking a modest beginning; however, 2018 saw a sharp decline to zero citations, suggesting either a slowdown in impactful research or delayed recognition of published sectoral studies during that year. The momentum resumed again in 2019, with citations increasing to 183, suggesting renewed interest and the publication of more influential research articles.



**Figure 1.**  
Citations by Year.

Significant growth was evident in 2020 and 2021, with citations increasing to 269 and 625, respectively. This upward trend highlighted a period of increased academic engagement and possibly reflected emerging policy discussions or green finance initiatives in the EAC region. In 2022, the most remarkable leap, with skyrocketing citations of 2,207, occurred. This exceptional increase could signify

a critical mass of high-quality research or a pivotal shift in the field, perhaps driven by regional sustainability or global agendas aligning closely with green finance and environmental policies.

However, the data for 2023 indicates a sharp decrease to 1,055 citations. Despite this representing a plunge compared to the previous year, it still demonstrates strong academic interest. The decline may suggest a change in research focus or the maturation of previously dominant themes. Finally, by 2024, citations further declined to 218, possibly reflecting a phase of consolidation in the field, where fewer but perhaps more focused studies were cited. Therefore, this pattern could also indicate a shift towards exploring new study directions or a reorientation of academic discourse. Conclusively, the citation trends signify the dynamic nature of research in green finance and environmental policy within the EAC, showcasing periods of intense influence and the evolving scholarly landscape over the analyzed years.

### 3.2.2. *Top-Most Frequently Cited Articles*

Table 1 below showcases the top-most frequently cited articles in the field of green finance and environmental policy, indicating influential studies that have significantly contributed to the academic discourse. The most cited article among the 10 articles is “How Does Green Finance Affect Green Total Factor Productivity? Evidence from China” by Lee & Lee [41], published in *Energy Economics*, which received 648 citations, presenting its strong impact on the sector. This is followed by the highly cited paper by Irfan, et al., [42] published in *Technological Forecasting and Social Change*, which explores the mechanism of influence between green finance and green innovation, accumulating 417 citations.

The top ten list also includes Zhang et al. [43], whose work on the environmental effects of green credit policy in China received 363 citations. Furthermore, Madaleno et al. [44] and Hafner et al. [45] offered valuable insights into the nexus between green technology, clean energy, and green finance, with 226 and 192 citations, respectively. Notably, studies focusing on macroprudential policies D’Orazio et al. [46] and the role of green finance in OECD economies Umar et al. [47] further demonstrate the diverse applications and regional insights within this research domain. These highly cited works in Table 1 below emphasise the dynamic interplay between green finance, environmental policy, and sustainable development, providing foundational knowledge for ongoing and future research in East African countries (EAC).



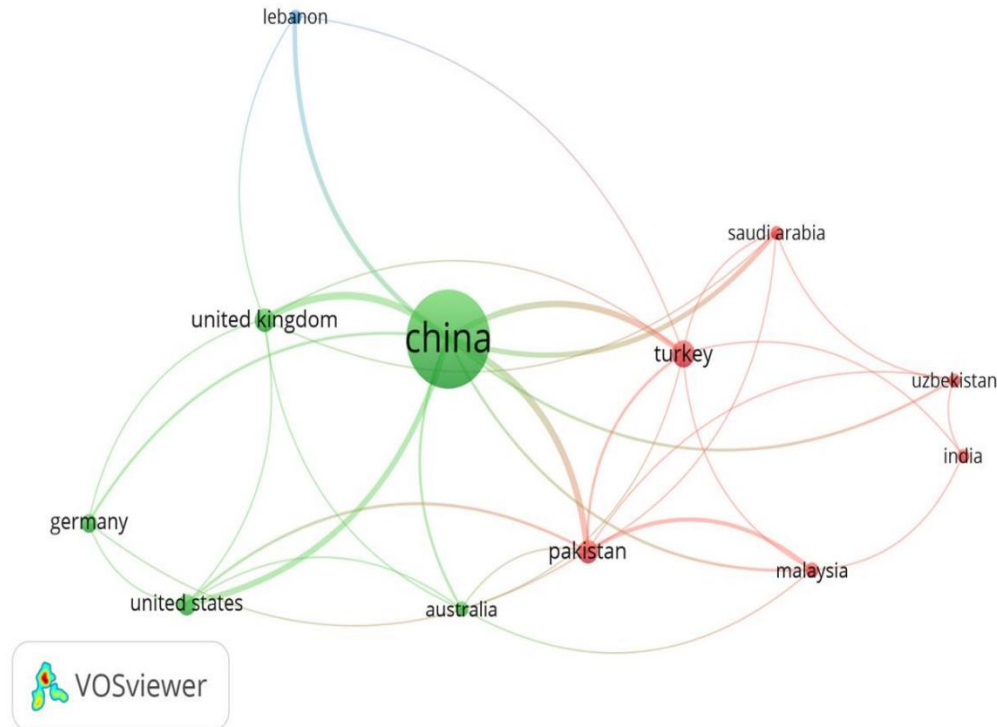
**Table 1.**  
Top-most frequently cited articles.

#	Title	Journal	Citations	Year	References
1	How does green finance affect green total factor productivity? Evidence from China	Energy Economics	648	2022	Lee and Lee [48]
2	Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China	Technological Forecasting and Social Change	417	2022	Irfan, et al. [49]
3	Fostering green development with green finance: An empirical study on the environmental effect of green credit policy in China	Journal of Environmental Management	363	2021	Zhang, et al. [50]
4	A step forward on sustainability: The nexus of environmental responsibility, green technology, clean energy and green finance	Energy Economics	226	2022	Madaleno, et al. [51]
5	Closing the green finance gap – A systems perspective	Environmental Innovation and Societal Transitions	192	2020	Hafner, et al. [52]
6	Clean energy investment and financial development as determinants of environment and sustainable economic growth: evidence from China	Environmental Science and Pollution Research	173	2022	Zahoor, et al. [53]
7	Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies?	Ecological Economics	165	2019	D’Orazio and Popoyan [54]
8	“Green” innovation, privacy regulation and environmental policy	Renewable Energy	137	2023	Pan, et al. [55]
9	How environmental regulations affect the development of green finance: Recent evidence from polluting firms in China	Renewable Energy	136	2022	Xu, et al. [56]
10	Do green finance and innovation matter for environmental protection? A case of OECD economies	Energy Economics	132	2023	Umar, et al. [57]

### 3.2.3. Influential Countries

A VOSviewer network visualization was developed to find the top 10 influential countries and their collaborative relationships in the research domain. Co-authorship analysis was chosen as the type of analysis, with the unit of analysis set to countries, while fractional counting was applied as the counting method. Henceforth, to ensure meaningful representation, a minimum threshold of 10 documents and 10 citations per country was established.

China has emerged as the most dominant country in the field of green financing and environmental regulatory policies, as indicated by its central position and largest node size in the network shown in Figure 2 below. China has maintained strong connections with multiple countries, which indicates its pivotal role in fostering international collaborations. Remarkably, China has strong co-authorship linkages with Asia, Middle Eastern, and Eastern countries, stressing its important role in shaping research discussions and knowledge production. China’s partnerships with major economies such as the UK, the USA, Australia, Pakistan, and Germany reinforce its strategic position as a leading research hub within the field of green financing and environmental policies.



**Figure 2.**  
Influential Countries.

The Western research cluster, which includes Germany, the United States, the United Kingdom, and Australia, demonstrates substantial research networks, particularly with China. Germany, the United States, and the United Kingdom stand out as some of the most active contributors. This underscores their historical position in global academic and economic discourse. As per Figure 2 below, Australia shows visible interconnectivity, indicating that while it may not be as dominant as the UK or the US, it contributes meaningfully to the research network globally. The high degree of collaboration within the stated group of countries suggests that developed nations continue to lead in scientific advancements, knowledge dissemination, and policy development.

In contrast, the Asia-Middle Eastern cluster includes Uzbekistan, Malaysia, India, Turkey, Pakistan, and Saudi Arabia, all of which exhibit varying degrees of collaboration with China. Pakistan has emerged as a key intermediary country, establishing strong links between China and Middle Eastern countries such as Turkey and Saudi Arabia. The Turkey-Malaysia connection suggests shared research interests, likely influenced by regional economic and trade relations. Finally, Uzbekistan and India, while present in the network, have relatively smaller node sizes, suggesting that although their contributions are growing, they remain moderate players in global research collaborations.

#### 3.2.4. Top-Most Frequently Cited Sources

Table 2 presents the primary academic sources in the field of green financing within AEC, emphasizing the impact of important journals. “Energy Economics”, published by Elsevier, ranks as the most impactful journal, accumulating 1,084 citations from 11 publications. With an impressive citations per publication rate of 98.55, a Cite Score of 18.6, a strong SNIP of 2.637, and an SJR of 3.555, it significantly contributes to green finance research. “Renewable Energy”, also published by Elsevier, maintains a strong presence with six publications and 431 citations, achieving a citation per publication ratio of 71.83 and a high h-index of 250. Additionally, the “Journal of Environmental Management”

shows lasting influence with 13 publications, 547 citations, and an h-index of 243, highlighting its research relevance.

Other important journals include “Environmental Science and Pollution Research by Springer Nature, which offers 25 publications with 546 citations and a steady citation per publication rate of 21.84. Although its impact metrics are moderate, it remains a valuable source in this field. “Technological Forecasting and Social Change,” another Elsevier journal, boasts the highest citation per publication ratio (127.75) among the listed sources. Notably, journals published by Taylor & Francis, such as “Climate Policy” and “Journal of Environmental Management,” also make significant contributions with impressive citation metrics. Overall, these journals, particularly those published by Elsevier, play a crucial role in advancing research and discussions on green finance and environmental policy within the EAC region.

**Table 2.**

Top-most frequently cited sources.

Sources	TP	TC	CPP	Cite Score	SNIP	SJR	H-Index	Publisher
Climate Policy	4	94	23.5	12.9	1.987	2.245	85	Taylor & Francis
Energy Economics	11	1084	98.5455	18.6	2.637	3.555	210	Elsevier
Environmental Science and Pollution Research	25	546	21.84	8.7	1.141	1.006	179	Springer Nature
International Journal of Environmental Research and Public Health	7	215	30.7143	7.3	1.077	0.808	198	Multidisciplinary Digital Publishing Institute (MDPI)
Journal Of Environmental Management	13	547	42.0769	2.6	0.384	0.346	243	Taylor & Francis
Renewable Energy	6	431	71.8333	18.4	1.934	1.923	250	Elsevier
Resources Policy	10	178	17.8	13.4	2.083	2.063	114	Elsevier
Technological Forecasting and Social Change	4	511	127.75	21.3	2.945	3.118	179	Elsevier

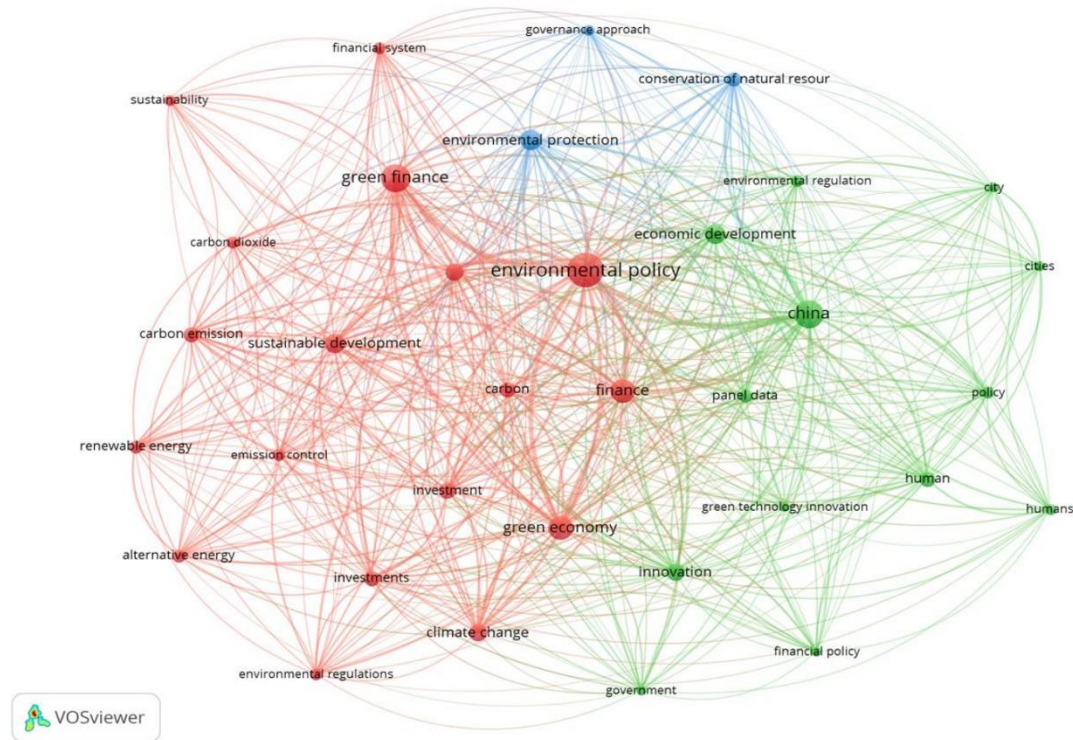
### 3.3. Keywords

The analysis of the 142 authors ‘keywords’ in the field of ‘Green Finance and Environmental Policy in EAC’ discloses distinct thematic clusters and frequently occurring terms, illuminating the primary focus of the research landscape as illustrated in Figure 3. The study employed VOSviewer, which revealed three main clusters of keywords, each representing a critical aspect of green financing and environmental policy research. The first and most significant cluster is dominated by the keyword “Green Finance,” which frequently co-occurs with related terms like “Green Investment, Green Technology Innovation, and Green Bonds.” These keywords emphasize the importance of financial instruments and innovations in promoting economic growth and environmental sustainability.

The second most important cluster includes keywords such as “Sustainability, Renewable Energy, and Environmental Policy,” reflecting a strong focus on policy frameworks and sustainable practices that contribute to reducing carbon emissions and enhancing green initiatives. Moreover, the data analysis underlines “Climate Change, Environmental Regulation, and Carbon Neutrality” as critical terms, highlighting the importance of regulation and policies and achieving long-term climate sustainability goals.

The third last cluster that has drawn the attention of the author is the cluster that features analytical methods such as “CS-ARDL, Difference-in Difference (DiD), and Panel VAR,” signifying the in-depth methodological approaches in evaluating the green financing effects on economic and environmental outcomes. The emergence of concepts like “Sustainable Development Goals, Fintech, and Green Economy” proposes a growing interest in integrating technological know-how and socio-economic initiatives into the discourse of green financing. Overall, the analysis of the key research

words indicates a comprehensive research domain concerning financial, policies, and technological perspectives aimed at promoting sustainable development in the EAC region.



**Figure 1.**  
Analysis of the co-occurrence of keywords.

### 3.4. Citation Analysis by Author

Citation analysis is a method used to identify groups of publications that are frequently cited, offering valuable insights into emerging research themes within the field under study. The technique of co-citation analysis of highly referenced authors/co-authors helps researchers to comprehend the foundational structure of a discipline and explore potential avenues for further research. The following Figure 4 illustrates the co-citation matrix and how often two authors are cited together [58].

The VOSviewer enables co-citation analysis by sources, references, and authors. In this paper, author-level co-citation analysis is applied using a preset threshold to prioritize the most relevant connections. Given the huge number of authors in the dataset, this threshold confirms that only meaningful co-citation relationships are visualized, allowing for the identification of structured intellectual clusters within the research network.

Based on the VOSviewer clustering visualization, the intellectual structure can be sorted into the below 4 distinct thematic groups.

#### 3.4.1. Red Cluster – Core Network (Green Finance and Sustainability)

The red cluster represents a well-established co-citation network of scholars specializing in green financing, investment strategies, and sustainability. Leading scholars in this category include Wang et al.[26]; Zhang et al.[43]; Li et al.[59] and Zou et al.[3] who have made remarkable contributions to the search for financial mechanisms. Their contribution supported sustainable development, the role of policy interventions in environmental financing, and empirical studies of green investment.

### 3.4.2. Green Cluster (*Empirical Investigations in Financial Development Energy Policy*)

This cluster primarily focuses on empirical research examining financial development, sustainable financial frameworks, and energy policy. The most frequently cited scholars in this cluster include Pesaran et al.[60]; Umar et al.[47] and Abbas et al.[61] whose research articles explore the intersection of financial markets, energy transition policies, and macroeconomic trends. Their work offers critical insights into how financial systems influence the adoption of renewable energy and contribute to long-term economic stability.

### 3.4.3. Blue Cluster (*Financial Markets, Market Innovation, and Investment Strategies*)

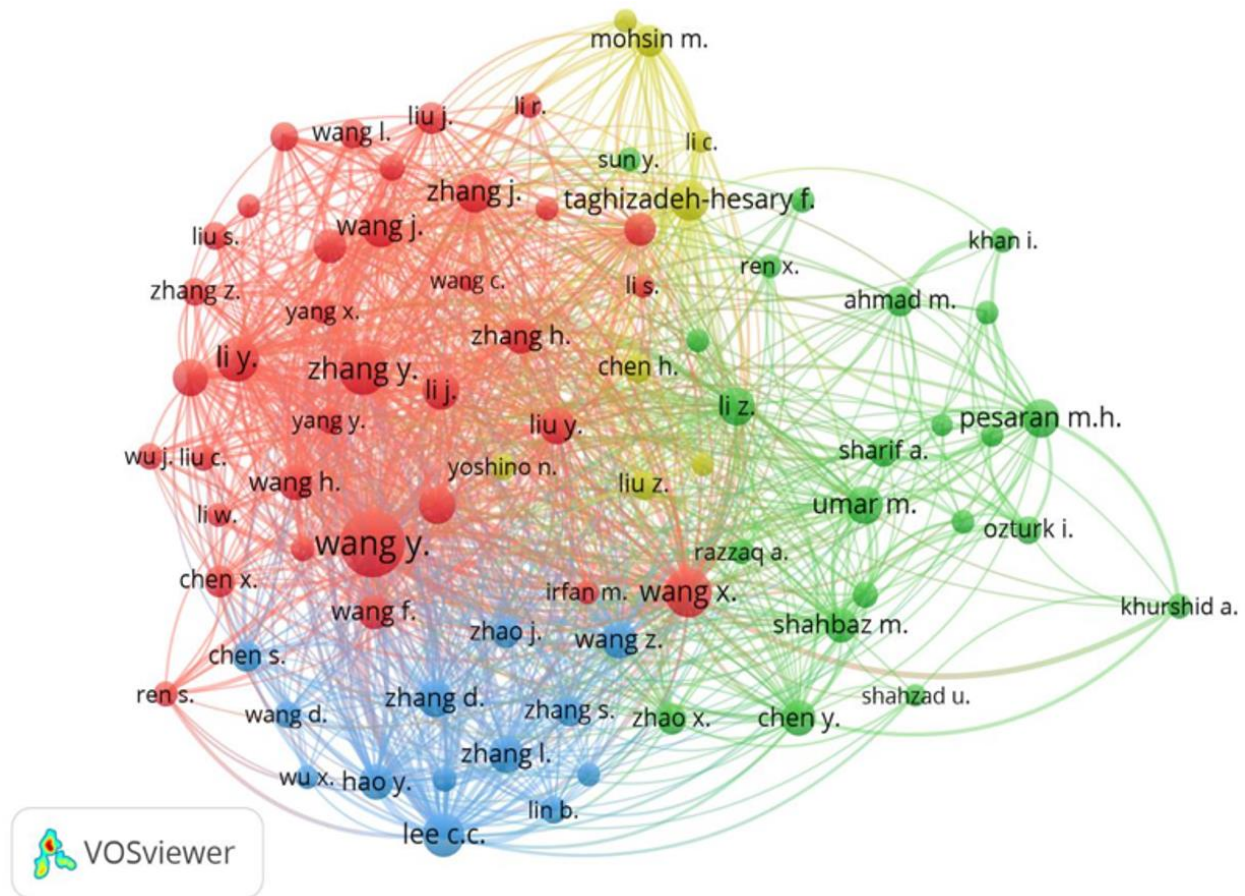
The blue cluster focuses on financial economics, investment behaviors, and innovation in financial markets. Scholars such as Song et al.[62], Sun et al.[63], and Lee & Chen [64] play an important role in the green financing and environmental policy areas, contributing to the academic debates on financial market integration, economic growth, and, most importantly, investment decision-making processes. These scholars' work examines financial liberalization, cross-border capital flows, and technological advancement in shaping systems of finance.

### 3.4.4. Yellow Cluster (*Sustainable Financial Systems and Policy Governance*)

The final yellow cluster consists of a specialized group of researchers focusing on sustainable financial governance and regulatory policies. Key authors, including Shahbaz et al. [65] and Mohsin et al.[66] contribute to research on green financial systems, broader implications of financial governance for environmental and economic transitions, and policy interventions for sustainability.

Therefore, the co-citation analysis discussed above highlights the multidisciplinary nature of financial research, revealing clusters dedicated to green finance, investment strategies, empirical green finance studies, and, most importantly, sustainable policy frameworks. The scholars' interconnectedness suggests a growing emphasis on addressing sustainability challenges through financial instruments, regulatory frameworks, and investment policies, demonstrating the evolving intellectual landscape of financial research.





**Figure 2.**

Citation Analysis by Author.

Source: Wang, et al. [67]; Wang, et al. [68]; Li, et al. [69]; Li, et al. [70]; Li, et al. [71]; Zahoar, et al. [53]; Zakari and Khan [72]; Zhang, et al. [50]; Zhao, et al. [73]; Zou, et al. [74]; Umar, et al. [57] and Shahbaz, et al. [65]

#### 4. Results and Discussions

The study undertook a detailed bibliometric analysis of 147 published papers from 523 scholars based on green financing and environmental policy in East African Countries (EAC) from 2017 to 2024. The aim was to get an in-depth understanding of the gaps and issues surrounding green finance and environmental policy in EAC. The bibliometric analysis enhanced understanding of the research space, the major issues, trends, prominent authors, articles, and newly developed concepts within the domain of green financing.

As pointed out by Khan et al. [32] the impact of green finance tends to fluctuate across regions for a variety of reasons, such as GDP, innovation, and environmental quality. Such fluctuations are even more distinct within EAC owing to the unsophisticated structural market fragmentation, weak institutional quality, and uneven adoption of sustainability frameworks. Furthermore, Krastev & Krasteva-Hristova [1] argue that the impact of green finance is deeply rooted in the institutional maturity and the level of policy compliance. This implies that for EAC countries, there are green finance plans that directly respond to situational capitals and are pro-local environmental and socioeconomic objectives [1, 35].

More recently, Darko et al. [75] highlighted the use of policy incentives and financial technology solutions for green finance, specifically in policy-deficient developing countries. In EAC countries, digital financial technologies blended with new policy instruments have the potential to bust the

barriers of traditional banking systems. Nasim [36] further argues that excluding fintech from the perspective of green financing lowers access for already marginalized small businesses, which makes the issue even more pressing for the EAC states to act. EAC governments could learn from China's rapid adoption of green fintech ecosystems[23].

The linkage between green finance and business environmental, social, and governance (ESG) practices is gaining significance. Wang et al. [76] showed that green financial policies boost corporate ESG performance, although there are geographic gaps in policy promotion and implementation. Krastev & Krasteva-Hristova [1] also noted that the implementation of ESG policies is now commonplace in business administration, assessment of financial risks, and decision-making regarding investments. For the case of the EAC region, the establishment of ESG tracking and disclosure rules in national laws may improve governance and reduce cynicism while enhancing the level of sustainable investment[1].

Renyong & Sedik [5] argued that foreign direct investment (FDI) can lead to enhanced environmental quality over the long term when accompanied by sustainability policies, even though deterioration may occur initially. This is particularly important in the EAC region where FDI is frequently received with no or little unnecessary environmental conditions attached. More robust environmental, institutional, and regulatory frameworks can help ensure that the new FDI meets with local sustainability goals. Additionally, policy frameworks should encourage sustainable cross-border investments, drawing on lessons from ASEAN countries where green bonds and green energy funds are successfully tied to foreign capital inflows [61].

Luo, et al. [77]proved that green technology innovation firmly underpins green finance in achieving carbon neutrality. The EAC region lacks sufficient research and development (R&D) investment in this area currently and relies highly on imported technologies. Increasing indigenous R&D capacity and fostering innovation ecosystems are central to backing homegrown solutions for environmental problems. According to Chou et al.[78], bridging renewable energy integration and sustainable economic growth is also essential to long-term carbon mitigation. The EAC countries need to emphasize public-private innovation collaborations and utilize regional organizations to facilitate technology transfer and knowledge sharing [58, 77].

Ozili [22] noted the challenge of the lack of consistent definitions and policy harmonization initiatives for green finance at the global level. Similarly, Maria et al. [35] noted that green finance terminology, from climate finance to sustainable finance, is applied loosely without definition across the board, leading to fragmented policymaking. For the EAC countries, harmonization of green finance definitions both at regional and national levels is necessary to avoid regulatory duplication, reduce investor confusion, and promote standardized reporting and evaluation practices [1, 35].

The study of green banking trends in China also disclosed that green credit portfolios are more stable financially, having much lower non-performing loan ratios than conventional lending approaches [23]. This is overwhelming evidence to back the claim that financial institutions that are part of EAC can gain from transitioning to green portfolios. Policymakers and regulators should implement incentives such as minimum capital reserve ratios for green credit banks and establish regulations whose primary focus is addressing climate risks [1, 23].

As demonstrated by the findings, green financing has emerged as an important for promoting sustainable development and addressing environmental challenges. According to Nguyen & Khominich[31], economic development is directly influenced by green finance, while it also indirectly reduces environmental pollution in Russia. Their studies covering 85 constituent entities from 2010 to 2021 further indicated that the quality of green economic development is significantly influenced by green investment. East Africa's green finance initiatives have the potential to reduce CO<sub>2</sub>, particularly through investment in renewable energy and the rehabilitation of land projects [79]. Additionally, remote sensing analysis exhibited that reforestation efforts financed by green bonds in East Africa, particularly Tanzania and Kenya, have led to measurable carbon sequestration [9, 10]. However, as Maria et al. [35]noted, the scale of green investment remains significantly lower in developing regions. This resulted in fragmented outcomes rather than systemic carbon reduction. According to Wang et

al.[26], East Africa needs to significantly upscale sustainable energy, urban infrastructure, and agroforestry investments to realize comparable environmental benefits to developed nations that achieved 20% reductions in urban air pollution.

Similar to the studies by Nguyen & Khominich[31], Tangl & Desalegn[80], Lee J. [30], and Van Song et al.[81], this study confirms that public-private partnerships (PPPs), green ponds, and other related financial mechanisms are of interest to scholars in the EAC region. Nonetheless, in correlation to the analysis of section 3.1, which was focused on descriptive analysis, the research outputs regarding green financing alongside environmental policy are considerably low with respect to global standards. Within this sharp gap of research, there is indeed room for growth and further sectorial analysis, as well as some level of obstruction that can restrict prospective academic involvement efforts. East Africa faces unique environmental challenges that directly influence the adoption and success of green initiatives[82]. Deforestation, desertification, persistent droughts, and floods intensify the region's vulnerability to climate change, impacting lives and livelihoods and increasing the financial risk correlated with green investment[35, 83, 84].

Unlike China, well-established and strong institutions have buffered green finance against economic and environmental volatility Wang et al.[26], East African countries operate within unpredictable and highly fragmented regulatory environments exacerbated by a lack of harmonized frameworks [1, 22, 35]. In addition to the above, studies demonstrated that financial technology platforms are not yet fully leveraged to build climate resilience through micro-level-green lending in rural communities [36, 85]. To address the aforementioned challenges, the East African Community must design green finance instruments that are not only climate-smart but also risk-sensitive, particularly for agriculture, water, and energy sectors, which are disproportionately climate-sensitive.

The citation pattern exhibits unstable academic interest, peaking in 2022 followed by a gradual decline, indicating potential saturation in certain themes or a shift towards more niche topics. Leading scholarly articles, such as those by Irfan et al. [42] on the green finance and innovation nexus and Lee & Lee [41] on green total factor productivity, serve as a cornerstone of this scholarly discourse. It is worth noting that the most highly cited papers originate from institutions in the Global North, which reinforces the existing literature gap in localized research for the EAC region [80].

Furthermore, the paper revealed strong co-citation clusters related to green innovations, financial economics, empirical financial development, and policy analysis. Although this intellectual structure aligns with the global findings as evidenced by scholars like Lee & Chen [64] and Wang et al.[76], there remains a clear absence of Africa-specific frameworks. China and other developed nations dominated the research outputs of this sector, which highlights the discrepancy between the research outputs of developed and developing nations. This necessitates the need for capacity strengthening and knowledge transfer into the EAC countries and in Africa generally.

Green finance has evolved toward a mainstreaming tool for sustainability globally Maria et al., [35], particularly visible in the financial systems of the European Union (EU), OECD, and China[1, 76]. According to Choi et al.[23], China's policies on green credit and environmental regulations have played a crucial role in transforming industrial investment patterns towards low-carbon alternatives, significantly reducing emissions and enhancing air quality. However, EAC's experience diverges in key ways, notably institutional weakness, limited access to investment resources, and fragmented environmental policy frameworks that constrain the scope and effectiveness of green finance in the region [22, 86]. While Kenya's green bond initiatives and Tanzania's afforestation bonds offer promising models [66, 9], scaling these requires concerted policy alignment, reform in the financial sector, and targeted climate risk management that is still emerging in the East African countries [69, 70]. There, the East African Community region can leverage the best global green finance practices while tailoring these lessons to the unique vulnerabilities and institutional realities of East Africa[35, 58].



## 5. Conclusion and Recommendations

Building on the study findings, it is evident that green finance plays an important role in promoting environmental sustainability and economic resilience across EAC [35, 79]. However, significant policy interventions are needed to maximize its potential, especially by scaling green bond financing for reforestation, sustainable agriculture, and solar energy projects [24, 87-89]. Drawing on successful international approaches, particularly China's integrated green finance policies, that have significantly reduced air pollution and promoted ESG practices [26, 23]. This section outlines strategic interventions and recommendations specifically tailored for the EAC context. Importantly, future research should focus on climate finance, sustainable agriculture, and geospatial technologies to monitor green investment outcomes.

The co-occurrence analysis of keywords indicated three significant research clusters focusing on innovative green finance approaches, policy frameworks, and advanced econometric methodologies. The introduction of new approaches, such as financial technology and sustainable development goals, suggests a growing recognition of multidisciplinary approaches. However, there is still insufficient contextualization of these methodologies for the fragmented markets and institutional structures characteristic of the EAC countries.

Considering the findings discussed above, this study emphasizes the importance of new research programs that employ strict empirical processes and also take advantage of the distinct economic environments of EAC countries. Future research should aim to bridge the geographic and institutional gaps, incorporating African-specific financial instruments and policies that promote environmental sustainability. Moreover, promoting international and cross-nation collaborations between scholars and institutions in the Eastern Africa Communities (EAC) region and more developed economies is important in developing green finance and environmental policy.

In light of these results, some of the key recommendations to the East African Community (EAC) region include promoting green finance and environmental policymaking. First, regional policy harmonization and institutional capacity building are imperative steps to ensure that discrepancies in green finance application and implementation are taken care of, as indicated [35]. Harmonizing national policy with regional policy will ensure a smoother investment climate and a cooperative approach to research. Second, the EAC nations are required to promote public-private partnerships and green cross-border investments, drawing inspiration from ASEAN's and the European Union's successful experiences, where collective action has scaled up green finance flows and innovation [1, 61]. Third, fintech solutions must be utilized to enhance green investment financial inclusion, especially for SMEs and rural communities that have less access to conventional financing channels. China's frenetic embrace of fintech-facilitated green credit scoring and online platforms is a valuable example for the EAC countries. Moreover, it is important to reinforce environmental institutions so that foreign direct investment (FDI) is consistent with sustainability goals and adheres to high environmental performance criteria. Lastly, investing in domestic research, technology innovation, and cooperation with tertiary education institutions will be key to closing the innovation gap, enabling contextualization of international best practices, and developing homegrown solutions that are suited to the unique environmental and economic realities of the EAC nations.

### Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

### Copyright:

© 2025 by the authors. This open-access article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## References

- [1] B. Krastev and R. Krasteva-Hristova, "Challenges and Trends in Green Finance in the Context of Sustainable Development—A Bibliometric Analysis," *Journal of Risk and Financial Management*, July 14 2024.
- [2] S. D. Beyene and B. Kotos, "Testing the environmental Kuznets curve hypothesis: an empirical study for East African countries," *International Journal of Environmental Studies*, vol. 77, no. 4, pp. 636–654, November 28 2020.
- [3] L. Zou, Y. Liu, Y. Wang, and X. Hu, "Assessment and analysis of agricultural non-point source pollution loads in China: 1978–2017," vol. 263, June 1 2020.
- [4] E. Chambile, J. D. D. Hakizimana, and N. E. Kiprotich, "Exploring Implication of Renewable Energy Transition on the Cost of Electricity and Green House Gases Emission in East African Countries," in *Kigali, Rwanda 2021: IEEE Southern Power Electronics Conference (SPEC)*.
- [5] H. Renyong and A. A. Sedik, "Environmental Sustainability and Foreign Direct Investment in East Africa: Institutional and Policy Benefits for Environmental Sustainability," *Sustainability*, January 12 2023.
- [6] R. K. Shakyia, "Green Public Procurement Initiatives in East African Community (EAC): The Way Forward," pp. 1–15, 2019.
- [7] K. K. Muna, "Green Financing," *Economics, Environmental Science Development*, March 25 2017.
- [8] N. Ngepah, J. H. Eita, C. R. T. Djemo, and C. S. Saba, "Towards environmental sustainability path in Africa: The critical role of ICT, renewable energy sources, agriculturalization, industrialization and institutional quality," *Energy Reports*, vol. 10, pp. 4025–4050, November 2023.
- [9] I. K. Rotich, H. Chepkirui, and P. K. Musyimi, "Renewable energy status and uptake in Kenya," *Elsevier*, vol. 54, p. 101453, July 2024.
- [10] J. C. Ingram *et al.*, "Evidence of Payments for Ecosystem Services as a mechanism for supporting biodiversity conservation and rural livelihoods," *Ecosystem Services*, vol. 7, pp. 10–21, March 2014.
- [11] R. Kumar *et al.*, "Agroforestry and Its Potential for Sustainable Land Management and Climate Action: A Review," *International Journal of Environment and Climate Change* vol. 13, no. 12, pp. 620–629, December 22 2023.
- [12] P. Datta, B. Behera, and D. B. Rahut, "Climate change and Indian agriculture: A systematic review of farmers' perception, adaptation, and transformation," *Environmental Challenges*, vol. 8, p. 100543, August 2022.
- [13] J. Zhao, L. Li, Z. Li, Z. Chen, L. Xiao, and G. Chen, "Multi-segment fuzzy control for start-up optimizing of LCC-based high-voltage power supply," *Elsevier*, vol. 8, pp. 552–559, April 2022.
- [14] V. Nzabarinda *et al.*, "Expanding forest carbon sinks to mitigate climate change in Africa," *Environmental Management*, vol. 207, pp. 411–419, January 2025.
- [15] Y. Sun *et al.*, "Emission accounting and drivers in East African countries," *Applied Energy*, vol. 312, April 15 2022.
- [16] J. Hu, M. Umair, and J. M. Chen, "Green finance and renewable energy growth in developing nations: A GMM analysis," vol. 10, July 13 2024.
- [17] D. R. Dusengemungu *et al.*, "BRI effect on the environmental performance of energy consuming and producing enterprises in East African Countries: Perspectives and recommendations," *Energy*, vol. 320, p. 135184, 2025.
- [18] R. Agrawal, S. Agrawal, A. Samadhiya, A. Kumar, S. Luthra, and V. Jain, "Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions," *Geoscience Frontiers*, vol. 15, no. 4, p. 101669, July 2024.
- [19] C. S. Saba, C. R. T. Djemo, J. H. Eita, and N. Ngepah, "Towards environmental sustainability path in Africa: The critical role of ICT, renewable energy sources, agriculturalization, industrialization and institutional quality," *Energy Reports* vol. 10, pp. 4025–4050, November 2023.
- [20] C. Debrah, A. Darko, and A. P. C. Chan, "A bibliometric-qualitative literature review of green finance gap and future research1 directions," *Taylor & Francis in Climate and development*, July 17 2022.
- [21] M. K. Muchiri, S. Erdei-Gally, M. Fekete-Farkas, and Z. Lakner, "Bibliometric Analysis of Green Finance and Climate Change in Post-Paris Agreement Era," *Journal of Risk and Financial Management*, November 29 2022.
- [22] P. K. Ozili, "Green finance research around the world: a review of literature," *Munich Personal RePEc Archive (MPRA)*, 2022.
- [23] J. Choi, D. Escalante, and M. L. Larsen, "Green Banking in China – Emerging Trends - With a spotlight on the Industrial and Commercial Bank of China (ICBC)," *International Institute of Grene Finance, CUF*, August 2020.
- [24] S. Khan, A. Akbar, I. Nasim, M. Hedvičáková, and F. Bashir, "Green finance development and environmental sustainability: A panel data analysis," *Frontiers in Environmental Science*, November 01 2022.
- [25] J. Peng and Y. Zheng, "Does Environmental Policy Promote Energy Efficiency? Evidence From China in the Context of Developing Green Finance," *Frontiers in Environmental Science*, vol. 9, July 23 2023.
- [26] Y. Wang, M. Song, F. Wang, W. Mbanyele, and H. Huang, "Climbing the quality ladder of green innovation: Does green finance matter?," *Technological Forecasting and Social Change*, vol. 184, November 2022.
- [27] F. O. Areche, A. A. Sheikh, and A. Lahiani, "Green Finance and Green Energy Nexus in ASEAN Countries: A Bootstrap Panel Causality Test," *Energies*, July 11 2022.
- [28] A. Zakari and I. Khan, "The Introduction of Green Finance: A Curse or a Benefit to Environmental Sustainability?," vol. 3, no. 3, 2022.

- [29] X. Jian and S. Afshan, "Dynamic effect of green financing and green technology innovation on carbon neutrality in G10 countries: fresh insights from CS-ARDL approach," *Economic Research-Ekonomika Istraživanja*, November 18 2022.
- [30] J. W. Lee, "Green Finance and Sustainable Development Goals: The Case of China," vol. 7, no. 7, pp. 577 - 586, June 10 2020.
- [31] D. H. Nguyen and I. P. Khominich, "Green investment and green economic development in Russia, 2010–2021," vol. 14, no. 3, pp. 509–539, 2024.
- [32] A. Khan *et al.*, "settings Order Article Reprints Open AccessArticle FDI, Green Innovation and Environmental Quality Nexus: New Insights from BRICS Economies," *Sustainability*, vol. 14, no. 4, February 14 2022.
- [33] A. M. Nur, "The Role of Digital Banking Services on Commercial Banks Performance in Somalia: A Descriptive and OLS Approach," *International Journal of Financial Research*, vol. 13, no. 4, pp. 16–25, October 12 2022.
- [34] Y. Coulbaly, "The effects of resource-backed loans on deforestation: Evidence from developing countries," *World Development*, vol. 188, April 2025.
- [35] M. R. Maria, R. Ballini, and R. F. Souza, "Evolution of Green Finance: A Bibliometric Analysis through Complex Networks and Machine Learning," *sustainability*, January 5 2023.
- [36] I. Nasim, "Role of Green Finance for Sustainable Environment So Far: A Bibliometric Analysis and Policy Framework," vol. 02, no. 11, pp. 882–895, May 12 2023.
- [37] I. Passas, "Bibliometric Analysis: The Main Steps," June 20 2024.
- [38] A. H. Alsharif, N. Z. M. Saleh, and R. Baharun, "Research Trends of Neuromarketing: A Bibliometric Analysis," vol. 98, no. 15, August 15 2020.
- [39] L. Bornmann, R. Mutz, C. Neuhaus, and H.-D. Daniel, "Citation counts for research evaluation: standards of good practice for analyzing bibliometric data and presenting and interpreting results," *Ethics in Science and Environmental Politics*, vol. 8, pp. 93–102, February 12 2008.
- [40] L. Bornmann and H.-D. Daniel, "What do we know about the h index?," *Journal of the American Society for Information Science and Technology*, vol. 58, pp. 1381–85, June 13 2007.
- [41] C.-C. Lee and C.-C. Lee "How does green finance affect green total factor productivity? Evidence from China," *Energy Economics*, vol. 107 March 2022.
- [42] M. Irfan, A. Razzaq, and A. Sharif, "Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China," *Technological Forecasting and Social Change*, vol. 182, September 2022.
- [43] H. Zhang *et al.*, "Short-term effects of air pollution and weather changes on the occurrence of acute aortic dissection in a cold region," *Sec. Environmental Health and Exposome* vol. 11, August 2 2023.
- [44] M. Madaleno, E. Dogan, and D. Taskin, "A step forward on sustainability: The nexus of environmental responsibility, green technology, clean energy and green finance," *Energy Economics*. <https://doi.org/10.1016/j.eneco.2022.105945>, vol. 109, 2022.
- [45] S. Hafner, A. Jones, A. Anger-Kraavi, and J. Pohl, "(2020). Closing the green finance gap—A systems perspective. ," *Environmental Innovation and Societal Transitions*. <https://doi.org/10.1016/j.eist.2019.11.007>, vol. 34, pp. 26–60, 2020.
- [46] P. D'Orazio and L. Popoyan, "Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies," *Ecological Economics*. <https://doi.org/10.1016/j.ecolecon.2019.01.029>, vol. 160, pp. 25–37, 2019.
- [47] M. Umar, L. Huang, N. Mirza, and Z. Chen "Green Banking—Can Financial Institutions support green recovery?," *Economic Analysis and Policy*, vol. 75, pp. 389–395, September 2022.
- [48] C.-C. Lee and C.-C. Lee, "How does green finance affect green total factor productivity? Evidence from China," *Energy economics*, vol. 107, p. 105863, 2022.
- [49] M. Irfan, A. Razzaq, A. Sharif, and X. Yang, "Influence mechanism between green finance and green innovation: exploring regional policy intervention effects in China," *Technological Forecasting and Social Change*, vol. 182, p. 121882, 2022.
- [50] H. Zhang *et al.*, "Short-term effects of air pollution and weather changes on the occurrence of acute aortic dissection in a cold region," *Frontiers in Public Health*, vol. 11, p. 1172532, 2023.
- [51] M. Madaleno, E. Dogan, and D. Taskin, "A step forward on sustainability: The nexus of environmental responsibility, green technology, clean energy and green finance," *Energy Economics*, vol. 109, p. 105945, 2022. <https://doi.org/10.1016/j.eneco.2022>
- [52] S. Hafner, A. Jones, A. Anger-Kraavi, and J. Pohl, "Closing the green finance gap—A systems perspective," *Environmental Innovation and Societal Transitions*, vol. 34, pp. 26–60, 2020. <https://doi.org/10.1016/j.eist.2019.11.007>
- [53] N. Zahoor, F. Donbesuur, M. Christofi, and D. Miri, "Technological innovation and employee psychological well-being: The moderating role of employee learning orientation and perceived organizational support," *Technological Forecasting and Social Change*, vol. 179, p. 121610, 2022.
- [54] P. D'Orazio and L. Popoyan, "Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies?," *Ecological Economics*, vol. 160, pp. 25–37, 2019. <https://doi.org/10.1016/j.ecolecon.2019.01.029>

- [55] A. Pan *et al.*, "Do the rewards justify the means? measuring trade-offs between rewards and ethical behavior in the machiavelli benchmark," presented at the In International Conference on Machine Learning (pp. 26837-26867). PMLR, 2023.
- [56] M. Xu *et al.*, "A full dive into realizing the edge-enabled metaverse: Visions, enabling technologies, and challenges," *IEEE Communications Surveys & Tutorials*, vol. 25, no. 1, pp. 656-700, 2022.
- [57] M. Umar, L. Huang, M. N., and Z. Chen, "Green banking—can financial Institutions support green recovery?," *Economic Analysis and Policy*, vol. 75, pp. 389-395, 2022.
- [58] C.-H. Chou, S. L. Ngo, and P. P. Tran, "Renewable Energy Integration for Sustainable Economic Growth: Insights and Challenges via Bibliometric Analysis," *Sustainability*, vol. 15, no. 20, October 18 2023.
- [59] J. Li, F. Tang, S. Zhang, and C. Zhang, "The effects of low-carbon city construction on bus trips," vol. 25, 2023.
- [60] M. H. Pesaran, K. So Im, and Y. Shin "Testing for unit roots in heterogeneous panels," *Journal of Econometrics*, vol. 115, no. 1, pp. 53-74, July 1 2003.
- [61] S. Abbas, H. Mahmood, M. I. Shah, M. Murshe, M. Ahmad, and Z. Ahmed, "How do green energy technology investments, technological innovation, and trade globalization enhance green energy supply and stimulate environmental sustainability in the G7 countries?," *Gondwana Research*, vol. 112, pp. 105-115, December 2022.
- [62] X. Song, J. Li, Y. Hao, and H. Chen, "The impact of environmental regulation, shadow economy, and corruption on environmental quality: Theory and empirical evidence from China," *Elsevier Journal of Cleaner Production*, vol. 195, pp. 200-214, September 10 2018.
- [63] Z. Sun, X. Zhang, R. Long, S. Zhang, and F. Dong, "Determinants of haze pollution: An analysis from the perspective of spatiotemporal heterogeneity," *Journal of Cleaner Production*, vol. 222, pp. 768-783, June 10 2019.
- [64] C.-C. Lee and Y. Chen, "Does technological innovation reduce CO2 emissions?Cross-country evidence," *Journal of Cleaner Production*, vol. 263, August 1 2020.
- [65] M. Shahbaz, B. A. Topcu, S. S. Sarigül, and X. V. Vo, "The effect of financial development on renewable energy demand: The case of developing countries," *Renewable Energy*, vol. 178, pp. 1370-1380, 2021.
- [66] M. Mohsin, X. V. Vo, F. Taghizadeh-Hesary, Q. Abbas, S. Anwar, and N. Panthamit, "Developing Low Carbon Finance Index: Evidence From Developed and Developing Economies," *Finance Research Letters*, vol. 43, November 2021.
- [67] X. Wang, E. Elahi, and Z. Khalid, "Do green finance policies foster environmental, social, and governance performance of corporate?," *International journal of environmental research and public health*, vol. 19, no. 22, p. 14920, 2022.
- [68] Z. Wang, Y. Ma, S. Wang, C. Luo, and Y. Wang, "The evolution of the collaborative environmental governance network in Guizhou Province, China," *Sustainability*, vol. 15, no. 13, p. 10012, 2023. <https://doi.org/10.3390/su151310012>
- [69] G. Li, X. Jia, A. A. Khan, S. U. Khan, M. A. S. Ali, and J. Luo, "Does green finance promote agricultural green total factor productivity? Considering green credit, green investment, green securities, and carbon finance in China," *Environmental Science and Pollution Research*, vol. 30, no. 13, pp. 36663-36679, 2023.
- [70] J. Li, F. Tang, S. Zhang, and C. Zhang, "The effects of low-carbon city construction on bus trips," *Journal of Public Transportation*, vol. 25, p. 100057, 2023.
- [71] W. Li, G. Cui, and M. Zheng, "Does green credit policy affect corporate debt financing? Evidence from China," *Environmental Science and Pollution Research*, vol. 29, no. 4, pp. 5162-5171, 2022.
- [72] A. Zakari and I. Khan, "The introduction of green finance: A curse or a benefit to environmental sustainability?," *Energy Research Letters*, vol. 3, no. 3, 2022.
- [73] J. Zhao, L. Li, Z. Li, Z. Chen, L. Xiao, and G. Chen, "Multi-segment fuzzy control for start-up optimizing of LCC-based high-voltage power supply," *Energy Reports*, vol. 8, pp. 552-559, 2022. <https://doi.org/10.1016/j.egy.2021.11.166>
- [74] L. Zou, Y. Liu, Y. Wang, and X. Hu, "Assessment and analysis of agricultural non-point source pollution loads in China: 1978–2017," *Journal of Environmental Management*, vol. 263, p. 110400, 2020. <https://doi.org/10.1016/j.jenvman.2020.110400>
- [75] A. Darko, A. P. C. Chan, and C. Debrah, "Green finance gap in green buildings: A scoping review and future research needs," *Building and Environment*, vol. 207, January 2022.
- [76] X. Wang, E. Elahi, and Z. Khalid, "Do Green Finance Policies Foster Environmental, Social, and Governance Performance of Corporate?," *International Journal of Environmental Research and Public Health*, November 13 2022.
- [77] J. Luo, M. A. S. Ali, S. U. Khan, A. A. Khan, X. Jia, and G. Li, "Does green finance promote agricultural green total factor productivity? Considering green credit, green investment, green securities, and carbon finance in China," *Environmental Science and Pollution Research*, vol. 30, pp. 36663–36679, December 23 2022.
- [78] K.-T. Chou, T.-Y. Lee, and M.-X. Lin, "The Environmental Policy Stringency in Taiwan and Its Challenges on Green Economy Transition," *Development and Society*, vol. 47, no. 3, pp. 477-502, September 2018.
- [79] J. P. Namahoro , Q. Wu, H. Xiao, and N. Zhou, "The Impact of Renewable Energy, Economic and Population Growth on CO2 Emissions in the East African Region:Evidence from Common Correlated Effect Means Groupand Asymmetric Analysis," *energies*, vol. 14, no. 312, January 8 2021.

- [80] A. Tangl and G. Desalegn, "Enhancing Green Finance for Inclusive Green Growth: A Systematic Approach," vol. 14, no. 12, 17 June 2022.
- [81] N. Van Song, N. Cong Tiep, D. van Tien, T. V. Ha, N. T. M. Phuong, and T. T. H. Mai, "The role of public-private partnership investment and eco-innovation in environmental abatement in USA: evidence from quantile ARDL approach," *Environmental Science and Pollution Research*, vol. 29, pp. 12164–12175, February 1 2022.
- [82] M. Dallime, L. C. Stringer, and L. Xueqin, "The role of blue green infrastructure in the urban thermal environment across seasons and local climate zones in East Africa," *Sustainable Cities and Society*, vol. 80, p. 103798, May 2022.
- [83] "Africa Green Business and Financing Report," United Nations Development Programme (UNDP), 2024.
- [84] I. V. Edet, A. E. Jack, E. S. Udo, and I. P. Abner, *Green Finance and Sustainable Development Nexus in Sub-Saharan Africa*, vol. 18, no. 2, pp. 78-90, 2024.
- [85] N. Arunrat, S. Sereenonchai, and R. Hatano, "Effects of fire on soil organic carbon, soil total nitrogen, and soil properties under rotational shifting cultivation in northern Thailand," *Journal of Environmental Management*, vol. 302, p. 113978, January 15 2022.
- [86] M. Tebkew and H. B. Atinkut, "Impact of forest decentralization on sustainable forest management and livelihoods in East Africa," *Trees, Forests and People*, 2022.
- [87] H. H. A. Khan, N. Ahmad, N. M. Yusof, and M. A. M. Chowdhury, "Green finance and environmental sustainability: a systematic review and future research avenues," *Environmental Science and Pollution Research*, vol. 31, pp. 9784–9794, January 09 2024.
- [88] W. Li, G. Cui, and M. Zheng, "Does green credit policy affect corporate debt financing? Evidence from China," *Environmental Science and Pollution Research*, vol. 29, pp. 5162–5171, August 21 2021.
- [89] A. L. Mitchell, A. Rosenqvist, and B. Mora, "Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+," *Carbon Balance and Management*, vol. 12, April 17 2017.