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The Role of Financial Institutions in Advancing Global Carbon Reduction Targets: A Literature Review.

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Abstract

Financial institutions play a crucial role in advancing global carbon-reduction objectives by mobilizing capital to green investments, managing climate risk, and integrating ESG considerations in financial decisions. This study examines financial institutions' contribution to carbon-reducing objectives globally, concentrating on their function in green investment financing and their inclusion of climate risk in financial decisions. The paper adopts a comparative case study approach to compare green finance development in Europe, Asia, Africa, and America, observing the impact of regional systems of regulation, patterns of investments, and financial instruments. The analysis confirmed that there is a lead in green finance regulation and standardization in Europe, with EU Taxonomy and the European Green Deal guiding green investments. There is a dual reality in Asia, where there is a lead in green bond issuance in China and India, with fragmentation of regulation in other economies and a high reliance on fossil fuels. The analysis also confirmed that there is a high political risk and financing cost in Africa that inhibits access to climate finance, yet multilateral development banks facilitate closing gaps in investments. In America, there is a lead in ESG investing and carbon trading in North America, however, in Latin America, there is a challenge of volatility of economies and inconsistency of policies that inhibits green finance adoption. The analysis indicates that financial institutions should include climate risk in their lending decisions, and policymakers should also harmonize systems of regulation to scale up green finance and tackle climate change globally.

Keywords: Green Finance, Carbon Reduction, Sustainable Investment, Financial Institutions, ESG Investing, Climate Policy

1. Introduction

Climate change is one of the most pressing issues globally, having impacts on ecosystems, human health, and resilience in the economy (Rocha et al., 2022). The Intergovernmental Panel on Climate Change (IPCC, 2023) highlights that slowing down global warming to 1.5°C compared to pre-industrial temperatures is crucial to preventing permanent damage. Carbon dioxide (CO_2) is accountable for approximately 76% of total greenhouse gas emissions (World Bank, 2022), and therefore emission mitigation is crucial to protecting natural ecosystems, human lives, and economic growth. Atedhor (2023) noted that there is a need to meet carbon emission reductions in a speedy and systemic approach in every aspect of the world. However, given that financial institutions play a fundamental role in capital mobilization and redistribution to facilitate economic growth, their role in carbon emission reductions cannot be overrated. Gunningham (2020) noted that financial institutions play a fundamental role in a low-carbon transition. Banks, asset managers, insurers, and development banks control massive pools of capital and can guide investments towards low-carbon technologies and green energy. For instance, large asset managers such as BlackRock, Vanguard and State Street redirected billions of dollars of investments in fossil fuels to green efforts, guiding business behavior towards sustainability (Greenfield, 2019). Empirical evidence shows that financial institutions do more than manage risk—they set long-term investment strategies in line with green goals (Meng, Ye and Wang, 2024; Nazir et al., 2025). By investing capital in green investments, these institutions enable a transition towards a more sustainable economic system.

Regional variations in carbon emission patterns and green finance practices highlight the need for tailor-made approaches. Almeida et al. (2023) explained that Europe is a leader in sustainable finance owing to strong regulation and ambitious climate action. The European Union's policies, such as EU Taxonomy and the European Green Deal, facilitated sustainable investments that currently account for over 40% of total assets under management in some areas (EU Commission, 2024). Flammer (2020) also explained that there is higher green bond issuance in European banks, funding renewable energy, energy efficiency programs, and policy guidelines ensuring transparency and accountability. The situation is different in Asia. Studies in the region report that China and India's economic growth has resulted in high carbon emissions, yet these countries also continue to make

great strides in green finance (Mehmood et al., 2023; Wang, Ruan and Wang, 2024). World leader in green bonds, China issued approximately $68 billion in green bonds in 2022 to support renewable energy and infrastructure development (Statista, 2024a). There are still challenges in the region, as most economies remain reliant on coal and other fossil fuels (McCauley and Pettigrew, 2023). The challenge of maintaining economic growth and keeping up with environmental commitments makes Asia a compelling case study in low-carbon energy transition. Africa, having immense potential in renewable energy, is receiving less than 3% of total climate finance (AfDB, 2023). Political instability, poor infrastructure, and capital scarcity hampered large-scale green investments in the region (Dube and Horvey, 2023). Most green energy projects that are viable cannot get funding, hence there is a need for financial instruments that are specifically tailored to overcoming unique challenges in African countries. The case of America paints a diverse picture. The United States has made great advances in ESG investing (Lütkehermöller et al., 2020). Banks have ramped up investments in green energy, and efforts such as the Climate Action 100+ coalition have galvanized companies towards more transparency in reporting emissions (Lütkehermöller et al., 2020). However, economic volatility and regulation uncertainties hamper green finance adoption in some Latin American economies (Marín-Rodríguez, González-Ruiz and Botero, 2025). There are also success stories, such as in Argentina, Brazil and Chile, in which cities have undertaken innovative financing of green energy projects in cities (Rubio and Jáuregui, 2022).

This study looks at financial institutions' role in carbon reduction. It assesses their mobilization of capital and their role in making investments that lead to a low-carbon economy. The study adopts a broad approach focusing on case studies from Europe, Asia, Africa, and America to establish overall patterns and regionally unique challenges in green finance. An understanding of these dynamics is relevant to policymakers, investors, and scholars looking to accelerate efforts in sustainable finance.

2. Literature Review

Global Overview

Theme 1: Global Trends in Green Finance

The Rise of Green Finance

The finance sector is becoming more in sync with global climate goals by adopting green finance tools. Green finance such as investments in green bonds, carbon credits, and ESG has surged in recent years. All such financial instruments facilitate capital mobilization towards low-carbon investments and hasten the process of transitioning the world to a green economy (Zeng et al., 2023).

Expansion of Green Finance Instruments

Green bonds are among the most prominent financial instruments supporting sustainability. Since their introduction by the European Investment Bank (EIB) in 2007 and the World Bank in 2008, the green bond market has become increasingly popular. Alamgir and Cheng (2023) determine that the issuance of green bonds is positively linked with carbon emissions reductions, with per capita carbon emissions reported to decrease by as much as 0.8 tons and renewable energy production by 66 kWh. In the year 2021 alone, the issuance of green bonds globally totaled nearly $500 billion against $78 billion in 2015 (see figure 1 and 2) (Jones, 2022). Germany and the United States, with greater green bond issuance, have registered faster progress in sustainability goals.

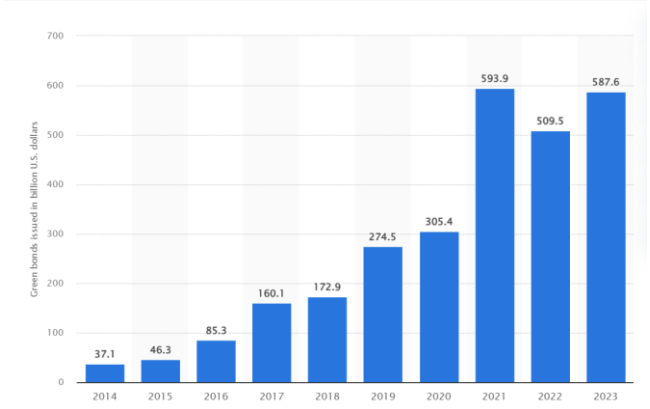

Figure 1: Value of green bonds issued worldwide from 2014 to 2023 (in billion U.S. dollars) (Statista, 2024b)

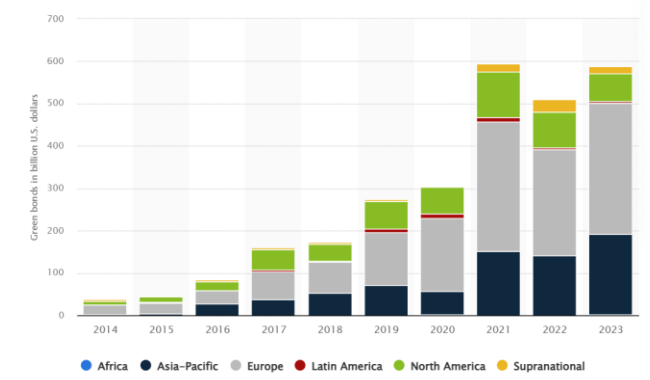

Figure 2: Value of green bonds issued worldwide 2014-2023, by region (Statista, 2024c)

Carbon credits are also a key component of green finance. The European Union Emissions Trading System (EU ETS) remains the largest carbon market, providing companies with financial incentives to reduce emissions (Dechezleprêtre, Nachtigall and Venmans, 2022). Zeng et al. (2023) note that carbon trading policies have decreased emissions in China significantly. Voluntary carbon markets are also expanding as companies purchase credits to offset their carbon footprints. However, concerns over greenwashing and fragmented regulatory regimes remain, potentially undermining their effectiveness (Free, Jones and Tremblay, 2024).

ESG investment has grown, with institutional investors incorporating ESG considerations into decision-making to sidestep financial risks associated with climate change. The Global Sustainable Investment Alliance (GSIA, 2022) estimates that ESG-concordant investments now amount to more than $35 trillion in assets under management, a foundational transformation in the allocation of capital. Research by Obiora et al. (2020) shows that financial institutions that adopt ESG considerations facilitate long-term reductions in carbon emissions. However, challenges in ESG metrics standardization persist, and different investment funds have been criticized for making misleading claims of sustainability.

Role of International Organizations

Global institutions and regulators have been key to defining green finance patterns around the globe. The World Bank and IMF have integrated climate risk into financial analysis to facilitate green investments in developing economies (Natalucci, Gautam and Goel, 2022; World Bank Group, 2024). The Glasgow Financial Alliance for Net Zero (GFANZ) has aligned more than 450

financial institutions managing $70 trillion in assets to net-zero emissions (GFANZ, 2021). The EU Taxonomy for Sustainable Activities has also set environmentally sustainable investments, providing transparency and preventing greenwashing (European Commission, 2024). In Asia, the Asian Development Bank (ADB) has funded climate-resilient infrastructure in developing economies, focusing on multilateral institutions in green finance (ADB, 2022).

Key Findings: Green Bond Growth and ESG Integration

The rapid expansion of green finance instruments is a reflection of a more widespread trend towards sustainability in financial systems around the world. The evidence of Alamgir and Cheng (2023) confirmed that more developed green bond markets in a nation result in more carbon emission reductions and renewable energy development. ESG integration has also been found to result in improved financial performance, such that studies provide evidence that companies that demonstrate high ESG performance have lower capital costs and financial volatility (Alduais, 2023; Wu, Zhu and Tao, 2024). However, ESG reporting discrepancies between developed economies and developing economies continue to impact the effectiveness of sustainable investments (Obiora et al., 2020).

Theme 2: Global Regulatory Frameworks and Policies

Global regulatory frameworks also steer financial institutions towards low-carbon investments by offering mechanisms such as carbon pricing and demanding more reporting of climate-related risk (Monasterolo et al., 2022). The frameworks steer financial markets towards green goals and provide financial flows that facilitate the green transition of the world's economy.

Carbon Pricing Mechanisms

Tsai (2020) noted that one of the most useful policy instruments is carbon pricing, including carbon taxes and cap-and-trade systems (also referred to as Emissions Trading System-ETS). The instruments place a price tag on CO_2 emissions to encourage companies to reduce their carbon intensity. The case of European Union Emissions Trading System (EU ETS) is one of the world's largest carbon markets. Ritchie and Rosado (2022) also clarified that Carbon Tax prices carbon by imposing a charge on the carbon content of fossil fuels or greenhouse gas emissions. The government, for example, imposes a charge per ton of CO_2 emitted by a power generation company or a factory. The cap-and-trade system imposes a limit (cap) on total greenhouse gas emissions permitted by all participants. Companies receive or purchase emission allowances, trading with each other as necessary. The cap is progressively reduced to reduce total emissions over time. The method achieves a given emission cutback but permits the price of carbon to be established in the marketplace. The carbon price in EU ETS, in line with recent reports, has risen from €8 per ton in early 2018 to around €85 towards the close of 2023 (Nguyen et al., 2024; Wei, Li and Wang, 2022). This is over a 1000% jump in six years, inducing carbon price bubbles in ETS in the EU and offering a strong price signal for investments in low-carbon technologies and energy efficiency. The carbon market has been hit by volatile price swings, making it challenging for companies to forecast emission reductions in the long term. To manage such a risk, investors employ hedging tools such as green bonds, green stocks, and derivatives in the renewable energy sector. Such financial tools stabilize volatile carbon prices, hence making it easy to make decisions regarding sustainability investments (Nguyen et al., 2024).

Gyimah et al. (2024) point out that a low-carbon trading system can be a basic policy reaction to curbing global warming in that it can affect business investment decisions in a straight-forward manner by making high-emitting behavior costly. Similarly, carbon taxes have been levied in many countries to instantaneously deter carbon-intensive behavior (Criqui, Jaccard and Sterner, 2019). The IMF has claimed that when well designed, such fiscal instruments not only reduce emissions but also raise revenue that can be invested in renewable energy initiatives (Mooij, Keen and Parry, 2012). These policy instruments have gradually influenced the actions of financial institutions, prompting them to change lending practices by incorporating climate risk in credit assessments.

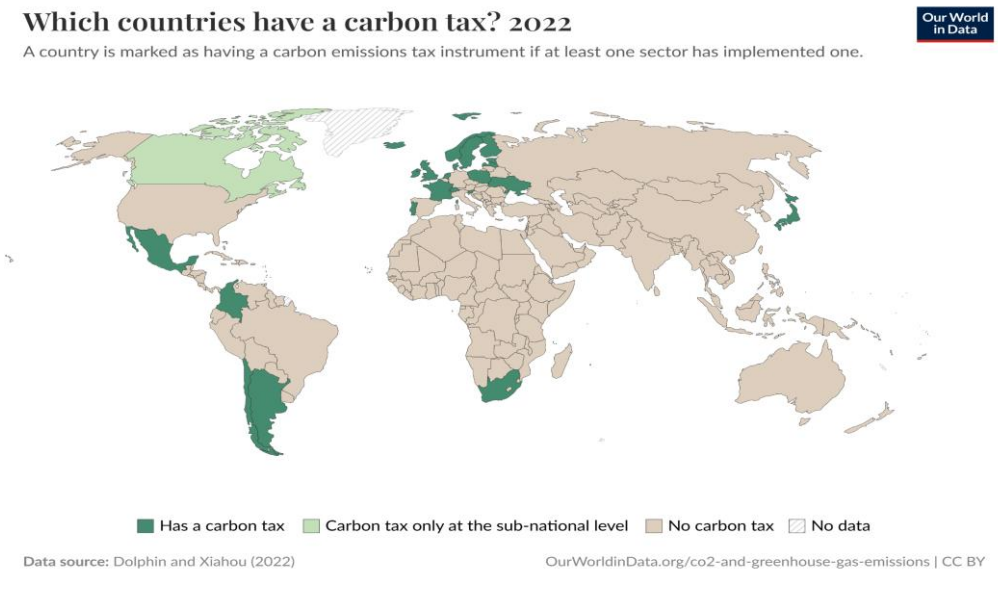

Figure 3: Countries that Implement Carbon Tax (Dolphin and Xiahou, 2022)

Figure 3 shows a world map of carbon taxes as of 2022, indicating the countries that have implemented a carbon tax policy. Countries shaded in dark green such as Canada, Argentina, Chile, South Africa, and Japan, have an existing carbon tax at the national level. Light green spots, such as parts of the United States and Canada, indicate places where carbon taxes only exist at the sub-national level. The majority of countries, colored beige, have not yet established a carbon tax, reflecting variation in climate policy and regulatory actions worldwide. The map identifies the uneven application of carbon pricing initiatives, which can influence global climate pledges and market-based emissions reduction programs.

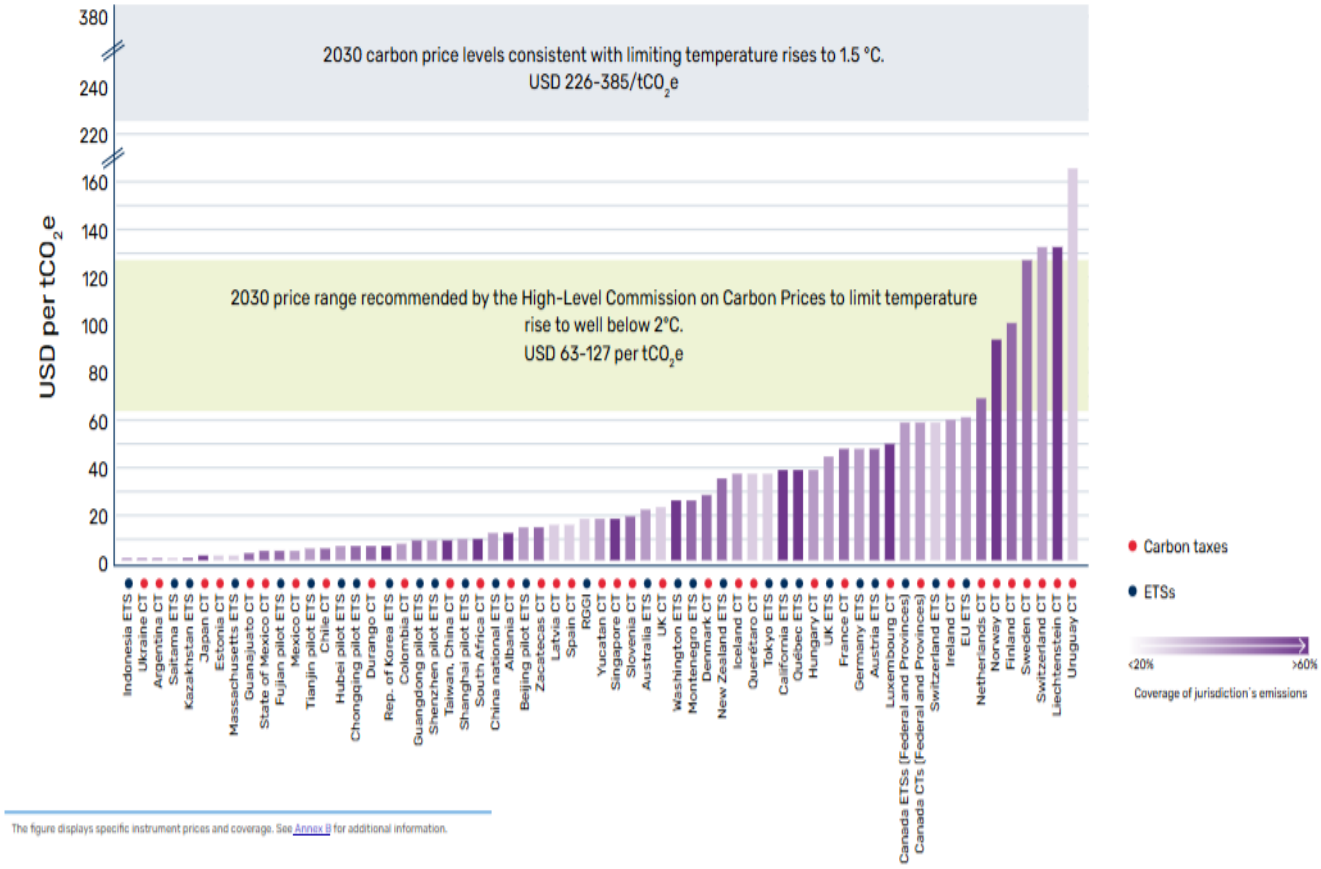

Figure 4: carbon pricing in Emissions Trading Systems (ETS) and Carbon Taxes (CT) as of April 1, 2024 (World Bank Group, 2024)

The chart shows carbon pricing in Emissions Trading Systems (ETS) and Carbon Taxes (CT) as of April 1, 2024, with significant variation in carbon price levels between jurisdictions. A number of European jurisdictions, such as Sweden, Switzerland, and Liechtenstein, have among the highest carbon prices, whereas many other jurisdictions fall far below these levels. The chart further presents 2030 carbon price targets, with the green area (USD 63–127/tCO_2e) representing the proposed range to limit temperature increase to below 2°C and the blue area (USD 226–385/tCO_2e) representing the price to stay within a 1.5°C warming pathway. The chart further differentiates between ETS and carbon taxes, showing that ETS prices (in blue) vary significantly by coverage, whereas carbon taxes (marked in red) are generally levied at higher price levels. In total, the chart shows that most jurisdictions fall below the proposed carbon pricing levels for effective climate action. This figure illustrates global divergence, marking how few jurisdictions have reached or surpassed the thresholds required. This divergence reflects the challenge in aligning financial incentives with climate goals, ultimately influencing green finance policy worldwide.

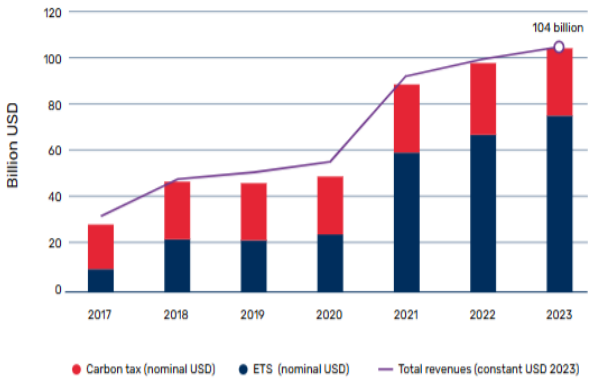

Figure 5: Revenues from Carbon Pricing Instruments (World Bank Group, 2024)

This chart plots the evolution of worldwide revenues from carbon pricing instruments (Emissions Trading Systems - ETS and Carbon Taxes) from 2017 to 2023. Overall revenue, in constant USD, was $104 billion in 2023, after a sustained rising trend. The stacked bars differentiate revenues from carbon taxes (red) and ETS (blue), showing that ETS revenues have consistently represented a larger share of the total. From 2020 to 2021, revenue surged sharply, reflecting the global expansion of carbon pricing schemes. The

trend reflects increasing utilization of carbon pricing as a tool of climate finance, with potential implications for green investment and policy-making.

Disclosure Requirements

Disclosure requirements of the Task Force on Climate-related Financial Disclosures (TCFD), have become a centerpiece in determining financial institutions' response to climate change. Principale and Pizzi (2023) noted that TCFD guidance is a roadmap for companies to provide disclosures on climate change risk and opportunity, improving transparency to investors. Fu, Lu, and Pirabi (2023) noted that strict regulation in the form of mandatory disclosure of climate risk enhances market discipline and yields more informed decisions in finance. An example is that more transparency in ESG reporting has caused divestment of capital in high-emission industries, given that investors price long-term risk better. Despite the progress, there are setbacks. One is that there is a lack of geographically integrated approaches to disclosure (Zeng et al., 2024). European and North American institutions to a great extent have embraced TCFD guidance, whereas in emerging economies, adoption is in pockets given that there is variance in regulation capabilities and standards (Park and Kim, 2020). Secondly, voluntary disclosure introduces information asymmetry, such that companies greenwash or underreport risk (Lubello, 2024). This is a loophole in regulation that denies a collective approach to the measurement of climate risk across the globe.

Impact on Financial Institutions' Behavior

The joint effect of carbon pricing and more stringent disclosure requirements has been significant. Banks increasingly take more active account of environmental factors in their risk management systems. Literature (e.g., Obiora et al., 2020; Park and Kim, 2020) shows that banks adapt their lending behavior towards low-carbon sectors, in part due to more stringent disclosure requirements making climate risk more visible. Furthermore, international organizations such as the World Bank and the IMF continue to advocate for harmonized regulatory standards to reduce differences between jurisdictions (Black, 2023). Though these regulatory measures have forced change, issues of implementation persist. Mengistu et al. (2019) shows that piecemeal adoption of frameworks, particularly by developing countries, and voluntary nature of some frameworks continue to hinder efforts at the international level. This regulatory fragmentation calls for greater international coordination and a move towards mandatory, harmonized standards for both carbon pricing and climate risk disclosures.

3. Discussion and Analysis

Regional Case Studies

Case Study 1: Europe

Europe has established itself as a global leader in green finance, underpinned by strong regulatory frameworks, policy guidance, and a rich ecosystem of public-private partnerships (Almeida et al., 2023). The European Union’s comprehensive policy instruments—most importantly the EU Taxonomy and the European Green Deal—have provided a solid foundation for guiding capital into sustainable projects, thereby putting Europe at the forefront of the low-carbon transition.

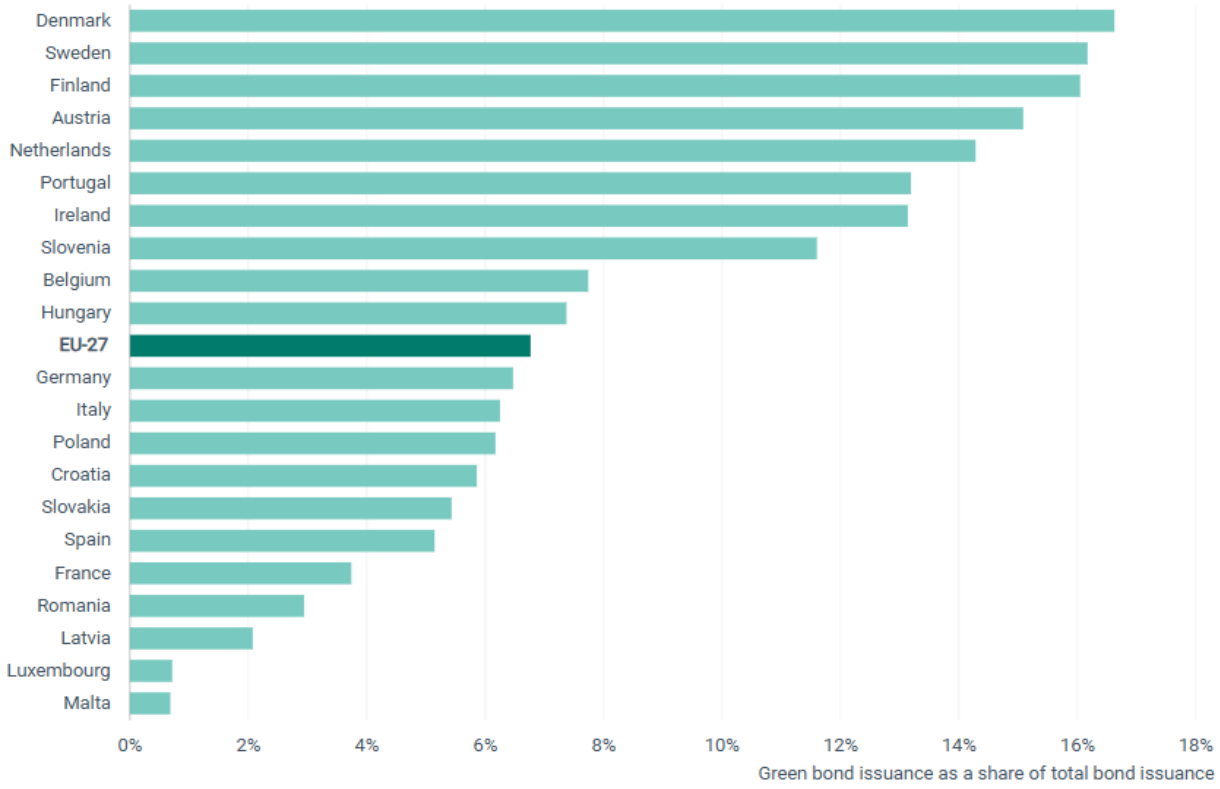

Figure 6: green bonds issued by governments and corporations in 2023 (European Environment Agency (EEA), 2023)

Figure 6 presents the percentage of green bonds issued by governments and corporations in 2023 as a proportion of overall bond issuance in EU member states. Denmark, Sweden, Finland, and Austria are the top performers in issuing green bonds, with over 14% of their overall bond issuance in green bonds. The Netherlands, Portugal, and Ireland also have significant levels of green bond uptake, demonstrating strong national commitments to sustainable finance. The EU-27 average, indicated by an isolated dark bar, stands at about the middle of the rankings, slightly below Hungary. Moderate levels of green bond issuance are exhibited by Germany, Italy, and Poland, while the lowest proportions are seen in nations like Latvia, Luxembourg, and Malta, indicating slower adoption of green finance instruments.

Regulatory Framework and Policy Support

At the center of Europe's green finance leadership is the EU Taxonomy, which offers clear criteria for identifying environmentally sustainable economic activities (Dziwok and Jäger, 2021). The framework minimizes the risk of greenwashing by ensuring that investments branded "green" are held to strict environmental standards. The European Commission (2024) noted that the Taxonomy will unlock about €1 trillion of green investments by 2030. Such clarity not only boosts investor confidence but also incentivizes financial institutions to reallocate their portfolios to renewable energy, energy efficiency, and other low-carbon sectors. The European Green Deal (EGD) published by the European Commission on 11 December 2019 as the new growth strategy for the EU reinforces this agenda by setting ambitious goals, including making Europe climate-neutral by 2050 (Ciot, 2021). This strategic response brings regulation, government funding, green bonds, and private capital in one direction, such that various EU member states in the Green Deal introduced mandatory requirements of TCFD-aligned climate risk disclosures to compel companies to integrate climate factors in their business models. The evidence in Obiora et al. (2020) indicates that more intense disclosure practices lead to more effective allocation of capital to low-emission sectors, thus accelerating the process of moving towards a low-carbon economy.

The Success of Green Bond Markets

Green bonds have become a flagship product in the green finance system in Europe. The green bonds in Europe were introduced in 2007 by the European Investment Bank (EIB) and continued to gain momentum exponentially after their introduction (Cortellini and Panetta, 2021). Following the Climate Bonds Initiative, green bond issuance shot up around the globe to over $500 billion in 2021 compared to around $78 billion in 2015 with a high contribution of European issuers to the market (Climate Bonds Initiative, 2022). The EGD seeks to raise funds for green investments through green bond issuance secured by the EU Sustainable Finance Framework. It seeks to finance green undertakings, green assets, and specific environmental and climate goals. The green bond issued in the EU between 2014 to 2023 reached a high of 6.8% of that in the world up from 0.3% suggesting a high demand for green financial investment and interest in moving to a low-carbon, green economy (European Environment Agency (EEA), 2023). The expansion is not just a reflection of investors' demand but also of regulatory incentive design. As a point of note, different green bonds have been used to finance large green energy undertakings such as wind farms in Denmark and Spanish solar parks (Djunisic, 2025; Segreto et al., 2020). In a study conducted by Alamgir and Cheng (2023), it was observed that in green bond-developed economies, there is a measurable decline in carbon emission-reporting in some cases a decline of up to 0.8 tons per capita. The results suggest that green bonds have been a success in keeping the capital costs of green energy undertakings in check and spurring more investments.

Role of Public-Private Partnerships

Public-private partnerships (PPPs) have been instrumental in green finance scaling up in Europe. In Germany and France, national institutions like KfW and Bpifrance have collaborated with private financial institutions to establish financing pipelines for energy efficiency and renewable energy projects (European Investment Bank, 2024). For example, Germany's KfW has co-financed dozens of solar and wind projects, de-risking green investment and mobilizing further private capital (Kfw-entwicklungsbank.de, 2024). Such partnerships not only facilitate access to long-term finance but also catalyze innovation in green financial instruments. Innovative instruments—in the form of sustainability-linked loans, which condition interest rates on a firm's environmental performance. Such products incentivize firms to improve their ESG scores, as better performance lowers financing costs.

Critical Discussion and Emerging Challenges

Despite Europe's leadership, several challenges persist. The regulatory framework, although comprehensive, is often criticized for being complex. According to Brühl (2021), the European Union has established a system of sophisticated rules to facilitate sustainable finance in a three-pronged manner in the form of the Taxonomy Regulation, the Sustainable Finance Disclosure Regulation (SFDR), and the Corporate Sustainability Reporting Directive (CSRD). The rules aim to harmonize definitions of sustainable activities, facilitate transparency, and institutionalize green elements in financial decision-making processes. However, the sophisticated nature of overlapping rules has caused challenges in their application and compliance for financial institutions and companies. Small and medium-sized enterprises (SMEs) sometimes find the administrative costs of complying with stringent disclosure and reporting requirements burdensome (Rzepecka et al., 2024). Moreover, despite the enhancements in transparency brought about by mandatory disclosures (e.g., TCFD-aligned reporting), inconsistencies in reporting standards and data quality among member states continue to frustrate a fully harmonized approach (Friedrich, Velte and Wulf, 2022).

Another area of tension involves the balance between encouraging green investments and managing potential risks. While carbon pricing mechanisms—such as the EU ETS—have successfully driven carbon prices up (well above €60 per ton in recent years) and encouraged abatement (Tiseo, 2024), critics argue that a price set too high would damage industrial competitiveness (Venmans, Ellis and Nachtigall, 2020). Moreover, despite the high performance of green bonds, the overall scale of green finance is still below the trillions of dollars needed to achieve the EU's long-term climate goals. The European Commission has made a commitment to mobilize at least €1 trillion in sustainable investments by 2030 to finance the EGD. However, achieving this target will require additional annual investments of about two percent of GDP between 2021 and 2030 (See figure 7). To reach a net-zero level, this level must be sustained for two decades (Pisani-Ferry and Tagliapietra, 2024). The EGD's ambitious investment goals underscore this gap, indicating the need for continued policy innovation and greater collaboration among public, private, and multilateral stakeholders.

	2011-2020		2021-2030 *To meet EU 2030 climate target*		2031-2050 *To achieve net-zero by 2050*	
		% of GDP		% of GDP		% of GDP
Energy supply	€80 billion	0.6%	€150 billion	0.9%	€308 billion *70% of which for the power sector*	1.5%
Energy demand	€167 billion	1.1%	€374 billion	2.2%	€356 billion *70% of which for residential buildings*	1.7%
Transport	€616 billion	4.1%	€780 billion	4.6%	€873 billion *60% of which for cars*	4.2%
Total	**€863 billion**	**5.8%**	**€1304 billion**	**7.7%**	**€1537 billion**	**7.4%**

Figure 7: EU total annual investments in energy and transport systems (2023 euros) (Pisani-Ferry and Tagliapietra, 2024)

Case Study 2: Asia

Asia is characterized by rapid economic growth, huge carbon emissions, and vibrant but uneven development of green finance activities (Diaz-Rainey et al., 2023). The study noted that major economies such as China and India have witnessed transformative shifts in their financial systems as they seek to balance high-growth ambitions with environmental sustainability. However, most developing economies in the region continue to struggle with institutional and market challenges to green finance scaling up.

Development of Green Finance in Key Economies

China has made significant contributions to the growth of green finance globally. The government of China has unveiled a series of policies to support low-carbon development in the past decade. For instance, China is currently the world's largest green bond issuer, with total volumes of hundreds of billions of dollars in recent years (Xiao et al., 2024). The green bonds support a wide range of projects, from large wind farms and solar farms to energy efficiency retrofits in cities. Empirical evidence shown in studies of Zeng et al. (2023) and Liu et al. (2024) has established that ambitious green finance in China reduces carbon emissions, in part, by overcoming maturity mismatch of financial instruments and encouraging technological innovation. In addition to green bonds, digital finance is increasingly playing a more dominant role. The studies of Wang et al. (2024) and Zhang et al. (2024) provide evidence that Fintech innovations are employed to enhance carbon emission efficiency by alleviating financing constraints and encouraging green technological investments. To illustrate this, Fintech platforms in large cities in China allowed more efficient capital allocation to low-carbon investments, and dynamic spatial analyses indicating spillover effects to neighboring areas (Zhang et al., 2024). In addition, a study in Sustainability utilized data from 100 of China's pilot smart cities between 2011 and 2019. The evidence indicates that digital finance has a U-shaped impact on green total factor productivity (GTFP) and that it has intense spillover effects in space. This means that digital finance's impact on GTFP increases when it matures, not only for the originating city but also for neighboring cities (Yu, Zhang and Song, 2023). Similarly, research by He and Jiang (2024) indicates that digital inclusive finance can reduce carbon intensity by promoting digital technology innovation, even if these gains are more likely to be greater in urban regions with more established digital infrastructure. India is also an interesting case in the region. Although its green finance market is less advanced than that of China, India has seen a growing emphasis on green banking. Gulzar et al. (2024) write about how Indian banks, including major ones like the State Bank of India (SBI), are integrating environmental data into their credit analysis. This is part of a broader trend where banks increasingly favor companies with lower carbon emissions, thus promoting investment in renewable energy and energy efficiency. However, Indian progress is hampered by institutional fragmentation consisting of multiple laws/authorities and a relatively less advanced regulatory framework compared to China (Sinha, Srikanth and Mahalingam, 2022). These are compounded by the country's high reliance (over 70%) on coal and other fossil fuels, which accounts for its high carbon emissions. The country seeks to address this by installing 100 gigawatts of nuclear power by 2047 to provide clean energy for about 60 million Indian homes per annum (Arasu, 2025).

Challenges and Emerging Initiatives in Asian Economies

Beyond China and India, several other Asian countries are beginning to adopt green finance mechanisms, though at varying paces and scales. In the Gulf Cooperation Council (GCC) nations, for example, green finance is emerging as a way to diversify economies traditionally reliant on fossil fuels. However, many of the developing economies in Asia aside from these two countries face structural challenges that limit their ability to scale green finance, such as high financing fees, fragmentation of regulation, and fossil fuel subsidies (Supriyanto, 2023).

According to Supriyanto (2023), the Asia-Pacific accounted for over 58% of carbon emissions in 2021, a reflection of its high reliance on fossil fuels to power economic growth. Most of these emissions come from China and India, which together account for over 35% of global CO_2 emissions. The region requires $1.1 trillion annually to meet its climate requirements, yet there is a wide funding gap, averaging $600 billion per annum. Belgacem et al. (2023) provide empirical evidence from the UAE and Saudi Arabia, showing that financial innovation and increased use of renewable energy sources are beginning to curtail carbon emissions. However, these countries still grapple with challenges such as aligning financial incentives with long-run sustainability goals and overcoming market distortions caused by subsidized fossil fuels. Other developing economies in Asia struggle more to scale green finance as they suffer from higher financing costs,

weaker regulatory capacity, and less digital infrastructure. While government-led pilots in some Southeast Asian countries are encouraging—such as the updated green credit framework in Vietnam—these efforts remain regionally fragmented and ad hoc (Lee, 2024). In most cases, financial institutions in these countries have yet to mainstream climate risk into their lending and investment decisions (Ho and Wong, 2021). This delays the transition towards more sustainable practices and renders green finance instruments more difficult to achieve a significant market share.

Despite these challenges, Asian-Pacific sustainable debt issuance exceeded $350 billion in 2022, indicating a growing interest in green finance. The green finance market in the region is led by China, which controls a massive 85% of total issuance, followed by ASEAN economies and India, collectively accounting for 15%. The distribution is extremely skewed, with most smaller economies getting less than 1% of total sustainable finance flows (Lim et al., 2024). This reflects the low share of adaptation financing in total climate finance as well as the many challenges facing countries with weak access to international capital markets. Recognizing these gaps, in 2023, the Asian Development Bank (ADB) launched the Energy Transition Mechanism (ETM) to mobilize $15 billion to support the early retirement of coal power generation and ramp up investments in clean energy (ADB, 2024). The ETM is set to facilitate the retirement of a minimum of 10 gigawatts of coal capacity in Southeast Asia, materially reducing regional emissions and making energy diversification possible. However, the long-term viability of this effort is contingent on regulation reforms, investor sentiment, and private sector participation (Ma, Liu and Liu, 2025).

Critical Discussion

One of the most significant challenges in Asia is how to reconcile rapid economic growth with environmental sustainability (Feng et al., 2024). Although both China and India have made considerable progress in developing green finance markets, the fundamental structure of the economy—often reliant on high-emission industries—can blunt the impact of such efforts. For instance, although green bond issuance in China has reached an impressive scale, the resulting reduction in carbon intensity is sometimes offset by continued high levels of industrial activity (Xiao et al., 2024). Zhang (2024) found that Fintech solutions improve the efficiency of carbon emissions and have also demonstrated promising results in urban areas but have limited applicability in rural and less developed regions where traditional sources of energy continue to dominate.

In addition, the regulatory environment in most Asian countries remains disparate. Unlike the coherent approach in Europe under the EU Taxonomy and the Green Deal, Asian regulatory systems are extremely divergent from one country to another (Iyer, 2024). Such divergence generates uncertainty for investors and makes it harder to scale up green finance across borders. Where regulatory supervision is weak, greenwashing risks and information asymmetry continue to prevail, that can be detrimental to the credibility of green finance initiatives. These findings highlight the need for focused policy action and cooperation in scaling up green finance in a way that is impactful and in making a meaningful carbon emission reduction in Asia.

Case Study 3: Africa

Africa presents a unique green finance terrain. With a high potential for renewable energy in the form of high solar radiation, wind corridors, and hydro potential (Mukhtar et al., 2023), it is getting less than 3% of total global climate finance (Freitas and Mwaniki, 2024). The explanation for this is a combination of challenges that range from poor infrastructure to undeveloped regulation frameworks. The same challenges also provide leeway for new financial instruments and policy interventions that have transformative potential.

Unique Challenges and Opportunities

The issuance of green bonds is also a new phenomenon in African financial markets, as the first bond was issued in 2010 and subsequently, most of the nations stayed dormant in green bond markets (Taghizadeh-Hesary et al., 2021). The African Development Bank (AfDB) plays a key role in the issuance of green bonds for climate-related purposes in Sub-Saharan Africa in addition to other countries, like Nigeria, Kenya, Morocco, and South Africa (Mutarindwa, Schäfer and Stephan, 2024). Marbuah (2020) stated that the green bond market in Africa is relatively small totalling $2 billion in 2019 from governments, cities/municipalities and corporate issuers. Despite the progress made so far, Africa's financing gap remains substantial. Most African nations have persistent electricity grid reliability challenges, low access to modern energy storage technologies, and limited digital financial services (Agoundedemba, Kim and Kim, 2023). Such infrastructural deficiencies raise the cost of capital and dissuade private sector participation in green energy projects. For instance, in sub-Saharan Africa, prohibitive transaction costs and fragmented financial markets have undermined attempts at scaling up green finance instruments, e.g., green bonds or sustainable loans (Obiora et al., 2020). Political instability in some regions, e.g., parts of the Sahel, conflict-affected areas, contributes to the precarious investor confidence that makes it difficult to implement green long-term projects (Raga, Lemma and Keane, 2023). Even then, the very challenges highlight the potential for massive improvements. If investment is successfully mobilized, modest increments in green finance can achieve enormous environmental, and economic benefits.

Role of Multilateral Development Banks

Multilateral development banks (MDBs) are now one of the key players in closing the green finance gap in Africa (AfDB, 2024). The African Development Bank (AfDB) has been in the lead in initiatives such as the “New Deal on Energy for Africa,” which is aimed at mobilizing significant funds each year towards clean energy initiatives (AfDB, 2018). The efforts support investments in such areas as solar photovoltaic systems in Kenya to wind farm investments in Morocco. The World Bank has also been in action, funding efforts in Nigeria, South Africa, and Ethiopia towards renewable energy infrastructure and energy efficiency (World Bank, 2023b; 2024b). Such efforts not only reduce carbon emissions but also catalyze local economies through job creation and increased energy access. Public-private partnerships (PPPs) have been instrumental in this. In Ghana, for example, various PPPs support solar energy efforts, pairing public finance with private capital in a move to share risk and raise more capital (Awuku et al., 2022). PPPs enable governments to leverage limited public funds to raise large-scale financing in the private sector, hence speeding up green investments on a large scale.

Barriers to Green Finance Adoption

Despite the promising potential of MDBs, there are serious challenges to scaling up green finance in Africa. Among such challenges is a lack of robust regulation frameworks (Tamasiga et al., 2023). Contrary to a unified system in Europe in line with EU

Taxonomy and Green Deal, most African countries have not yet established overarching sustainability standards. Such regulation uncertainty introduces information asymmetry and increases investors' perceived risk, thereby inhibiting green bonds and other financial instrument issuance (Obiora et al., 2020). Moreover, relatively low digital penetration in rural areas inhibits the application of Fintech tools that otherwise would enhance financial inclusion and facilitate green finance transactions (Perez-Saiz and Sharma, 2019).

Political instability and governance also play a crucial role here. Investors in unstable political jurisdictions will be more likely to demand a premium to carry out green projects, again making funding more expensive and limiting the overall supply of capital. Bhuvaneskumar, Benedict and Sankar (2023) point out that institutional governance reforms such as more rule of law and transparent regulatory behavior must be carried out to create a green finance-friendly ecosystem. In the absence of these reforms, the use of sustainable investment instruments is limited.

Opportunities for Developing Green Finance

Notwithstanding these limitations, Africa also offers immense opportunities. The rapid adoption of mobile banking technologies, exemplified by the likes of M-Pesa in Kenya, has fundamentally deepened financial inclusion on the continent (Adeniran et al., 2022). Such technologies can be harnessed to expand access to green finance, enabling SMEs to access credit for renewable energy projects and energy-efficient technologies. Furthermore, innovative financial models, including blended finance and microfinance tailored for green investments, have shown promise in de-risking projects and mobilizing private capital in less developed markets (Achumie, Bakare and Okeke, 2024; Anjanappa, 2024). In addition, regional collaboration initiatives can align standards and build investor trust. Collective efforts among African nations to develop shared platforms for green project certification and sustainability reporting, for example, could help attract greater foreign investment (Mutarindwa, Schäfer and Stephan, 2024). Pilot initiatives combining regional green bond frameworks are being tried in several countries in the region and this is expected to be scaled up across the continent. Some of this includes the 10-year water infrastructure green bond in Tanzania aimed at attracting $20m investments to finance environmental conservation activities and extend water supply and sanitation services infrastructure in the country. Others include the JSE's green bonds aimed to unlock the investment potential of green infrastructure, technologies and services and the sovereign green bond in Nigeria to support the implementation of climate mitigation and adaptation projects.

While multilateral development banks are enthusiastically encouraging green finance in Africa, their impacts are tempered by systemic bottlenecks that call for policy responses that need to be coordinated. Enhancing infrastructure, strengthening regulatory frameworks, and promoting political stability are essential steps that African governments need to take. Meanwhile, leveraging digital financial services is also a means of closing the green project finance gap. Such a move, if appropriately established, can accelerate the low-carbon transition of the continent and be a fundamental contribution to carbon-reduction efforts across the world.

Case Study 4: America

The American continent is characterised by diverse approaches to green finance that reflect the political, regulatory, and economic sophistication of the region. The United States and Canada in North America take a leadership position in sustainable finance owing to sophisticated capital markets, high ESG incorporation, and highly developed regulation (Fang, 2024; Jessop, 2025). Latin America is constrained by high barriers in the form of economic volatility, regulatory uncertainty, and weak access to long-term capital (Zapata-Cantu and González, 2021). The section examines these various approaches, highlights key accomplishments in United States and Canadian sustainable investing, and examines the challenges in Latin America.

North America: Sustainable Investment Leadership

In the United States and Canada, there has been a strong ESG investing culture coupled with a surge in the expansion of sustainable funds that has been driving leadership in green finance in the region. Asset owners such as BlackRock and Vanguard have dramatically escalated their ESG focus, triggering a massive capital re-order towards green energy and sustainable investments (Greenfield, 2019). BlackRock's high-profile commitment to divesting in coal and shifting portfolios towards sustainability, for example, has altered market practice, with US sustainable funds recording a boost in inflows in recent years (BlackRock, 2024). Similarly, Canada has experienced the rapid emergence of ESG funds, supported by a regulatory framework that favors transparency and accountability in sustainability reporting (Esgthereport, 2024). However, the situation appear more complex as recent data indicates declining inflow. Bioy (2025) reported that the US sustainable open-end funds suffered an outflow in two consecutive years, reaching $19.6 billion in 2024 and $13.3 billion in 2023 (see Figure 8).

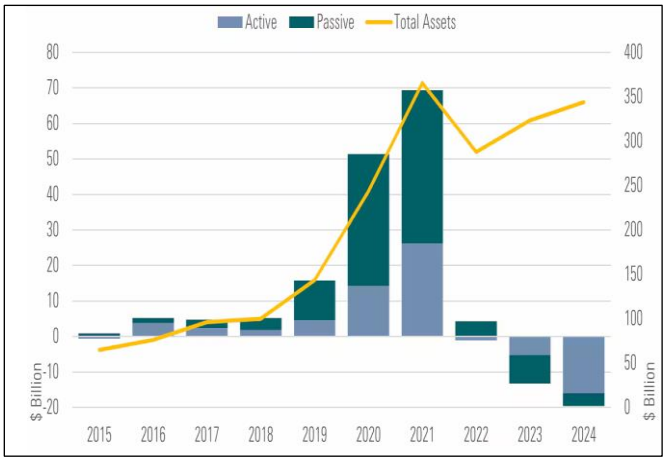

Figure 8: US Sustainable Funds Flows and Assets (Bioy, 2025).

The U.S. Regional Greenhouse Gas Initiative (RGGI) and California's cap-and-trade program are standout examples of market-based mechanisms that have successfully internalized the cost of carbon emissions. In California, carbon market prices have exceeded $20 per ton, stimulating companies to reduce emissions and invest in clean technology (Center for Climate and Energy Solutions, 2018). A recent study shows that the U.S. recognizes three mandatory carbon pricing initiatives (emissions trading schemes) at the state level and 11 voluntary agricultural carbon credit programs in pilot or action (Han and Niles, 2023). In addition, research by He and Jiang (2024) confirms that digital and inclusive finance programs in North America have helped reduce carbon intensities by facilitating renewable projects to be investment-friendly and fostering innovative Fintech applications. This nexus of policy, market innovation, and strong investor

demand has enabled North American financial institutions to steer a low-carbon transition.

Latin America: Green Finance Scaling Challenges

In contrast to the advanced markets of North America, Latin American economies face an uphill battle in scaling up green finance. While blessed with immense renewable energy potential—as evidenced by Brazil's vast wind and solar resources—most Latin American economies are struggling with regulatory and economic hurdles to the widespread application of sustainable finance instruments at scale (Zapata-Cantu and González, 2021). Research by Obiora et al. (2020) shows that political risk and segmented financial markets in some Latin American economies raise perceived green investment risk. An example is that even though it has recorded some success in issuing $7.2 billion in green bonds of sustainable debt and is a leader in the region in company green bonds (World Bank, 2024a). Such efforts, though, are countered by a deficiency in integrated environmental regulation and macroeconomic volatility that raises financing costs of green investments (Maisonnave, 2024). Similarly, in economies like Mexico and Argentina, green finance regulation is underdeveloped compared to that in Europe or the United States (Baquero et al., 2023). The lack of a system of standardized sustainability reporting and transparent carbon pricing mechanisms also raises the challenge. Such a regulation risk discourages private investors from investing in green long-term investments as risks appear higher and returns more uncertain. Reymond et al. (2020) show that green infrastructure is low in public investments in most Latin American economies, though multilateral development institutions such as the Inter-American Development Bank (IDB) intervened to provide a boost, yet total green finance is low to finance the scale of investments required. Brichetti et al. (2021) show that Latin America and the Caribbean need to invest US$2,220,736 million in various sectors such as water and sanitation, energy, transport and telecoms by 2030.

Opportunities and Initiatives

Notwithstanding the challenge of bottlenecks, there are tendencies in Latin America that suggest ways of overcoming such bottlenecks. For example, Chile has already been testing green bond pilot programs that combine government guarantees to help mitigate the risk of investing to unlock private capital (World Bank, 2023a). The country is set to issue a bond to incentivize efforts to provide a regular commitment to conservation (Griffin, 2024). In Brazil, there has been the creation of public-private partnerships (PPPs) to finance clean energy projects, albeit on a small scale compared to that possible in the country (Equipe GNPW Group, 2023). In addition, efforts to enable better cooperation in the region on sustainability standards are being made such as coordinating requirements of disclosure and green investment standard criteria. This can radically cut down on information asymmetry and enhance investors' trust in Latin America. In addition, Latin American innovations in Fintech can facilitate advancing financial inclusion and green finance simplification of access. As in a study by Wang et al. (2024), there is potential to close financial systems to excluded markets using Fintech, to enable new financing mechanisms that can reduce costs and enhance project bankability. Such technologies, when scaled up in a suitable manner, can enable small companies to be more dynamic in accessing credit for green finance and energy efficiency projects. The green finance divergence of Latin America and North America underscores professional action in policy. The developed capital markets of North America and regulation can be used to catalyze ESG integration, yet institutional capacity building and structural reforms are a challenge in Latin America. Environmental regulation, political stability, and adopting standardized sustainability reporting frameworks are key to Latin American economies accessing more green investments. Multilateral development banks can play the role of catalysts by enabling de-risking instruments and technical support to facilitate the bridging of the financing gap. By addressing these issues, Latin America can tap its vast renewable energy potential and contribute meaningfully towards the attainment of global carbon reduction targets.

4. Comparative Analysis

Green finance has evolved variably across regions, driven by variations in economic development, regulatory frameworks, institutional capacity, and market maturity.

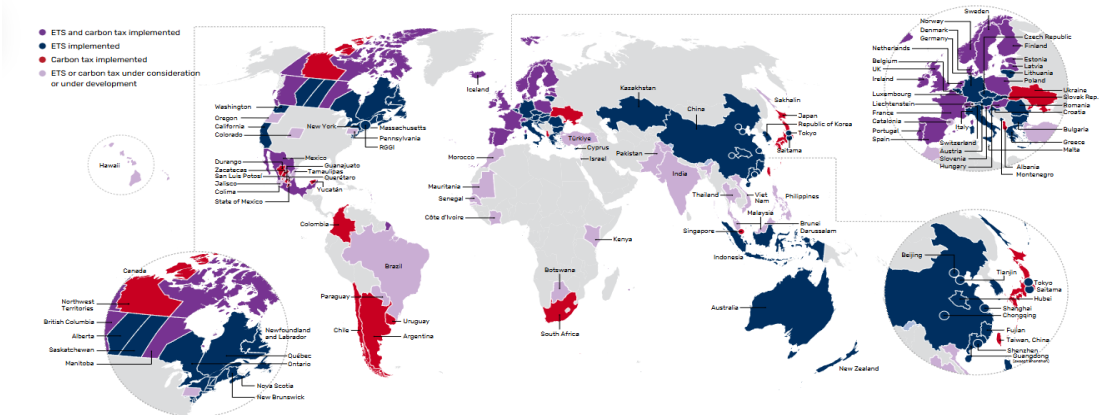

Figure 9: Global Map of Carbon Taxes and Emissions Trading Systems (World Bank Group, 2024)

This global map of carbon taxes and Emissions Trading Systems (ETSs) visually depicts the uptake of market-based carbon abatement instruments across regions. Dark blue nations, such as European countries, Canada, and some Asian nations, have implemented both an ETS and carbon tax, demonstrating strong carbon pricing commitment. Light blue regions, such as China, South Korea, and some U.S. territories, solely employ ETSs, while red regions, such as Argentina, Chile, and South Africa, have opted for carbon taxes. Additionally, light purple regions, such as India, Kenya, and some Latin American nations, represent jurisdictions

where carbon pricing instruments are being developed or are under consideration. The map highlights regional differences in policy stringency and market maturity, influencing the effectiveness of green finance policies and climate action strategies.

Regional Divergence in Regulatory and Institutional Frameworks

Europe has set the benchmark for green finance with a combination of robust regulatory frameworks and ambitious policy intervention. The passage of the EU Taxonomy and the European Green Deal has created a coherent and enabling framework for green investments. European regulators have standardized what it means for an activity to be environmentally sustainable, reducing greenwashing and bolstering investor confidence. Such regulatory clarity has facilitated the rapid development of green bonds—global issuance rose from around $100 billion in 2016 to nearly $500 billion in 2023, with European issuers taking a significant share – more than one-third (See Figures 10 and 11) (European Council, 2018).

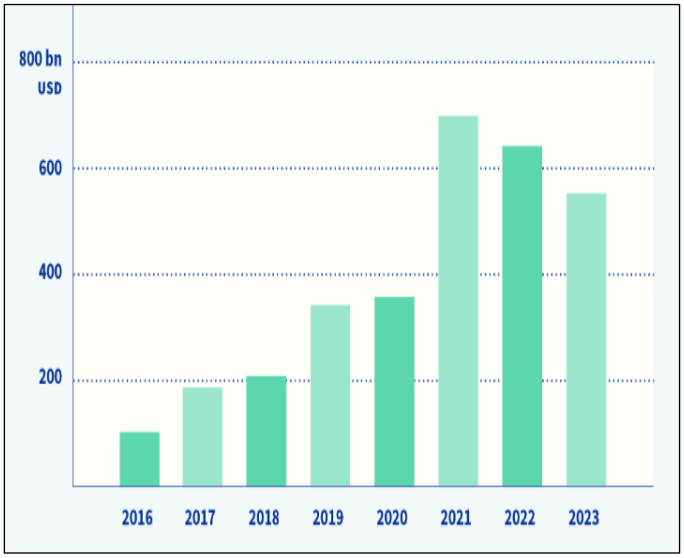

Figure 10: Green bonds issued by year, globally (European Council, 2023)

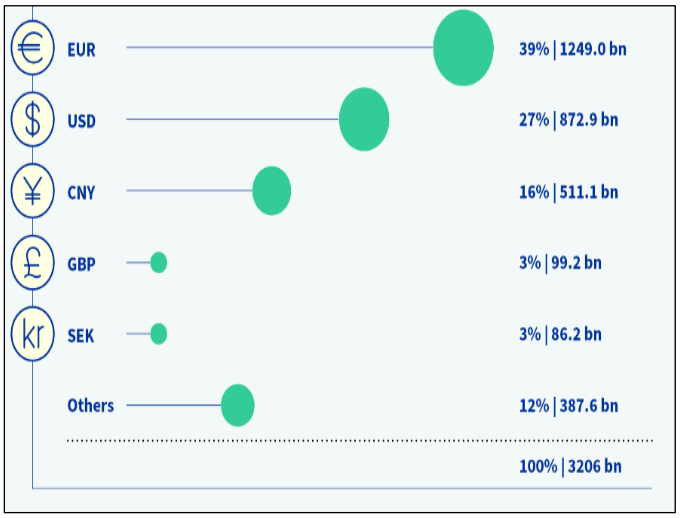

Figure 11: Global Green Bond Issuance by Currency (EUR Leads the Market) (European Council, 2023)

In comparison, Asia is more diverse. In bigger economies such as China and India, forceful policies and market reforms have stimulated significant green finance expansion. China's green bond market, now the biggest globally, demonstrates how state support, augmented by technological progress (including the uptake of Fintech), can drive green investment even in the setting of a high-carbon industrial foundation (Xiao et al., 2024; Zhang et al., 2024). In most other Asian economies, though, fragmented regulatory structures and institutional obstacles still limit the effect of green finance policies.

Africa, on the other hand, is confronted with severe infrastructural, political, and regulatory hurdles. Although the continent is endowed with renewable energy potential, the majority of nations lack the necessary regulatory structures and secure governance to spur large-scale private green investments. Multilateral development banks (MDBs) such as the African Development Bank (AfDB) are central to bridging this gap by providing concessional finance and technical support. Due to costly financing and political risk, though, green finance remains underdeveloped in Africa.

North and Latin America illustrate a contrast between mature markets and emerging ones. North America, Canada and the United States in particular, show strong leadership in ESG investing and active participation in carbon markets. The sophistication of sustainable investment products and carbon pricing mechanisms, such as the Regional Greenhouse Gas Initiative (RGGI) in the United States, are hallmarks of a mature market driven both by regulatory imperative and investor demand (Ho, 2021). Conversely, Latin America faces major obstacles, including lax environmental regulations, economic volatility, and a less integrated financial system (Zapata-Cantu and González, 2021). These are some of the factors that cause green finance instruments to be adopted at a slower pace despite the fact that the region boasts immense renewable potential.

Key Lessons Learned

One of the main lessons from Europe is that coherent, explicit regulatory frameworks can drive market confidence and attract enormous capital flows into green projects. That the EU Taxonomy and the European Green Deal have succeeded shows that if financial markets receive clear direction, sustainable investment instruments such as green bonds and ESG funds can flourish. Such regulatory clarity reduces information asymmetry and improves the overall risk profile of environmental projects.

Asia's experience underscores the importance of leveraging technological innovation in overcoming market obstacles. In China, Fintech's introduction has not only enhanced the efficiency of the allocation of green finance but also increased the spatial spillover effects of green investments, thereby accelerating regional take-up. Yet the plight of smaller and less advanced Asian economies shows that policy support must be tailored to local conditions. Tailored incentives and capacity-building measures are necessary to extend the gains of green finance to economies beyond the major ones.

Africa also teaches that multilateral institutions can be vital in surmounting systemic barriers. MDBs have successfully mobilized green investments by de-risking projects and introducing technical expertise. Nonetheless, sustainable scaling in Africa will require more robust domestic regulatory frameworks, political stability, and infrastructural development to mobilize private capital and reduce dependence on concessional finance.

North and Latin America provide a contrast between mature and emerging markets. North America's leadership in ESG integration and active carbon markets provide an example of how market and regulatory tools can work together to decrease emissions. In Latin America, regulatory fragmentation and economic volatility must be overcome. Regional coordination, standard harmonization, and targeted public-private partnerships can mitigate these challenges and ease the growth of sustainable finance.

Best Practices for Scaling Green Finance Globally
Across regions, several best practices emerge:

1. Regulatory Harmonization: There is a need to have transparent and clear-cut policies, such as in Europe, to ban greenwashing and raise investors' trust.
2. Leveraging Technology: The adoption of Fintech products in Asia is a reflection of digital innovations that can enable financial inclusion and reduce transactional costs.
3. Institutional Support: MDBs help to de-risk investments, particularly in areas that lack developed capital markets such as in Africa.
4. Public-Private Partnerships: Models of cooperation that bridge public support to private sector innovation hold the key to scaling up green finance, as is already apparent in both the North American and European regions.

These lessons provide a roadmap to financial institutions and policymakers around the world, demanding region-based approaches that take note of local contexts yet propose a unified approach to sustainable finance.

Synthesis of Findings
This research offers an examination of financial institutions' contribution to advancing carbon-reduction objectives globally. The picture around the world is one of green financial instruments such as green bonds, carbon credits, and ESG investing having evolved over the years. The main findings of this study are that transparent policy and standard reporting such as EU Taxonomy and TCFD recommendations function to guide a large amount of capital to green investments. As an example, the green bond market in Europe has evolved exponentially, with issuance of nearly $500 billion in 2023, facilitated by a policy that discourages greenwashing and provides certainty to investors. Strong government policy and innovations in Fintech have propelled green finance expansion in Asia (China and India in particular), despite the presence of regional heterogeneity. The African experience is evidence of the key role that multilateral development banks, the AfDB, and the World Bank play in de-risking and financing renewable energy in the face of prevalent challenges such as political instability and weak infrastructure. In North America, leadership in ESG investing and active carbon markets contrasts with the less conducive regulatory and economic environment of Latin America, where policy incoherence and higher financing costs hold back green finance.

Interconnections among international trends and domestic practices are apparent. Robust regulatory frameworks at the international scale create an enabling environment for green finance to be scaled up but regional adaptations are necessary to address local challenges. For example, while the EU's harmonized framework has driven substantial investment in renewables, Asia's digitalization via Fintech is beginning to bridge the gap between market potential and regulatory constraints. Still, gaps in the literature remain. While several studies document the growth of green finance, few offer long-term evaluations that link financial innovation with measurable emission reductions across diverse economies. Moreover, the effectiveness of voluntary disclosure frameworks versus mandatory standards remains contested, particularly in emerging markets where data quality and regulatory enforcement vary significantly (Obiora et al., 2020).

Current research strengths include extensive empirical evidence on the performance of green bonds and a growing body of research on ESG integration. Weaknesses are also apparent. Many studies rely on national or regional aggregate data that may mask significant intra-regional heterogeneity. In addition, whereas the promise of digital finance is surfacing in Asia and North America, in Africa and Latin America it is still understudied.

5. Conclusion

This research highlights the crucial role of financial institutions in catalyzing global carbon mitigation efforts. By mobilizing capital, green finance innovations, and adding environmental risk to investments, they facilitate low-carbon technological transition. Green bonds, carbon credits, and ESG investing are a few of the innovations that have revolutionized capital flows to enable sustainability-oriented growth. Regional patterns display diverse approaches indicating strong regulation in Europe and Asian economies as a result of the growth of Fintech innovations. Multilateral banks facilitate de-risking investments in Africa to address infrastructural and political challenges, while in established ESG markets in North America, there is a contrasting picture of Latin America's challenges in regulation and economies, indicating a need for regulation in a region-specific manner. The success of green finance is dependent on international frameworks in conjunction with national circumstances. Banks and financial institutions must use advanced analysis to assess climate risk, while policymakers must standardize norms and incentivize green investments. This would require a collective effort to be done by the various stakeholders in scaling up green finance and tackling climate change.

6. Recommendations

These recommendations are based on this study's analysis. It will assist in ensuring that policymakers, financial institutions, and researchers can work in unison to facilitate a sustainable financial transition to manage financial risks associated with climate change.

For banks, it is essential to integrate climate risks in credit analysis and in decisions regarding asset allocation in designing new green financial instruments. Banks must include climate stress testing in their risk management systems to restrict exposure to carbon-intensive sectors. One such example is HSBC, which has adopted climate risk modeling to transition towards low-carbon financing. Banks must also scale up green finance instruments in the form of more green bonds, sustainability-linked loans, and carbon credit financing to finance renewable energy and energy efficiency investments. The European Investment Bank (EIB) has issued over €300 billion in climate bonds, significantly ramping up green investments. The use of Fintech innovations and ESG analysis can also enable low-carbon investment opportunities identification and risk mitigation to ensure that capital is allocated to carbon-reduction-oriented projects.

Policymakers should also harmonize regulation standards and be more transparent in sustainability reporting to limit greenwashing and increase investors' trust. Enhancing ESG and climate reporting standards to be in line with frameworks such as TCFD (Task Force on Climate-Related Financial Disclosures) or GRI (Global Reporting Initiative) is also of paramount importance, as BlackRock's example indicates, demanding portfolio companies to make climate-related disclosures. In addition, there must be cooperation between the public and private sectors to craft enabling policies such as carbon pricing, tax credits, and subsidies for green energy financing. An example of a working approach is that of the Green Finance Institute (UK), which bridges financing gaps through cooperation with policymakers. The application of sectoral incentives, in particular in weak regulation countries, is crucial to unleashing large green financing potential.

For future research, researchers can conduct longitudinal studies that measure the long-term impact of green finance on emission reductions and economic performance. An investigation of digital financial innovations in low-income economies can provide insights on how Fintech can facilitate a low-carbon transition. Further, a review of how regional regulatory conventions influence investors' behavior can assist in making more informed policymaking decisions. An example is that of the Asian Development Bank's Energy Transition Mechanism (ETM), which mobilized $15 billion to phase out coal power earlier and support clean energy investments in Southeast Asia. Further studies of such programs would be helpful in crafting global strategies for green finance.

Data Availability

No new data were generated or analyzed in this study. All data and information was obtained from publicly available sources, as cited in the manuscript.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Reference list

[1] Achumie, G.O., Bakare, O.A. and Okeke, N.I. (2024). Innovative financial and operational models for affordable housing: A review of emerging market strategies. International Journal of Applied Research in Social Sciences, 6(10), pp.2342–2362. doi:https://doi.org/10.51594/ijarss.v6i10.1617.

[2] Adeniran, I.A., Abhulimen, A.O., Obiki-Osafiele, A.N., Osundare, O.S., Efunniyi, C.P. and Agu, E.E. (2022). Digital banking in Africa: A conceptual review of financial inclusion and socio-economic development. International Journal of Applied Research in Social Sciences, 4(10), pp.451–480. doi:https://doi.org/10.51594/ijarss.v4i10.1480.

[3] African Development Bank Group (AfDB) (2018). The New Deal on Energy for Africa. [online] AfDB. Available at: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_New_Deal_2-En.pdf [Accessed 14 Feb. 2025].

[4] African Development Bank Group (AfDB) (2023). Africa urges a spotlight on climate finance as the world heads to COP28. [online] AfDB. Available at: https://www.afdb.org/en/news-and-events/press-releases/africa-urges-spotlight-climate-finance-world-heads-cop28-66331 [Accessed 12 Feb. 2025].

[5] African Development Bank Group (AfDB) (2024). Joint MDBs Report: Climate financing hits record $125 billion in 2023. [online] African Development Bank Group. Available at: https://www.afdb.org/en/news-and-events/press-releases/joint-mdbs-report-climate-financing-hits-record-125-billion-2023-74288? [Accessed 14 Feb. 2025].

[6] Agoundedemba, M., Kim, C.K. and Kim, H.-G. (2023). Energy Status in Africa: Challenges, Progress and Sustainable Pathways. Energies, 16(23), p.7708. doi:https://doi.org/10.3390/en16237708.

[7] Alamgir, M. and Cheng, M.-C. (2023). Do Green Bonds Play a Role in Achieving Sustainability? Sustainability, 15(13), p.10177. doi:https://doi.org/10.3390/su151310177.

[8] Alduais, F. (2023). Unravelling the intertwined nexus of firm performance, ESG practices, and capital cost in the Chinese business landscape. Cogent economics & finance, 11(2). doi:https://doi.org/10.1080/23322039.2023.2254589.

[9] Almeida, D.V., Kolinjivadi, V., Ferrando, T., Roy, B., Herrera, H., Gonçalves, M.V. and Van Hecken, G. (2023). The 'Greening' of Empire: the European Green Deal as the EU First Agenda. Political Geography, 105(102925). doi:https://doi.org/10.1016/j.polgeo.2023.102925.

[10] Anjanappa, J. (2024). Breaking Barriers: Collaborative Models for Scaling Renewable Energy Financing in Developing Countries. SSRN. doi:https://doi.org/10.2139/ssrn.5040515.

[11] Arasu, S. (2025). India nuclear power reduce greenhouse gases. [online] AP News. Available at: https://apnews.com/article/india-nuclear-power-energy-modi-trump-890f1cd86bef55e1708cc0a264743d33 [Accessed 13 Feb. 2025].

[12] Asian Development Bank (ADB) (2022). ADB's Work on Climate Change and Disaster Risk Management. [online] Asian Development Bank. Available at: https://www.adb.org/what-we-do/topics/climate-change/overview [Accessed 12 Feb. 2025].

[13] Asian Development Bank (ADB) (2024). Energy Transition Mechanism (ETM). [online] Asian Development Bank. Available at: https://www.adb.org/what-we-do/energy-transition-mechanism-etm [Accessed 14 Feb. 2025].

[14] Atedhor, G.O. (2023). Greenhouse gases emissions and their reduction strategies: Perspectives of Africa's largest economy. Scientific African, 20, p.e01705. doi:https://doi.org/10.1016/j.sciaf.2023.e01705.

[15] Awuku, S.A., Bennadji, A., Muhammad-Sukki, F. and Sellami, N. (2022). Public-private partnership in Ghana's solar energy industry: The history, current state, challenges, prospects and theoretical perspective. Energy

Nexus, 6, p.100058. doi:https://doi.org/10.1016/j.nexus.2022.100058.

[16] Baquero, J.A., Berner, C., Costantini, X., Francés, D., Goraieb, E. and Salazar de Lara, F. (2023). Sustainable finance in Latin America. [online] www.mckinsey.com. Available at: https://www.mckinsey.com/industries/financial-services/our-insights/are-latin-american-financial-institutions-ready-for-sustainability [Accessed 14 Feb. 2025].

[17] Belgacem, S.B., Khatoon, G. and Alzuman, A. (2023). Role of Renewable Energy and Financial Innovation in Environmental Protection: Empirical Evidence from UAE and Saudi Arabia. Sustainability, 15(11), p.8684. doi:https://doi.org/10.3390/su15118684.

[18] Bhuvaneskumar, A., Benedict, J. and Sankar, M. (2023). Does Financial Inclusion and Human Development Progress Sustainably? Evidence from Emerging Countries. Social Indicators Research, 171(1), pp.189–213. doi:https://doi.org/10.1007/s11205-023-03240-4.

[19] Bioy, H. (2025). US Sustainable Funds Suffer Another Year of Outflows. [online] Morningstar, Inc. Available at: https://www.morningstar.com/sustainable-investing/us-sustainable-funds-suffer-another-year-outflows [Accessed 14 Feb. 2025].

[20] Black, S. (2023). The IMF-World Bank Climate Policy Assessment Tool (CPAT): A Model to Help Countries Mitigate Climate Change. IMF Working Papers, 2023(128), p.1. doi:https://doi.org/10.5089/9798400242342.001.

[21] BlackRock. (2024). 2030 Net Zero Statement. [online] Available at: https://www.blackrock.com/corporate/sustainability/2030-net-zero-statement [Accessed 14 Feb. 2025].

[22] Brichetti, J.P., Mastronardi, L., Rivas, M.E., Serebrisky, T. and Solís, B. (2021). The Infrastructure Gap in Latin America and the Caribbean: Investment Needed Through 2030 to Meet the Sustainable Development Goals. doi:https://doi.org/10.18235/0003759.

[23] Brühl, V. (2021). Green Finance in Europe — Strategy, Regulation and Instruments. Intereconomics, 56(6), pp.323–330. doi:https://doi.org/10.1007/s10272-021-1011-8.

[24] Center for Climate and Energy Solutions (2018). California Cap and Trade. [online] Center for Climate and Energy Solutions. Available at: https://www.c2es.org/content/california-cap-and-trade/ [Accessed 14 Feb. 2025].

[25] Ciot, M.-G. (2021). On European Green Deal and Sustainable Development Policy (the Case of Romania). Sustainability, 13(21), p.12233. doi:https://doi.org/10.3390/su132112233.

[26] Climate Bonds Initiative. (2022). Sustainable Debt Tops $1 Trillion in Record Breaking 2021, with Green Growth at 75%: New Report. [online] Available at: https://www.climatebonds.net/2022/04/sustainable-debt-tops-1-trillion-record-breaking-2021-green-growth-75-new-report? [Accessed 13 Feb. 2025].

[27] Cortellini, G. and Panetta, I.C. (2021). Green Bond: A Systematic Literature Review for Future Research Agendas. Journal of Risk and Financial Management, 14(12), p.589. doi:https://doi.org/10.3390/jrfm14120589.

[28] Criqui, P., Jaccard, M. and Sterner, T. (2019). Carbon Taxation: A Tale of Three Countries. Sustainability, 11(22), p.6280. doi:https://doi.org/10.3390/su11226280.

[29] Dechezleprêtre, A., Nachtigall, D. and Venmans, F. (2022). The joint impact of the European Union emissions trading system on carbon emissions and economic performance. Journal of Environmental Economics and Management, 118, p.102758. doi:https://doi.org/10.1016/j.jeem.2022.102758.

[30] Diaz-Rainey, I., Corfee-Morlot, J., Volz, U. and Caldecott, B. (2023). Green finance in Asia: challenges, policies and avenues for research. Climate Policy, 23(1), pp.1–10. doi:https://doi.org/10.1080/14693062.2023.2168359.

[31] Djunisic, S. (2025). Spain's Greening launches EUR-30m green bond programme. [online] Renewables Now. Available at: https://renewablesnow.com/news/spains-greening-launches-eur-30m-green-bond-programme-1268825/ [Accessed 13 Feb. 2025].

[32] Dolphin, G. and Xiahou, Q. (2022). World carbon pricing database: sources and methods. Scientific Data, 9(1). doi:https://doi.org/10.1038/s41597-022-01659-x.

[33] Dube, A. and Horvey, S.S. (2023). Institutional quality and renewable energy capital flows in Africa. Future Business Journal, 9(1). doi:https://doi.org/10.1186/s43093-023-00234-z.

[34] Dziwok, E. and Jäger, J. (2021). A Classification of Different Approaches to Green Finance and Green Monetary Policy. Sustainability, 13(21), p.11902. doi:https://doi.org/10.3390/su132111902.

[35] Equipe GNPW Group (2023). The Rise of Public-Private Partnerships in the Sustainable Energy Sector in Brazil - GNPW Group. [online] GNPW Group. Available at: https://www.gnpw.com.br/en/public-private-partnerships/the-rise-of-public-private-partnerships-in-the-sustainable-energy-sector-in-brazil [Accessed 14 Feb. 2025].

[36] Esgthereport (2024). Navigating ESG in Canada: Key Insights and Best Practices. [online] ESG | The Report. Available at: https://esgthereport.com/navigating-esg-in-canada-key-insights-and-best-practices/ [Accessed 14 Feb. 2025].

[37] European Commission (2024). EU taxonomy for sustainable activities. [online] European Commission. Available at: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en [Accessed 12 Feb. 2025].

[38] European Council (2023). European green bonds. [online] Consilium. Available at: https://www.consilium.europa.eu/en/infographics/european-green-bonds [Accessed 14 Feb. 2025].

[39] European Environment Agency (EEA) (2023). Green bonds. [online] www.eea.europa.eu. Available at: https://www.eea.europa.eu/en/analysis/indicators/green-bonds-8th-eap [Accessed 13 Feb. 2025].

[40] European Investment Bank (EIB) (2024). BPIfrance renewable energy framework loan. [online] European Investment Bank. Available at: https://www.eib.org/en/projects/pipelines/all/20240357 [Accessed 13 Feb. 2025].

[41] Fang, K. (2024). Time 100 Climate 2024. [online] TIME. Available at: https://time.com/7172419/karen-fang/ [Accessed 14 Feb. 2025].

[42] Feng, S., Shafiei , M.W.M., Ng, T.F., Ren, J. and Jiang, Y. (2024). The intersection of economic growth and environmental sustainability in China: Pathways to achieving SDG. Energy Strategy Reviews, 55, p.101530. doi:https://doi.org/10.1016/j.esr.2024.101530.

[43] Flammer, C. (2020). Green Bonds: Effectiveness and Implications for Public Policy. Environmental and Energy Policy and the Economy, 1(1), pp.95–128. doi:https://doi.org/10.1086/706794.

[44] Free, C., Jones, S. and Tremblay, M.-S. (2024). Greenwashing and sustainability assurance: a review and call for future research. Journal of Accounting Literature. doi:https://doi.org/10.1108/jal-11-2023-0201.

[45] Freitas, A.S. and Mwaniki, G. (2024). Climate Finance in Africa. [online] UNDP. Available at: https://www.undp.org/sites/g/files/zskgke326/files/2024-09/climate_finance_africa_v.6_lq.pdf [Accessed 14 Feb. 2025].

[46] Friedrich, T.J., Velte, P. and Wulf, I. (2022). Corporate climate reporting of European banks: Are these institutions compliant with climate issues? Business Strategy and the Environment, 32(6), pp.2817–2834. doi:https://doi.org/10.1002/bse.3272.

[47] Fu, C., Lu, L. and Pirabi, M. (2023). Advancing green finance: a review of sustainable development. Digital Economy and Sustainable Development, 1(1). doi:https://doi.org/10.1007/s44265-023-00020-3.

[48] Glasgow Financial Alliance for Net Zero (GFANZ) (2021). The Glasgow Financial Alliance for Net Zero Our progress and plan towards a net-zero global economy. [online] Available at: https://assets.bbhub.io/company/sites/63/2021/11/GFANZ-Progress-Report.pdf [Accessed 12 Feb. 2025].

[49] Global Sustainable Investment Alliance (GSIA) (2022). Global Sustainable Investment Review 2022. [online] Available at: https://www.gsi-alliance.org/wp-content/uploads/2023/12/GSIA-Report-2022.pdf [Accessed 12 Feb. 2025].

[50] Greenfield, P. (2019). World's top three asset managers oversee $300bn fossil fuel investments. The Guardian. [online] 12 Oct. Available at: https://www.theguardian.com/environment/2019/oct/12/top-three-asset-managers-fossil-fuel-investments [Accessed 12 Feb. 2025].

[51] Griffin, O. (2024). Chile government readying bond to incentivize future conservation. Reuters. [online] 29 Oct. Available at: https://www.reuters.com/world/americas/chile-government-readying-bond-incentivize-future-conservation-2024-10-29/ [Accessed 14 Feb. 2025].

[52] Gulzar, R., Bhat, A.A., Mir, A.A., Athari, S.A. and Al-Adwan, A.S. (2024). Green banking practices and environmental performance: navigating sustainability in banks. Environmental Science and Pollution Research, 31(15), pp.23211–23226. doi:https://doi.org/10.1007/s11356-024-32418-7.

[53] Gunningham, N. (2020). A Quiet Revolution: Central Banks, Financial Regulators, and Climate Finance. Sustainability, 12(22), p.9596. doi:https://doi.org/10.3390/su12229596.

[54] Gyimah, J., Hayford, I.S., Nyantakyi, G., Adu, P.S., Batasuma, S. and Yao, X. (2024). The era of global warming mitigation: The role of financial inclusion, globalization and governance institutions. Heliyon, 10(1), p.e23471. doi:https://doi.org/10.1016/j.heliyon.2023.e23471.

[55] Han, G. and Niles, M.T. (2023). Interested but Uncertain: Carbon Markets and Data Sharing among U.S. Crop Farmers. Land, 12(8), pp.1526–1526. doi:https://doi.org/10.3390/land12081526.

[56] He, Q. and Jiang, H. (2024). Digital Inclusive Finance, Digital Technology Innovation, and Carbon Emission Intensity. Sustainability, 16(15), p.6407. doi:https://doi.org/10.3390/su16156407.

[57] Ho, B. (2021). The Regional Greenhouse Gas Initiative Is a Model for the Nation. [online] NRDC. Available at: https://www.nrdc.org/resources/regional-greenhouse-gas-initiative-model-nation [Accessed 14 Feb. 2025].

[58] Ho, K. and Wong, A. (2021). Effect of Climate-Related Risk on the Pricing of Bank Loans: Evidence from Syndicated Loan Markets in Asia Pacific. SSRN Electronic Journal. doi:https://doi.org/10.2139/ssrn.3970474.

[59] Iyer, R.N. (2024). Sustainable finance in Asia: A comparative study of national taxonomies. [online] Ieefa.org. Available at: https://ieefa.org/resources/sustainable-finance-asia-comparative-study-national-taxonomies [Accessed 14 Feb. 2025].

[60] Jessop, S. (2025). Politics, not climate, to drive sustainable finance trends in 2025. Reuters. [online] 10 Jan. Available at: https://www.reuters.com/sustainability/politics-not-climate-drive-sustainable-finance-trends-2025-2025-01-10/ [Accessed 14 Feb. 2025].

[61] Jones, L. (2022). $500bn Green Issuance 2021: social and sustainable acceleration: Annual green $1tn in sight: Market expansion forecasts for 2022 and 2025. [online] Climate Bonds Initiative. Available at: https://www.climatebonds.net/2022/01/500bn-green-issuance-2021-social-and-sustainable-acceleration-annual-green-1tn-sight-market [Accessed 12 Feb. 2025].

[62] Kfw-entwicklungsbank.de. (2024). Loans for energy-saving investments - KfW Development Bank. [online] Available at: https://www.kfw-entwicklungsbank.de/Global/Latin-America-and-the-Caribbean/Project-information-Mexico-energy-efficiency/ [Accessed 13 Feb. 2025].

[63] Lee, K. (2024). Vietnam's central bank announces updated green credit framework. [online] Green Central Banking. Available at: https://greencentralbanking.com/2024/08/28/vietnam-central-bank-green-credit-framework/ [Accessed 14 Feb. 2025].

[64] Lim, C.H., Basu, R., Carriere-Swallow, Y., Kashiwase, K., Kutlukaya, M., Li, M., Refayet, E., Seneviratne, D., Sy, M. and Yang, R. (2024). Unlocking Climate Finance in Asia-Pacific. International Monetary Fund.

[65] Liu, X., Cui, J., Wu, Y., Yue, X., Shen, J. and Guo, P. (2024). The Nexus between Green Finance and Carbon Emissions: Evidence from Maturity Mismatch in China. Sustainability, 16(10), p.4319. doi:https://doi.org/10.3390/su16104319.

[66] Lubello, F. (2024). From Brown to Green: Climate Transition and Macroprudential Policy Coordination.

Journal of Risk and Financial Management, 17(10), p.448. doi:https://doi.org/10.3390/jrfm17100448.

[67] Lütkehermöller, K., Mooldijk, S., Roelfsema, M., Höhne, N. and Kuramochi, T. (2020). Unpacking the finance sector's climate-related investment commitments. [online] Available at: https://newclimate.org/sites/default/files/2020/09/NewClimate_Unpacking_Finance_Sector_Sept20.pdf [Accessed 12 Feb. 2025].

[68] Ma, Z., Liu, G. and Liu, S. (2025). Foreign Investors Could Stall Coal Plant Closures in Asia. [online] World Resources Institute. Available at: https://www.wri.org/insights/foreign-investment-could-stall-early-coal-retirement [Accessed 14 Feb. 2025].

[69] Maisonnave, F. (2024). Environmental groups condemn new laws threatening soybean restrictions in Brazil's Amazon. [online] AP News. Available at: https://apnews.com/article/dfeb8b1e5cf48c7ea7bf881499c8f508 [Accessed 14 Feb. 2025].

[70] Marín-Rodríguez, N.J., González-Ruiz, J.D. and Botero, S. (2025). Dynamic Linkages Between Economic Policy Uncertainty and External Variables in Latin America: Wavelet Analysis. Economies, 13(2), p.22. doi:https://doi.org/10.3390/economies13020022.

[71] McCauley, D. and Pettigrew, K.A. (2023). Building a just transition in Asia-Pacific: Four strategies for reducing fossil fuel dependence and investing in clean energy. Energy Policy, 183, p.113808. doi:https://doi.org/10.1016/j.enpol.2023.113808.

[72] Mehmood, U., Tariq, S., Haq, Z.U., Aslam, M.U. and Imran, M.A. (2023). How Economic Growth Contributes to CO2 Emissions in the Presence of Globalization and Eco-Innovations in South Asian Countries? World, 4(1), pp.202–213. doi:https://doi.org/10.3390/world4010014.

[73] Meng, J., Ye, Z. and Wang, Y. (2024). Financing and investing in sustainable infrastructure: A review and research agenda. Sustainable Futures, 8, p.100312. doi:https://doi.org/10.1016/j.sftr.2024.100312.

[74] Mengistu, A.T., Benitez, P., Tamru, S., Medhin, H. and Toman, M. (2019). Exploring Carbon Pricing in Developing Countries: A Macroeconomic Analysis in Ethiopia. Sustainability, 11(16), p.4395. doi:https://doi.org/10.3390/su11164395.

[75] Monasterolo, I., Mandel, A., Battiston, S., Mazzocchetti, A., Oppermann, K., Coony, J., Stretton, S., Stewart, F. and Dunz, N. (2022). The Role of Green Financial Sector Initiatives in the Low-Carbon Transition A Theory of Change. [online] Available at: https://documents1.worldbank.org/curated/en/099548409142222955/pdf/IDU0881e4d02027f504e120898502121116e2eb7.pdf [Accessed 12 Feb. 2025].

[76] Mooij, R., Keen, M. and Parry, I. (2012). Chapter 1. What Is the Best Policy Instrument for Reducing CO2 Emissions. International Monetary Fund. doi:https://doi.org/10.5089/9781616353933.071.ch001.

[77] Mukhtar, M., Adun, H., Cai, D., Obiora, S., Taiwo, M., Ni, T., Ozsahin, D.U. and Bamisile, O. (2023). Juxtaposing Sub-Sahara Africa's energy poverty and renewable energy potential. Scientific Reports, 13(1), p.11643. doi:https://doi.org/10.1038/s41598-023-38642-4.

[78] Mutarindwa, S., Schäfer, D. and Stephan, A. (2024). Certification against greenwashing in nascent bond markets: lessons from African ESG bonds. Eurasian Economic Review. doi:https://doi.org/10.1007/s40822-023-00257-5.

[79] Natalucci, F., Gautam, D. and Goel, R. (2022). Sustainable Finance in Emerging Markets: Evolution, Challenges, and Policy Priorities. IMF Working Papers, 2022(182). doi:https://doi.org/10.5089/9798400218101.001.

[80] Nazir, M.I., Tariq, A., Nazir, M.R. and Hasan, S.Z. (2025). Financial Technology, Greenfield Investment, and Sustainable Development: Role of Institutional Quality. Sustainable Futures, [online] p.100462. doi:https://doi.org/10.1016/j.sftr.2025.100462.

[81] Nguyen, N.T., Nguyen, M.T.N., Do, T.T.H., Le, T.Q. and Nguyen, N.H.U. (2024). Hedging Carbon Price Risk on EU ETS: A Comparison of Green Bonds from the EU, US, and China. Sustainability, 16(14), p.5886. doi:https://doi.org/10.3390/su16145886.

[82] Obiora, S.C., Bamisile, O., Opoku-Mensah, E. and Kofi Frimpong, A.N. (2020). Impact of Banking and Financial Systems on Environmental Sustainability: An Overarching Study of Developing, Emerging, and Developed Economies. Sustainability, 12(19), p.8074. doi:https://doi.org/10.3390/su12198074.

[83] Park, H. and Kim, J.D. (2020). Transition towards green banking: role of financial regulators and financial institutions. Asian Journal of Sustainability and Social Responsibility, 5(1). doi:https://doi.org/10.1186/s41180-020-00034-3.

[84] Perez-Saiz, H. and Sharma, P. (2019). FinTech in Sub-Saharan African Countries: A Game Changer? Departmental Papers, 2019(004). doi:https://doi.org/10.5089/9781484385661.087.A001.

[85] Pisani-Ferry, J. and Tagliapietra, S. (2024). An investment strategy to keep the European Green Deal on track. [online] Bruegel - The Brussels-based economic think tank. Available at: https://www.bruegel.org/policy-brief/investment-strategy-keep-european-green-deal-track? [Accessed 13 Feb. 2025].

[86] Principale, S. and Pizzi, S. (2023). The Determinants of TCFD Reporting: A Focus on the Italian Context. Administrative Sciences, 13(2), p.61. doi:https://doi.org/10.3390/admsci13020061.

[87] Raga, S., Lemma, A. and Keane, J. (2023). Emerging Analysis. [online] Available at: https://odi.cdn.ngo/media/documents/Final_Sahel_spillover_effects_to_other_WA_countries_17Apr23.pdf [Accessed 14 Feb. 2025].

[88] Reymond, A., Egler, H.-P., Masullo, D. and Pimentel, G. (2020). Financing Sustainable Infrastructure in Latin America and the Caribbean: Market Development and Recommendations. [online] doi:https://doi.org/10.18235/0002298.

[89] Ritchie, H. and Rosado, P. (2022). Which countries have put a price on carbon? [online] Our World in Data. Available at: https://ourworldindata.org/carbon-pricing [Accessed 12 Feb. 2025].

[90] Rocha, J., Oliveira, S., Viana, C.M. and Ribeiro, A.I. (2022). Chapter 8 - Climate change and its impacts on health, environment and economy. ScienceDirect, [online] pp.253–279. Available at: https://www.sciencedirect.com/science/article/pii/B9780128227947000095.

[91] Rubio, T.G. and Jáuregui, J.G. (2022). Chinese Overseas Finance in Renewable Energy in Argentina and Brazil: Implications for the Energy Transition. Journal of Current Chinese Affairs, 51(1), pp.137–164. doi:https://doi.org/10.1177/18681026221094852.

[92] Rzepecka, J., Fuksiewicz, A., Squillante, F., Alijošius, L., Godlovitch, I., Stamm, P., Wielgosch, J. and Lundborg, M. (2024). The impact of EU legislation in the area of digital and green transition, particularly on SMEs. Publication for the Committee on Internal Market and Consumer Protection, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg.

[93] Segreto, M., Principe, L., Desormeaux, A., Torre, M., Tomassetti, L., Tratzi, P., Paolini, V. and Petracchini, F. (2020). Trends in Social Acceptance of Renewable Energy Across Europe—A Literature Review. International Journal of Environmental Research and Public Health, 17(24), p.9161. doi:https://doi.org/10.3390/ijerph17249161.

[94] Sinha, S.K., Srikanth, R. and Mahalingam, S. (2022). Regulatory framework for India's energy security and sustainability. Energy Policy, 162, p.112815. doi:https://doi.org/10.1016/j.enpol.2022.112815.

[95] Statista. (2024a). China: value of green bonds issued 2022. [online] Available at: https://www.statista.com/statistics/1289032/value-of-green-bonds-issued-china/ [Accessed 12 Feb. 2025].

[96] Statista. (2024b). Green bonds issued worldwide 2014-2021. [online] Available at: https://www.statista.com/statistics/1289406/green-bonds-issued-worldwide/ [Accessed 14 Feb. 2025].

[97] Statista. (2024c). Value of green bonds issued worldwide 2014-2023, by region. [online] Available at: https://www.statista.com/statistics/1294449/value-of-green-bonds-issued-worldwide-by-region/ [Accessed 14 Feb. 2025].

[98] Supriyanto, E.E. (2023). Green and Renewable Energy Financing Policy in Indonesia. Penerbit BRIN eBooks. doi:https://doi.org/10.55981/brin.900.c786.

[99] Taghizadeh-Hesary, F., Yoshino, N. and Phoumin, H. (2021). Analyzing the Characteristics of Green Bond Markets to Facilitate Green Finance in the Post-COVID-19 World. Sustainability, 13(10), p.5719. doi:https://doi.org/10.3390/su13105719.

[100] Tamasiga, P., Molala, M., Bakwena, M., Nkoutchou, H. and Onyeaka, H. (2023). Is Africa Left behind in the Global Climate Finance Architecture: Redefining Climate Vulnerability and Revamping the Climate Finance Landscape—A Comprehensive Review. Sustainability, 15(17), p.13036. doi:https://doi.org/10.3390/su151713036.

[101] The Intergovernmental Panel on Climate Change (IPCC) (2023). IPCC — Intergovernmental Panel on Climate Change. [online] Ipcc.ch. Available at: https://www.ipcc.ch/ [Accessed 11 Feb. 2025].

[102] Tiseo, I. (2024). EU-ETS carbon pricing 2022. [online] Statista. Available at: https://www.statista.com/statistics/1322214/carbon-prices-european-union-emission-trading-scheme/ [Accessed 13 Feb. 2025].

[103] Tsai, W.-H. (2020). Carbon Emission Reduction—Carbon Tax, Carbon Trading, and Carbon Offset. Energies, 13(22), p.6128. doi:https://doi.org/10.3390/en13226128.

[104] Venmans, F., Ellis, J. and Nachtigall, D. (2020). Carbon pricing and competitiveness: are they at odds? Climate Policy, 20(9), pp.1–22. doi:https://doi.org/10.1080/14693062.2020.1805291.

[105] Wang, C., Wang, L., Zhao, S., Yang, C. and Albitar, K. (2024). The impact of Fintech on corporate carbon emissions: Towards green and sustainable development. Business Strategy and the Environment, 33(6), pp.5776–5796. doi:https://doi.org/10.1002/bse.3778.

[106] Wang, J., Ruan, Y. and Wang, C. (2024). Foreign Direct Investment, Technology Innovation and Carbon Emissions: Evidence from China. Sustainability, 16(22), p.10014. doi:https://doi.org/10.3390/su162210014.

[107] Wei, Y., Li, Y. and Wang, Z. (2022). Multiple price bubbles in global major emission trading schemes: Evidence from European Union, New Zealand, South Korea and China. Energy Economics, 113, p.106232. doi:https://doi.org/10.1016/j.eneco.2022.106232.

[108] World Bank (2023a). Chile to Accelerate its Green Hydrogen Industry with World Bank Support. worldbank.org. Available at: https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support [Accessed 14 Feb. 2025].

[109] World Bank (2023b). Development Projects : Nigeria Distributed Access through Renewable Energy Scale-up Project - P179687. [online] World Bank. Available at: https://projects.worldbank.org/en/projects-operations/project-detail/P179687 [Accessed 14 Feb. 2025].

[110] World Bank Group (2024). World Bank FY24 Climate-Related Financial Disclosures. [online] Available at: https://thedocs.worldbank.org/en/doc/5178a3bf998d8ee94b74ea5c426c6975-0040012024/original/WB-AR-2024-Financial-Disclosures.pdf [Accessed 12 Feb. 2025].

[111] World Bank. (2024a). Brazil Sovereign Sustainable Bond: Financing a greener, more inclusive, and equitable economy. [online] Available at: https://www.worldbank.org/en/news/feature/2024/02/08/brazil-sovereign-sustainable-bond-financing-a-greener-more-inclusive-and-equitable-economy [Accessed 14 Feb. 2025].

[112] World Bank. (2024b). Energizing Ethiopia: New World Bank Program Expands Access to Electricity. [online] Available at: https://www.worldbank.org/en/news/press-release/2024/04/03/energizing-afe-ethiopia-new-world-bank-program-expands-access-to-electricity [Accessed 14 Feb. 2025].

[113] Wu, F., Zhu, B. and Tao, S. (2024). Can good ESG performance of listed companies reduce abnormal stock price volatility? Mediation effects based on investor attention. PLoS ONE, 19(9), pp.e0307535–e0307535. doi:https://doi.org/10.1371/journal.pone.0307535.

[114] Xiao, M., Guo, X., Chen, G., Ji, X. and Sun, W. (2024). The Spatial Analysis of the Role of Green

Finance in Carbon Emission Reduction. Risks, 12(9), p.138. doi:https://doi.org/10.3390/risks12090138.

[115] Yu, Y., Zhang, Q. and Song, F. (2023). Non-Linear Impacts and Spatial Spillover of Digital Finance on Green Total Factor Productivity: An Empirical Study of Smart Cities in China. Sustainability, 15(12), p.9260. doi:https://doi.org/10.3390/su15129260.

[116] Zapata-Cantu, L. and González, F. (2021). Challenges for Innovation and Sustainable Development in Latin America: The Significance of Institutions and Human Capital. Sustainability, 13(7), p.4077. doi:https://doi.org/10.3390/su13074077.

[117] Zeng, L., Li, H., Lin, L., Juan, D. and Liu, H. (2024). ESG Standards in China: Bibliometric Analysis, Development Status Research, and Future Research

[121]

Directions. Sustainability, 16(16), p.7134. doi:https://doi.org/10.3390/su16167134.

[118] Zeng, S., Fu, Q., Haleem, F., Shen, Y. and Zhang, J. (2023). Carbon-Reduction, Green Finance, and High-Quality Economic Development: A Case of China. Sustainability, 15(18), p.13999. doi:https://doi.org/10.3390/su151813999.

[119] Zhang, C. (2024). Digital governance leveraging urbanization and fintech synergies for sustainable development in BRICS. Scientific Reports, 14(1). doi:https://doi.org/10.1038/s41598-024-81712-4.

[120] Zhang, Y., Chen, M., Zhong, S. and Liu, M. (2024). Fintech's role in carbon emission efficiency: dynamic spatial analysis. Scientific Reports, 14(1). doi:https://doi.org/10.1038/s41598-024-74834-2.