

## Green Bonds for a Greener Tomorrow: Evaluating G20 Strategies in Emission Reduction and Sustainable Development

Aditi SARAWAGI

<https://orcid.org/0000-0002-4076-7682>

Department of Commerce, Faculty of Commerce and Management  
Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, India  
[sarawagiaditi123@gmail.com](mailto:sarawagiaditi123@gmail.com)

Amit GUPTA

<https://orcid.org/0009-0004-2525-6042>

Department of Commerce, Faculty of Commerce and Management  
Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, India  
[ressch.amit.gupta@igntu.ac.in](mailto:ressch.amit.gupta@igntu.ac.in), [nishuamit2608@gmail.com](mailto:nishuamit2608@gmail.com)

Moirangthem Sanjoy SINGH

<https://orcid.org/0000-0002-5364-9263>

Department of Commerce, Faculty of Commerce and Management  
Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, India  
[msanjoy.singh@igntu.ac.in](mailto:msanjoy.singh@igntu.ac.in), [joysingh357@gmail.com](mailto:joysingh357@gmail.com)

Shailendra SINGH BHADOURIA

<https://orcid.org/0000-0002-3195-6879>

Department of Commerce, Faculty of Commerce and Management  
Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, India  
[shailendra.bhadouria@igntu.ac.in](mailto:shailendra.bhadouria@igntu.ac.in), [shailendra\\_27@yahoo.co.in](mailto:shailendra_27@yahoo.co.in)

### Article's history:

Received 5<sup>th</sup> of January, 2025; Received in revised form 31<sup>st</sup> of January, 2025; Accepted 15<sup>th</sup> of February, 2025; Available online: 16<sup>th</sup> of February, 2025. Published as article in the Volume XX, Spring, Issue 1(87), 2025.

Copyright© 2025 The Author(s). This article is distributed under the terms of the license [CC-BY 4.0.](https://creativecommons.org/licenses/by/4.0/), which permits any further distribution in any medium, provided the original work is properly cited.

### Suggested citation:

Sarawagi, A., Gupta, A., Sanjoy Singh, M., & Singh Bhadouria, S. (2025). Green Bonds for A Greener Tomorrow: Evaluating G20 Strategies in Emission Reduction and Sustainable Development. *Journal of Applied Economic Sciences*, Volume XX, Spring, 1(87), 145 – 161. [https://doi.org/10.57017/jaes.v20.1\(87\).10](https://doi.org/10.57017/jaes.v20.1(87).10)

### Abstract:

This study examines the green finance strategies of G20 economies, with a particular focus on green bond issuance and its impact on greenhouse gas (GHG) emissions. Utilizing secondary data from the Statista database and the Emissions Database for Global Atmospheric Research, the analysis employs percentage evaluation, simple linear regression, heat maps, and cluster analysis. A Python-based algorithm in Jupyter Notebook facilitates the data processing.

Findings indicate that China leads in both green bond issuance and GHG emissions, followed by the United States. Regression analysis confirms that green bonds contribute to reducing GHG emissions. Notably, developed and developing countries exhibit similar patterns in green bond issuance and emissions, suggesting that these variables are not necessarily aligned with their respective development levels.

This research offers a wide assessment of the interplay between green bond issuance and environmental sustainability among G20 economies, highlighting the potential of green finance in fostering sustainable and inclusive growth. The findings provide insights into areas for improvement and policy recommendations for G20 nations to enhance their green financing strategies, increase green bond issuance, and reduce emissions in pursuit of global sustainability goals.

**Keywords:** G20 alliance, green finance, greenhouse gas, green bonds, developing nations, developed nations.

**JEL Classification** G18, O44, Q54.

## Introduction

Climate change, environmental degradation, and resource scarcity are all interconnected issues the world encounters (Warner et al., 2010). These issues signify a grave threat to global sustainable development (Cramer et al., 2018). Concerns about financial and environmental sustainability are widespread, particularly among G20 countries. Amidst climate change, resource depletion, and environmental deterioration, economic progress must be coupled with environmental protection (Peng et al., 2020; Yang et al., 2022). Green finance is an emerging area that attempts to resolve these issues by mobilizing resources for long-term investments (Ezroj, 2020). Green finance projects are being implemented in many nations by governments, financial institutions, and other stakeholders (Durrani et al., 2020; Ezuma, 2022). Since they dominate global economic activity and greenhouse gas (GHG) emissions, G20 economies are ahead in these efforts. Green financing is the financial drift that warrants investment in renewable energy, energy efficiency, sustainable infrastructure, and other environmental projects (Ning et al., 2023; Ozili, 2022). Green financing may be mobilized via several avenues, namely green bonds, green loans, and green equity investments. Green finance is driven by increased awareness of climate change and environmental degradation, institutional and retail investor demand for sustainable investments, and supporting government policies and regulations.

The G20 alliance was established in 1999 to tackle the evolving global financial system (Wade, 2011). It comprises 19 nations plus the European Union (Fues & Messner, 2016). The G20 economies consist of Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom (UK), the United States (US), and the European Union (EU). They account for almost 80% of the world's Gross Domestic Product (GDP) and around two-thirds of the world's population (Chongyang Institute for Financial Studies, 2016; Dubey, 2015). The G20 consists of nations from several continents exhibiting diverse degrees of economic development, distinct natural resources, and different demographic traits. Each of these nations has substantial economic strength and faces unique challenges. Their policies and actions can bring about significant change, individually or together (Bildirici, 2023). It is essential to comprehensively assess green finance projects' impact on sustainable economic development, particularly in G20 nations with distinct challenges and possibilities. These nations have the necessary resources, infrastructure, and skills to lead in transitioning to more sustainable economic practices. Nevertheless, they have also developed economic structures and interests deeply entrenched in conventional sectors that rely heavily on substantial resources hazardous to the environment. Hence, it is crucial to thoroughly examine the intricate relationship between pursuing green financing and attaining sustainable development.

The conventional focus on indicators to measure progress has been questioned, as it is now recognized that the environment's health and the economy's stability are interconnected, resulting in a shift in perspective (Edwards, 2005). Sustainable development has gained popularity within systems (Ziolo, 2019), highlighting the importance of aligning models with environmental compatibility and economic viability (Liu & Chen, 2020). This study examines how implementing and advocating for financial practices impact the sustained growth of G20 countries – essential global economies that significantly influence economic progress and ecological preservation worldwide. This study utilized various data sources, such as government reports, economic indicators, and investment-related statistics, to tackle these nations' challenges and suggest measures to enhance green finance policies.

The study focuses on the green finance initiatives and environmental alignment of the G20 nations from several aspects and, therefore, evaluates the following areas:

- The investment in green finance initiatives across G20 economies has been comprehensively examined. The study considers the total value of green bonds issued.
- This includes the GHG emissions of G20 economies. It evaluates the effect of the issuance of green bonds on GHG emissions.
- The alignment of green bond issuance with GHG emissions of nations at their developmental level was evaluated.

## 1. Review of Literature

Although there is an increasing acknowledgment of the importance of financial activities in encouraging sustainability objectives, obstacles continue to exist. Govindan et al. (2021) observed that development is often hindered by regulatory barriers, the absence of established measures for evaluation, and competing interests among stakeholders. Busch et al. (2016) emphasize several opportunities due to the emergence of inventive financial systems and the growing social need for investment options that prioritize environmental responsibility. Zhongping et al. (2023) state that adopting environmentally friendly financial instruments can significantly benefit economic development and environmental protection. Green financing is essential to sustainable development (Mohd & Kaushal, 2018; Yang & Masron, 2022). He et al. (2023) and Wu (2023) emphasize the importance of green finance in promoting investment in ecologically friendly initiatives. This integration encompasses a range of financial products, including green bonds, sustainability-linked loans, and impact investment.

Green finance is a pretty novel sphere of finance. Economists and international organizations have failed to establish an unambiguous definition or agree upon one unanimously (Taghizadeh-Hesary et al., 2021). However, workable definitions have been developed by various scholars, organizations, and governments (Labatt & White, 2003). An interesting variation in this is that specific organizations, rather than defining green finance, have coined the following phrase: a sustainable financial system (Hira, 2012). Their mechanisms and tools remain constant. According to the UNEP, a sustainable financial system combines the improvement of values. It assists in managing financial assets, intending that real wealth may be exploited to progressively satisfy the requirements of an environmentally sustainable and inclusive economy. According to the Green Finance Study Group of the G20 (Berensmann et al., 2017), green financing promotes the adoption of technologies that lower pollution. Green finance encompasses all types of investment or financing that consider the environmental effect and promote environmental sustainability. Green finance prioritizes sustainable investing and banking, using environmental screening and risk assessment to ensure adherence to environmental sustainability requirements (Volz et al., 2015).

The attention to the role of green finance initiatives in promoting sustainable growth (Cheung & Hong, 2020) has increased significantly in recent years (Desalegn & Tangl, 2022; Wang et al., 2022), particularly among G20 economies, which account for a substantial portion of the world's economic activity. According to Fues & Messner (2016), G20 nations continue to have differences in their commitment to aligning with environmental goals. While several countries demonstrate strong efforts and regulations to promote sustainability, others are falling behind, hindering the advancement of common environmental objectives. Some studies have emphasized the advantages of green finance, and others have discussed the negative consequences. In their study, Li et al. (2022) mention how green financing, specifically through green bonds and environmental policies such as implementing environmental taxes, has a notable and favourable impact on encouraging investments in renewable energy sources. Ozili (2022) highlights the potential of green finance to significantly impact the environment, society, and climate change mitigation.

However, challenges like inconsistent definitions, unawareness, policy disarray, and lack of profitable incentives for investors and financial institutions must be addressed. Ma et al. (2023) found that green finance improves energy-environmental performance in regions with less developed credit and capital markets, promotes green innovation in developing countries, and negatively impacts green product innovation in industrialized countries with high sustainability policies. Zhang et al. (2022) similarly stated that green finance, renewable energy investment, and technological innovation lead to reduced CO<sub>2</sub> emissions in the environment. Green bonds have also emerged as a potential financial tool for financing initiatives that have positive environmental impacts and reduce the effects of climate change. Research has shown that the issue of green bonds is linked to reductions in carbon emissions at both the state and national levels (Flammer, 2023).

The green bond market has witnessed significant growth, with a rising proportion of investments directed towards renewable energy, clean water, and low-carbon transportation projects (Tolliver et al., 2019). However, there exists a difference in the effectiveness of green bonds in mitigating CO<sub>2</sub> emissions across developed and developing nations, with a more noticeable negative impact reported in developing nations (Saha & Maji, 2023). On the other hand, factors including economic growth, energy consumption, rapid urbanization, and foreign direct investment are accountable for increased CO<sub>2</sub> emissions (Arshad et al., 2024).

According to Jahanger et al. (2023), green finance and clean energy positive shocks improve ecological quality, while adverse shocks harm environmental quality. Moreover, economic growth and urbanization share a share of harmful pollutants. Jiang (2008) stated that by lowering operational and ecologically beneficial activities, a green credit scheme might have a higher deterrent impact on heavily polluting firms. The studies have discussed the role of G20 economies in green finance. Berensmann et al. (2017) suggest that the G20 can promote green investments and align financial markets with sustainable development by standardizing green finance practices, enhancing information transparency, supporting global market development for green investments, and aiding developing countries in developing national sustainable finance roadmaps. Few studies have discussed green innovation and environmental sustainability. In their research, Liu et al. (2022) stated that a company's environmental performance is influenced by its green innovation and resource management, which can lead to the production of eco-friendly products. Further research delves into the nexus between green finance and the COVID-19 pandemic. Fang (2023) found that public support during the COVID-19 crisis significantly impacted green funding measures.

However, public assistance funds couldn't consistently play a consistent role in green finance. G20 countries invested 17% of their green funding, resulting in a 4% GDP increase. COVID-19 reduced energy reliance by 16% and increased renewable energy generation by 24%. Bogacheva & Smorodinov (2017) highlighted several challenges in green finance, including the non-existence of a universal definition, inadequate international standards, merger alignment between sustainable growth objectives and national investment policy priorities, an absence of a regulatory framework, ecological externalities, mismatch of maturity, inadequate green project selection and management, information asymmetry in capital markets, and non-existence of analytical tools and competence to identify and assess risks associated with green projects.

## 2. Research Methodology

### Statement of Problem

Despite the increasing recognition among G20 nations of the importance of sustainable and equitable growth, there is still a lack of information regarding the effectiveness of green finance initiatives in achieving these objectives. Although G20 countries have embraced finance as a solution to address environmental issues and promote social inclusion, there is a shortage of comprehensive empirical studies evaluating these initiatives' real impact across various economies. This study assessed how the success of green financing initiatives differs between G20 nations, considering their GHG emission as per the green bonds' issuance and G20 nations' variability in terms of developmental stage.

### Objectives

1. To assess the adoption and implementation of green finance initiatives through green bonds in G20 economies.
2. To evaluate whether green bond issuance and GHG emissions of G20 nations align with their development level.
3. To provide G20 nations with policy ideas and insights to enhance green finance policies for sustainable and equitable growth.

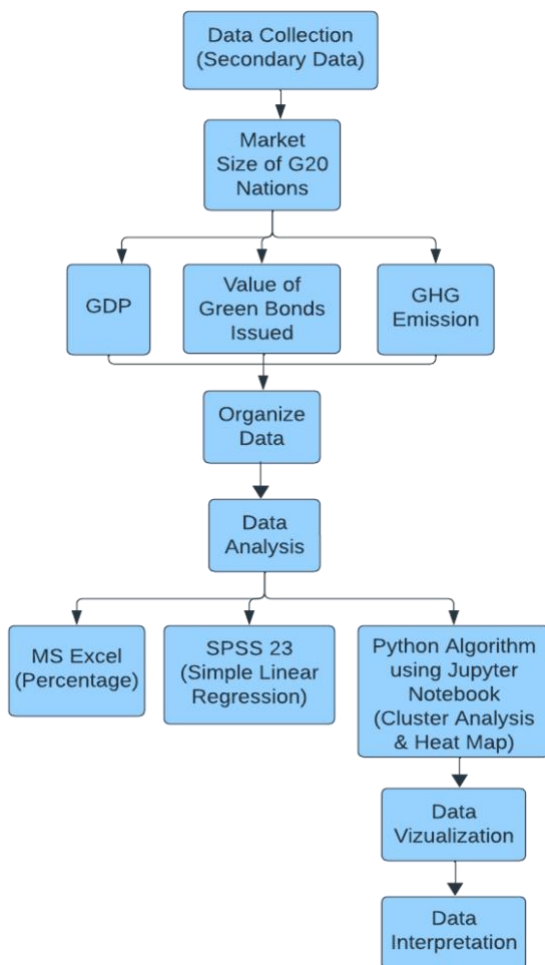
### Hypotheses

H<sub>01</sub>: The issue of green bonds results in a reduction in GHG emissions in G20 nations.

H<sub>02</sub>: There is a strong negative relationship between green bond issuance and GHG emissions in developed nations compared to developing nations.

The study assessed the impact of green financing initiatives on sustainable growth in G20 nations via a comparative analysis methodology. The analysis focused on the value of green bonds and the amount of GHG emissions. To make comparisons, it was calculated as a percentage of GDP. The G20 nations were categorized as developed and developing nations to evaluate the issuance of green bonds and GHG emissions depending on their respective development level. Consequently, the study suggested ways G20 countries may strengthen their green financing initiatives for sustainable and inclusive growth.

Figure 1. Research methodology



### Variables Used in the Study

1. Total value of green bonds issued.
2. Greenhouse Gas Emission.
3. Gross Domestic Product (GDP).

Source: Author-created visualization using Lucid App

### 3. Results and Discussion

Green bonds are a key financial instrument in the global financial landscape, directing funds toward environmentally sustainable projects. They are a pioneering approach to combat climate change, with significant investment from public and private sectors over the past decade. We assessed the impact of green bonds on GHG emissions and understand how they accelerate adaptation to a low-carbon and sustainable future.

#### Value of Green Bonds Issued by G20 Economies

According to the data given in Table 1, the issuance of green bonds in China surpassed 83 billion US dollars in 2023, with Germany following closely behind with 67.51 billion US dollars and the US with 59.85 billion US dollars' worth of green bonds. The issuance of green bonds by developed economies greatly surpasses that of developing countries except for China. This could be because of the available financial market and regulatory framework. The worth of green bonds issued by the EU comprising 27 countries is the highest among all at 308.50 USD. However, when considering green bonds issued as a percentage of the GDP, EU stands first (1.6812%), followed by Germany (1.5150%) and Saudi Arabia (1.4060%).

Table 1: Total value of green bonds issued, in USD billion

Country	Value of green bonds issued in 2023 (a)	Cumulative value of green bonds issued between 2014-2023 (b)	GDP in 2023 (c)	Green Bonds issued as % of GDP(a/c*100) (d)
Argentina	NA*	1.98	640.59	-
Brazil	2.16	13.57	2,173.67	0.0993
China	83.51	371.90	17,794.78	0.4693
India	15.39	36.94	3,549.92	0.4335
Indonesia	2.36	8.74	1,371.17	0.1721
Mexico	NA*	4.9	1,788.89	-
Russia	NA*	2.65	2,021.42	-
Saudi Arabia	15.01	20.41	1,067.58	1.4060
South Africa	NA*	2.99	377.78	-
Turkey	NA*	1.44	1,108.02	-
Australia	8.78	32.78	1,723.83	0.5093
Canada	4.66	59.60	2,140.09	0.2177
France	29.97	228.70	3,030.91	0.9888
Germany	67.51	287.10	4,456.08	1.5150
Italy	30.34	91.30	2,254.85	1.3455
Japan	15.02	70.50	4,212.95	0.3565
Republic of Korea	9.90	40.09	1,712.79	0.5780
UK	32.67	101.40	3,340.03	0.9781
US	59.85	454.40	27,360.94	0.2187
EU	308.50	1,305.70	18,349.39	1.6812

Note: \* Statista Database does not provide green bond values for these nations since their value are less than 1 billion USD. We marked them NA.

Source(s): Statista-Leading countries in terms of the value of green bonds issued worldwide in 2023; Climate Bonds Initiative, 2023; Gross Domestic Product, 2023-World Bank.

### Greenhouse Gas Emission of G20 Economies

According to the data given in Table 2, the GHG emission by China is highest at 15943.99 metric tonnes, followed by the US at 5960.80 metric tonnes. On average, the GHG emission by the developed countries except the US is much less than that of the developing countries. However, when GHG is considered a percentage of GDP, the highest emitter is South Africa (0.61%), followed by China (0.51%) and Russia (0.46%).

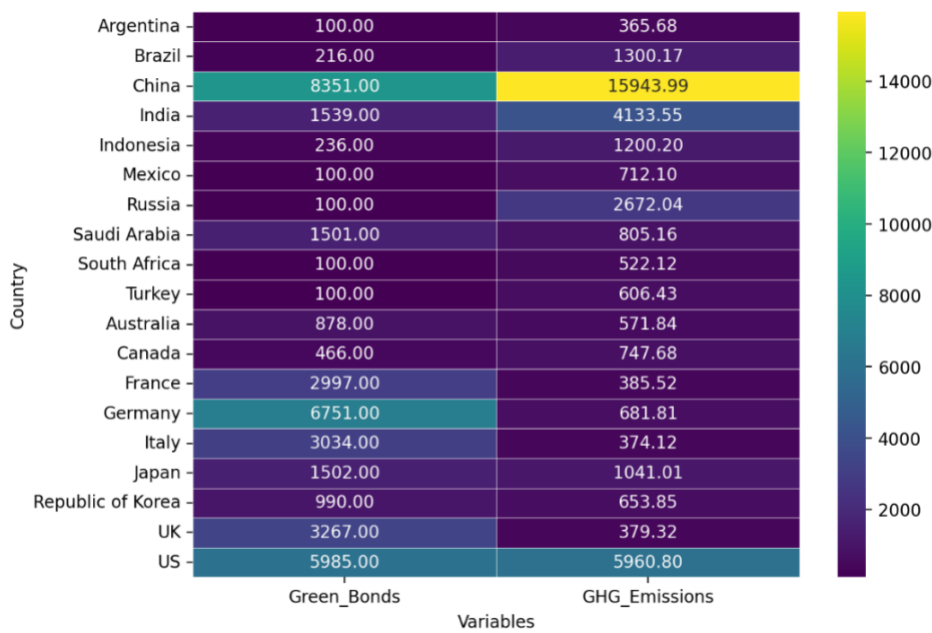
Table 2: Greenhouse gas emission

Country	GHG total emissions in 2023 (in metric tonnes)	GHG per GDP emission in 2023 (in ton GHG/1k\$)
Argentina	365.68	0.30
Brazil	1,300.17	0.32
China	15,943.99	0.51
India	4,133.55	0.32
Indonesia	1,200.20	0.31
Mexico	712.10	0.25
Russia	2,672.04	0.46
Saudi Arabia	805.16	0.44
South Africa	522.12	0.61
Turkey	606.43	0.21
Australia	571.84	0.36
Canada	747.68	0.33
France	385.52	0.10
Germany	681.81	0.13
Italy	374.12	0.12
Japan	1041.01	0.18
Republic of Korea	653.85	0.25
UK	379.32	0.10
US	5,960.80	0.24
EU	3,221.79	0.13

Source: Emissions Database for Global Atmospheric Research- GHG emissions of all world countries, 2024 by European Commission.”

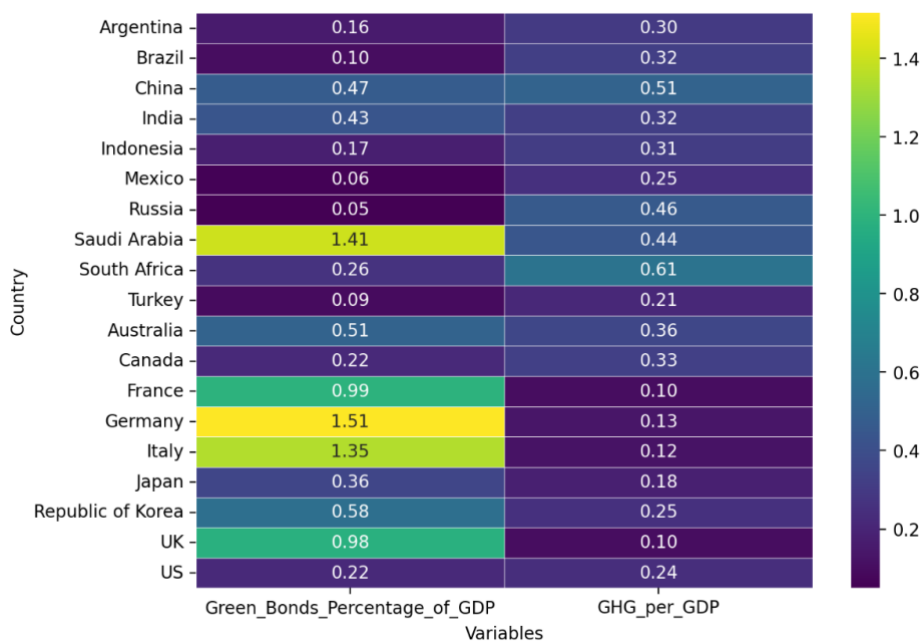
GHG emissions by China and the US are high in comparison to other G20 economies, and their relative issue of green bonds is also high, indicating that these two countries are working towards reducing the impact of GHG by making investments in green projects and sustainable infrastructure.

Figure 2: Visualization of total value of green bonds and GHG emission



Source: created using Python

Figure 3: Visualization of green bonds and GHG emission as a percentage of GDP



Source: created using Python

The visualization of data is made using a heatmap. The light (or hot) colours indicate higher values, while the darker (or cool) colours indicate lower values. The results discussed above are visualized in the map. The value of green bonds issued is converted from billion to 10 million to make further calculations. China is leading in terms of the issue of green bonds and GHG emissions, followed by the US, as depicted in Figure 2. Brazil, India, and Russia have value of green bonds issued less as compared to the amount of greenhouse gas emitted by them. Figure 3 shows that Germany has the highest value of green bonds issued as a percentage of its GDP, followed by Saudi Arabia and Italy. If greenhouse gas emission is considered a percentage of GDP, the percentage is highest in South Africa, China, and Russia.



### Impact of Green Bonds on Greenhouse Gas Emission

For this purpose, the value of green bonds issued as a percentage of GDP was considered an independent variable. In contrast, GHG emission as a percentage of GDP was considered a dependent variable.

Table 3 confirms that a significant relationship exists between the considered dependent variable and the independent variable. Since the p-value is less than 0.05 ( $p=0.049$ ), it confirms that the issue of green bonds affects GHG emissions (Tolliver et al., 2019; Fatica & Panzica, 2021). Hence, we accept our first hypothesis. The calculated B value and t value are -0.118 and -2.106, respectively, which indicates that as the volume of green bonds increases, GHG emission reduces, indicating sustainable green investment, thus promoting sustainable development (Alamgir & Cheng, 2023; Saha & Maji, 2023). However, the value of the R square is .198, which explains that the green bonds contribute only 19.8% to the dependent variable, i.e., GHG emission. Other factors that contribute towards GHG emission reduction are Renewal Energy Adoption (Ferroukhi et al., 2016), Energy Efficiency Measures (Sorrell, 2015), Afforestation and Reforestation (Pan et al., 2011), Sustainable Agriculture (Smith et al., 2014), Carbon Capture and Storage (CCS) (Metz et al., 2005), Electrification of Transportation (Lutsey, 2015), Circular Economy and Waste Management (Ellen MacArthur Foundation, 2013), Policy and Regulations (Stern, 2007), and Behavioural Changes (Dietz et al., 2009).

Table 3: Regression analysis considering the impact of green bonds on GHG emissions

Model	Coefficients		
	B	t	Sig.
(Constant)	.352	8.044	0.000
Green Bonds issued as % of GDP	-.118	-2.106	0.049
R = 0.445, R Square = 0.198, F = 4.436			
Dependent Variable: GHG emission per GDP			

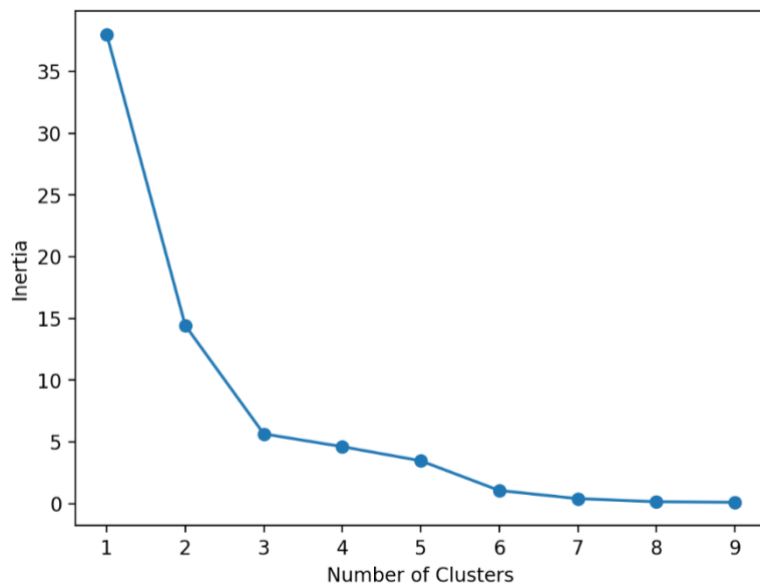
Note: Since the figures of the value of green bonds issued are not available for certain countries, we have assigned them the value of 1 billion USD to carry out calculations.

Source: computed from secondary data

### G20 Nations' Green Bonds & GHG Emissions by Level of Development

Given the study's objectives, we specifically used the K-Means clustering approach to assess data on the issuance of green bonds and the amount of greenhouse gas emissions in 2023. The categorization of the nations was determined by the issuance of green bonds and the amount of GHG emissions measured in metric tons. Initially, we used the predetermined group number that was determined by the application of the Elbow method. Figure 4 displays the outcome of using the elbow approach to identify the number of clusters. By charting the cluster numbers, we can see the elbow criteria, which indicates the optimal cluster number. Consequently, three clusters were used to categorize the G20 nations.

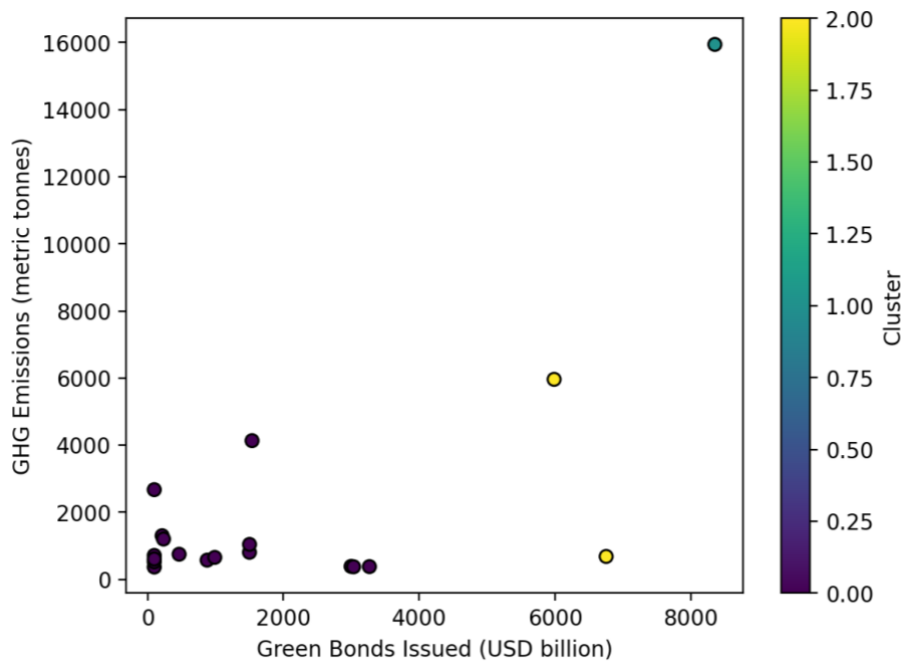
Figure 4: Number of clusters based on the Elbow method



Source: output of computation made using Python algorithm

The subsequent phase included determining the cluster's structure using the K-Means algorithm. The analysis revealed that just one country, China, is included in Cluster 3 (cyan colour), whereas Cluster 2 (yellow colour) consists of two nations, Germany and the US, as depicted in Figure 5. The remaining nations are categorized into cluster 1 (purple colour). Countries included under cluster 1 have modest levels of GHG emissions and issue a relatively small amount of green bonds. Evidence demonstrates that China is now at the forefront in terms of both the issuance of green bonds and the emission of GHGs. However, there is a need for aggressive decarbonization efforts. Germany's GHG emissions are lower than the value of the green bonds it has issued, as well as compared to the United States, which is likewise included in cluster 2. *Note that The European Union (EU) has not been considered for cluster analysis since the EU comprises several nations with varying levels of development.*

Figure 5: Cluster analysis of countries based on three clusters as per Elbow method



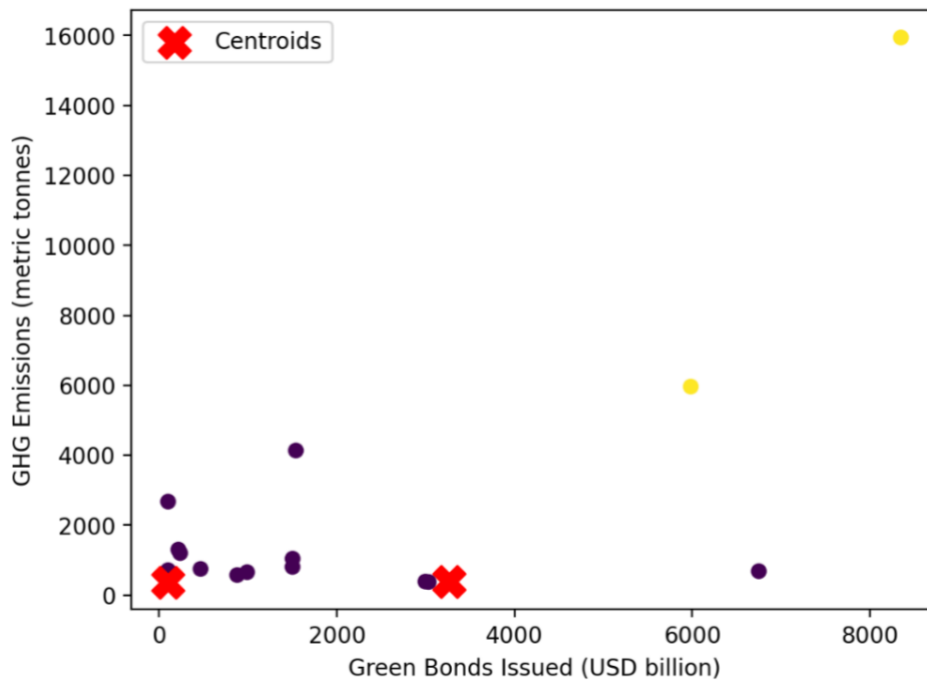
Source: output of analysis made using Python algorithm

Since the nations included in the list of the G20 nations are the developing and developed nations, it will not be justified to form three clusters per the study's objective. Therefore, we will divide these nations into two clusters per their development level, i.e., cluster 1 will comprise developing nations, and cluster 2 will comprise developed nations. Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, and South Africa are all developing nations and form part of cluster 1, while Turkey, Australia, Canada, France, Germany, Italy, Japan, Republic of Korea, US and UK are all developed nations and form part of cluster 2.

The elbow method for identifying the number of clusters to be formed has not been used and we determined the structure of the cluster using the K-Means algorithm. The process was to find the centroid coordinates for each cluster, which were randomly selected from a set of preset clusters. The first centroid point formed from cluster 1, representing developing countries, whereas the second centroid point formed from cluster 2, representing developed nations. The analysis findings, depicted in Figure 6, reveal that Cluster 1 includes all nations except China and the US, which belong to Cluster 2. This suggests that China is unique in its approach to green bonds and GHG emissions, while the US has higher GHG emissions compared to the value of green bonds issued.

All developing nations, except China, are grouped inside a preset cluster, indicating that these countries have a smaller value of green bonds issued and lower GHG emissions (Saha & Maji, 2023). Except for the US, all developed nations are grouped in cluster 1. This indicates that these countries while being developed, are similar to developing countries in terms of both green bond issuance and GHG emissions. Therefore, their level of development does not align with these factors, and hence, we reject our second hypothesis.

Figure 6: Cluster analysis of countries based on two predetermined clusters



Source: output of analysis made using Python algorithm

### China as Leader

The country had "Guidelines for Establishing the Green Financial System" in 2016, which shaped the roles of financial institutions and government agencies in developing the green financial system. In 2015, a "Green Bond Endorsed Projects Catalogue" was issued, covering sectors like renewable energy, energy efficiency, clean transportation, and pollution control. Commercial banks are guided by "Green Credit Guidelines" updated in 2019, which identify and assess green loans and lend to green projects. In 2011, a carbon emission trading mechanism policy was established to reduce GHG emissions. The Chinese government has also issued special funds and programs by the "People's Bank of China (PBOC)" and guidelines on green bonds and other green financial

products by the “China Securities Regulatory Commission.” (Sources: “Climate Bond Initiative” (CBI); “International Institute for Sustainable Development”; “PBOC”)

#### 4. Policy Recommendation & Strategic Insights for G20 Economies

Considering the regulatory environment of individual countries, there are areas where these countries can start taking necessary steps.

- **Harmonize Definitions and Taxonomies:** G20 economies should strive to harmonize definitions and taxonomies for green and sustainable finance, enhancing consistency and clarity for investors and businesses.
- **Strengthen Regulatory Frameworks:** G20 countries should enhance green finance regulatory frameworks by setting clear guidelines for green bonds, loans, and other sustainable financial products, ensuring they meet international best practices.
- **Mandatory Disclosure:** Mandatory climate and ESG disclosure requirements for companies and financial institutions can improve transparency, enable informed decision-making, and encourage sustainable practices.
- **Incentives and Subsidies:** Governments can boost green finance sector growth by offering tax breaks, subsidies, and grants to attract investors to green projects.
- **Capacity Building:** Invest in training programs, knowledge sharing, and international partnerships to enrich the capacity and capability of financial institutions, regulators, and other stakeholders in green finance.
- **Green Bond Markets:** The goal is to burgeon green bond markets by establishing guidelines, promoting issuance, and confirming that proceeds are allocated towards environmentally friendly projects.
- **Carbon Pricing:** Implement or enhance carbon pricing mechanisms to augment emission reduction and foster investment in low-carbon technologies.
- **Support for Innovation:** This may incorporate supporting research and development of green technologies and nurturing a culture of innovation.
- **International Collaboration:** The G20 nations should join forces to share best practices, learn from each other's experiences, and encourage global sustainability through international cooperation.
- **Education and Awareness:** Increase public awareness and education on green finance, enabling individuals to make informed investment decisions and promote sustainable practices.
- **Partnerships:** Fostering partnerships between public and private sectors can boost sustainable project investment by facilitating access to new funding sources and expertise.
- **Sustainable Financial Instruments:** The goal is to create and promote sustainable financial instruments, including green bonds, social impact bonds, and sustainability-linked loans, to tackle various sustainability challenges.
- **Engage Stakeholders:** Stakeholders like civil society, businesses, and academia should be involved in the creation and execution of green finance policies to ensure inclusivity and diverse viewpoints.

The “Sustainable Finance Working Group” during India's G20 presidency, proposed six recommendations for climate finance: mobilizing resources, implementing green and low-carbon technologies, increasing social impact investment, enhancing nature-related data, formulating the G20 Technical Assistance Action Plan, and addressing data-related obstacles to climate investments.

#### Conclusion and Implication

Green finance is an emerging field that seeks to address the challenges of climate change (Managi et al., 2022), environmental deterioration (Chin et al., 2024), and limited resources by facilitating the flow of funds toward long-term investments (Mahat et al., 2019). The G20 economies, which account for a large percentage of global economic activity (Den Elzen et al., 2016) and greenhouse gas (GHG) emissions (Yao et al., 2015), are pioneering green financing endeavours (Usman et al., 2021). The findings of the study indicate that green financing policies,

especially green bond issuance, significantly reduce GHG emissions (Arshad et al., 2024; Chang et al., 2022). Regression analysis shows that as the number of green bonds increases, GHG emissions decrease, emphasizing the importance of using green finance to enhance sustainable development and environmental protection.

The study discloses inequalities in green finance adoption and implementation among G20 economies. Developed countries like Germany and the US show better commitment to green finance, while developing economies like Russia and Mexico are lingering behind. China is at the forefront in terms of the issue of green bonds as well as GHG emissions, and the cluster analysis also reveals the same. Developed countries are performing the same as developing countries in terms of the issue of green bonds and GHG emissions, i.e., these variables are not in line with their level of development. Lower GHG emissions are a good indicator that countries are environmentally aware. However, these discrepancies accentuate the need for tailor-made strategies and support mechanisms based on a country's economic development status. Keeping in purview their level of development, the G20 countries should issue more value of green bonds or other green instruments, take corrective actions to reduce greenhouse gas emissions, and should focus more towards green finance.

The study proposed policy recommendations for G20 economies to enrich green finance initiatives, including harmonizing definitions, strengthening regulations, mandatory disclosure, incentives, capacity building, and international collaboration. These recommendations are decisive for policymakers and stakeholders in articulating and revising green finance policies. The study accentuates the importance of international collaboration and knowledge sharing in a global financial system, urging G20 nations to harmonize standards, share best practices, and collectively tackle climate-related challenges for green finance goals and to promote global sustainability.

#### Credit Authorship Contribution Statement

Aditi Sarawagi: Conceptualization, Data Curation, Investigation, Methodology, Formal analysis, Vizualization, Writing-Original draft. Amit Gupta: Conceptualization, Data Curation, Methodology, Writing-Original draft. Dr. Moirangthem Sanjoy Singh: Writing-Original draft, Project administration, Supervision. Prof. Shailendra Singh Bhadouria: Writing-Original draft, Project administration, Supervision.

#### Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships.

#### References

- Alamgir, M., & Cheng, M. C. (2023). Do Green Bonds Play a Role in Achieving Sustainability? *Sustainability*, 15(13), 10177. <https://doi.org/10.3390/su151310177>
- Arshad, A., Parveen, S., & Mir, F. N. (2024a). The role of green bonds in reducing CO2 emissions: a case of developing countries. *Journal of Economic and Administrative Sciences*. <https://doi.org/10.1108/JEAS-09-2023-0242>
- Berensmann, K., Volz, U., Alloisio, I., Bak, C., Bhattacharya, A., Leipold, G., Schindler, H., MacDonald, L., Huifang, T., & Yang, Q. (2017b). Fostering sustainable global growth through green finance—what role for the G20. *T20 Task Force on Climate Policy and Finance*. <https://www.cbd.int/financial/gcf/g20-greenfinance2017.pdf>
- Bildirici, M., Kayıkçı, F., & Ersin, Ö. Ö. (2023). Industry 4.0 and Renewable Energy Production Nexus: An Empirical Investigation of G20 Countries with Panel Quantile Method. *Sustainability*, 15(18), 14020. <https://doi.org/10.3390/su151814020>
- Bogacheva, O., & Smorodinov, O. (2017). Challenges to Green Finance in G20 Countries. *World Economy and International Relations*, 61(10), 16–24. <https://doi.org/10.20542/0131-2227-2017-61-10-16-24>
- Busch, T., Bauer, R., & Orlitzky, M. (2016). Sustainable Development and Financial Markets: Old Paths and New Avenues. *Business & Society*, 55(3), 303–329. <https://doi.org/10.1177/0007650315570701>
- Chang, L., Taghizadeh-Hesary, F., Chen, H., & Mohsin, M. (2022). Do green bonds have environmental benefits? *Energy Economics*, 115, 106356. <https://doi.org/10.1016/j.eneco.2022.106356>

- Cheung, F. M., & Hong, Y. Y. (2020). *Green Finance, Sustainable Development and the Belt and Road Initiative*. Routledge. ISBN: 978-0367675400
- Chin, M. Y., Ong, S. L., Ooi, D. B. Y., & Puah, C. H. (2024). The impact of green finance on environmental degradation in BRI region. *Environment, Development and Sustainability*, 26(1), 303–318. <https://doi.org/10.1007/s10668-022-02709-5>
- Chongyang Institute for Financial Studies Renmin University of China. (Ed.). (2016). *Who Will Govern the New World - the Present and Future of the G20*. Social Sciences Academic Press. [https://www.ibidem.eu/out/media/vlb\\_9783838209258\\_2.pdf](https://www.ibidem.eu/out/media/vlb_9783838209258_2.pdf)
- Climate Bonds Initiative. (2024). *Leading countries in terms of value of green bonds issued worldwide in 2023 (in billion USD)*. Statista. <https://www.statista.com/statistics/512030/share-of-green-bond-market-value-globally-by-major-country/>
- Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J. P., Iglesias, A., ... & Xoplaki, E. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change*, 8(11), 972–980. <https://doi.org/10.1038/s41558-018-0299-2>
- Den Elzen, M., Admiraal, A., Roelfsema, M., van Soest, H., Hof, A. F., & Forsell, N. (2016). Contribution of the G20 economies to the global impact of the Paris agreement climate proposals. *Climatic Change*, 137, 655–665. <https://doi.org/10.1007/s10584-016-1700-7>
- Desalegn, G., & Tangl, A. (2022). Enhancing Green Finance for Inclusive Green Growth: A Systematic Approach. *Sustainability*, 14(12), 7416. <https://doi.org/10.3390/su14127416>
- Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences*, 106(44), 18452–18456. <https://doi.org/10.1073/pnas.0908738106>
- Dubey, M. (2015). G-20: In Search of a Role. In J. Whalley (Ed.), *World Scientific Reference on Asia and the World Economy* (pp. 29–55). World Scientific. [https://doi.org/10.1142/9789814578622\\_0002](https://doi.org/10.1142/9789814578622_0002)
- Durrani, A., Rosmin, M., & Volz, U. (2020). The role of central banks in scaling up sustainable finance - what do monetary authorities in the Asia-Pacific region think? *Journal of Sustainable Finance & Investment*, 10(2), 92–112. <https://doi.org/10.1080/20430795.2020.1715095>
- Edwards, A. R. (2005). *The Sustainability Revolution: Portrait of a Paradigm Shift*. New Society Publishers. ISBN: 978-0865715318
- Ellen MacArthur Foundation. (2013). *Towards the circular economy Volume 1: An economic and business rationale for an accelerated transition*. <https://emf.thirdlight.com/file/24/xTyQj3oxiYNMO1xTFs9xT5LF3C/Towards%20the%20circular%20economy%20Vol%201%3A%20an%20economic%20and%20business%20rationale%20for%20an%20accelerated%20transition.pdf>
- European Commission, Joint Research Centre (2024). Crippa M, Guizzardi D, Schaaf E, Monforti-Ferrario F, Quadrelli R, Risquez Martin A et al. *GHG emissions of all world countries: 2024*. Publications Office of the European Union. <https://doi.org/10.3390/10.2760/953322>
- Ezroj, A. (2020). *Carbon Risk and Green Finance*. Routledge. <https://doi.org/10.4324/9781003095996>
- Ezuma, R. E. M. R., & Matthew, N. K. (2022). The perspectives of stakeholders on the effectiveness of green financing schemes in Malaysia. *Green Finance*, 4(4), 450–473. <https://doi.org/10.3934/GF.2022022>
- Fang, L. (2023). Dynamics of renewable energy index in G20 countries: Influence of green financing. *Environmental Science and Pollution Research*, 30(23), 63811–63824. <https://doi.org/10.1007/s11356-023-26804-w>
- Fatica, S., & Panzica, R. (2021). Green bonds as a tool against climate change? *Business Strategy and the Environment*, 30(5), 2688–2701. <https://doi.org/10.1002/bse.2771>
- Ferroukhi, R., Kieffer, G., Lopez-Perla, A., Nagpal, D., Hawila, D., Khalid, A., ... & Fernandez, V. (2016). *Renewable energy benefits: Measuring the economics*. International Renewable Energy Agency. [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA\\_Measuring-the-Economics\\_2016.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Measuring-the-Economics_2016.pdf)

- Flammer, C. (2023). Green bonds and carbon emissions. *Oxford Review of Economic Policy*, 39(4), 752-764. <https://doi.org/10.1093/oxrep/grad040>
- Fues, T., & Messner, D. (2016a). The G20: Balancing National Interests with the Global Common Good. *China Quarterly of International Strategic Studies*, 2(3), 293–309. <https://doi.org/10.1142/S2377740016500172>
- Govindan, K., Shaw, M., & Majumdar, A. (2021). Social sustainability tensions in multi-tier supply chain: A systematic literature review towards conceptual framework development. *Journal of Cleaner Production*, 279, 123075. <https://doi.org/10.1016/j.jclepro.2020.123075>
- He, J., Iqbal, W., & Su, F. (2023). Nexus between renewable energy investment, green finance, and sustainable development: Role of industrial structure and technical innovations. *Renewable Energy*, 210, 715–724. <https://doi.org/10.1016/j.renene.2023.04.010>
- Hira, T. K. (2012). Promoting sustainable financial behaviour: Implications for education and research. *International Journal of Consumer Studies*, 36(5), 502–507. <https://doi.org/10.1111/j.1470-6431.2012.01115.x>
- Jahanger, A., Balsalobre-Lorente, D., Ali, M., Samour, A., Abbas, S., Tursoy, T., & Joof, F. (2023). Going away or going green in ASEAN countries: Testing the impact of green financing and energy on environmental sustainability. *Energy & Environment*. <https://doi.org/10.1177/0958305X231171346>
- Jiang, Z. M. (2008). Reflections on energy issues in China. *Journal of Shanghai Jiaotong University (Science)*, 13, 257–274. <https://doi.org/10.1007/s12204-008-0257-7>
- Labatt, S., & White, R. R. (2003). *Environmental Finance: A Guide to Environmental Risk Assessment and Financial Products* (Volume 98). John Wiley & Sons. ISBN: 978-0-471-44738-2
- Li, Z., Kuo, T. H., Siao-Yun, W., & Vinh, L. T. (2022). Role of green finance, volatility and risk in promoting the investments in renewable energy resources in the post-covid-19. *Resources Policy*, 76, 102563. <https://doi.org/10.1016/j.resourpol.2022.102563>
- Liu, X., & Chen, H. (2020). Sharing Economy: Promote Its Potential to Sustainability by Regulation. *Sustainability*, 12(3), 919. <https://doi.org/10.3390/su12030919>
- Liu, X., Tong, D., Huang, J., Zheng, W., Kong, M., & Zhou, G. (2022). What matters in the e-commerce era? Modelling and mapping shop rents in Guangzhou, China. *Land Use Policy*, 123, 106430. <https://doi.org/10.1016/j.landusepol.2022.106430>
- Lutsey, N. (2015). *Transition to a global zero-emission vehicle fleet: A collaborative agenda for governments*. International Council on Clean Transportation. [https://theicct.org/sites/default/files/publications/ICCT\\_GlobalZEVAlliance\\_201509.pdf](https://theicct.org/sites/default/files/publications/ICCT_GlobalZEVAlliance_201509.pdf)
- Ma, M., Zhu, X., Liu, M., & Huang, X. (2023). Combining the role of green finance and environmental sustainability on green economic growth: Evidence from G-20 economies. *Renewable Energy*, 207, 128–136. <https://doi.org/10.1016/j.renene.2023.02.046>
- Mahat, T. J., Bláha, L., Uprety, B., & Bittner, M. (2019). Climate finance and green growth: reconsidering climate-related institutions, investments, and priorities in Nepal. *Environmental Sciences Europe*, 31(1), 1–13. <https://doi.org/10.1186/s12302-019-0222-0>
- Managi, S., Broadstock, D., & Wurgler, J. (2022). Green and climate finance: Challenges and opportunities. *International Review of Financial Analysis*, 79, 101962. <https://doi.org/10.1016/j.irfa.2021.101962>
- Metz, B., Davidson, O., De Coninck, H. C., Loos, M., & Meyer, L. (2005). *IPCC Special Report on Carbon Dioxide Capture and Storage*. Cambridge University Press. [https://www.ipcc.ch/site/assets/uploads/2018/03/srccs\\_wholereport-1.pdf](https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf)
- Mohd, S., & Kaushal, V. K. (2018). Green Finance: A Step towards Sustainable Development. *MUDRA: Journal of Finance and Accounting*, 5(1), 59–74. <https://doi.org/10.17492/mudra.v5i01.13036>

- Ning, Y., Cherian, J., Sial, M. S., Álvarez-Otero, S., Comite, U., & Zia-Ud-Din, M. (2023). Green bond as a new determinant of sustainable green financing, energy efficiency investment, and economic growth: a global perspective. *Environmental Science and Pollution Research*, 30(22), 61324–61339. <https://doi.org/10.1007/s11356-021-18454-7>
- Ozili, P. K. (2022). Green finance research around the world: A review of literature. *International Journal of Green Economics*, 16(1), 56–75. <https://doi.org/10.1504/IJGE.2022.125554>
- Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P. E., Kurz, W. A., ... & Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science*, 333(6045), 988-993. <https://doi.org/10.1126/science.1201609>
- Peng, B., Sheng, X., & Wei, G. (2020). Does environmental protection promote economic development? From the perspective of coupling coordination between environmental protection and economic development. *Environmental Science and Pollution Research*, 27, 39135–39148. <https://doi.org/10.1007/s11356-020-09871-1>
- Saha, R., & Maji, S. G. (2023). Do green bonds reduce CO2 emissions? Evidence from developed and developing nations. *International Journal of Emerging Markets*. <https://doi.org/10.1108/IJOEM-05-2023-0765>
- Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., ... & Bolwig, S. (2014). Agriculture, forestry and other land use (AFOLU). In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*: 811-922. Cambridge University Press. [https://backend.orbit.dtu.dk/ws/portalfiles/portal/103008543/ipcc\\_wg3\\_ar5\\_chapter11.pdf](https://backend.orbit.dtu.dk/ws/portalfiles/portal/103008543/ipcc_wg3_ar5_chapter11.pdf)
- Sorrell, S. (2015). Reducing energy demand: A review of issues, challenges and approaches. *Renewable and Sustainable Energy Reviews*, 47, 74-82. <https://doi.org/10.1016/j.rser.2015.03.002>
- Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511817434>
- Taghizadeh-Hesary, F., Yoshino, N., & Phoumin, H. (2021). Analyzing the characteristics of green bond markets to facilitate green finance in the post-COVID-19 world. *Sustainability*, 13(10), 5719. <https://doi.org/10.3390/su13105719>
- Tolliver, C., Keeley, A. R., & Managi, S. (2019a). Green bonds for the Paris agreement and sustainable development goals. *Environmental Research Letters*, 14(6), 064009. <https://doi.org/10.1088/1748-9326/ab1118>
- Usman, M., Makhdom, M. S. A., & Kousar, R. (2021). Does financial inclusion, renewable and non-renewable energy utilization accelerate ecological footprints and economic growth? Fresh evidence from 15 highest emitting countries. *Sustainable Cities and Society*, 65, 102590. <https://doi.org/10.1016/j.scs.2020.102590>
- Volz, U., Böhnke, J., Eidt, V., Knierim, L., Richert, K., & Roeber, G. M. (2015). Empirical Analysis of Supply of and Demand for Green Finance in Indonesia. In *Financing the green transformation: How to make green finance work in Indonesia* (pp. 56–94). Palgrave Macmillan. [https://doi.org/10.1057/9781137486127\\_4](https://doi.org/10.1057/9781137486127_4)
- Wade, R. H. (2011). Emerging World Order? From Multipolarity to Multilateralism in the G20, the World Bank, and the IMF. *Politics & Society*, 39(3), 347–378. <https://doi.org/10.1177/0032329211415503>
- Wang, K. H., Zhao, Y. X., Jiang, C. F., & Li, Z. Z. (2022). Does green finance inspire sustainable development? Evidence from a global perspective. *Economic Analysis and Policy*, 75, 412–426. <https://doi.org/10.1016/j.eap.2022.06.002>
- Warner, K., Hamza, M., Oliver-Smith, A., Renaud, F., & Julca, A. (2010). Climate change, environmental degradation and migration. *Natural Hazards*, 55(3), 689–715. <https://doi.org/10.1007/s11069-009-9419-7>
- Wu, H. (2023). Evaluating the role of renewable energy investment resources and green finance on the economic performance: Evidence from OECD economies. *Resources Policy*, 80, 103149. <https://doi.org/10.1016/j.resourpol.2022.103149>
- Yang, C., & Masron, T. A. (2022). Impact of Digital Finance on Energy Efficiency in the Context of Green Sustainable Development. *Sustainability*, 14(18), 11250. <https://doi.org/10.3390/su141811250>
- Yang, Z., Gao, W., & Li, J. (2022). Can economic growth and environmental protection achieve a “win–win” situation? Empirical evidence from China. *International Journal of Environmental Research and Public Health*, 19(16), 9851. <https://doi.org/10.3390/ijerph19169851>



- Yao, C., Feng, K., & Hubacek, K. (2015). Driving forces of CO<sub>2</sub> emissions in the G20 countries: An index decomposition analysis from 1971 to 2010. *Ecological Informatics*, 26(1), 93–100. <https://doi.org/10.1016/j.ecoinf.2014.02.003>
- Zhang, D., Mohsin, M., & Taghizadeh-Hesary, F. (2022). Does green finance counteract the climate change mitigation: Asymmetric effect of renewable energy investment and R&D. *Energy Economics*, 113, 106183. <https://doi.org/10.1016/j.eneco.2022.106183>
- Zhongping, S., Yongjun, G., Yunbao, X., Qifeng, X., & Andlib, Z. (2023). Green financial investment and its influence on economic and environmental sustainability: Does privatization matter? *Environmental Science and Pollution Research*, 30(39), 91046–91059. <https://doi.org/10.1007/s11356-023-28520-x>
- Ziolo, M., Filipiak, B. Z., Bağ, I., & Cheba, K. (2019). How to Design More Sustainable Financial Systems: The Roles of Environmental, Social, and Governance Factors in the Decision-Making Process. *Sustainability*, 11(20), 5604. <https://doi.org/10.3390/su11205604>
- World Bank, World Development Indicators. (2023). *Gross Domestic Product 2023* <https://datacatalogfiles.worldbank.org/ddh-published/0038130/DR0046441/GDP.pdf?versionId=2024-07-01T12:42:23.8710032Z>