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# Green finance and renewable energy investments: a comparative analysis of successes, challenges, and policy implications across regions

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**Aim:** This study examines recent green finance developments to evaluate how institutional, economic, and policy factors affect renewable energy investments globally. It employs a comparative approach to identify key success drivers and barriers influencing the effectiveness of green finance in promoting renewable energy across different national contexts.

**Research Methods:** The study systematically examines green finance impacts on renewable energy investments through a literature review, thematic analysis, and case studies. It reviews peer-reviewed articles (2015–2025). Prioritizing qualitative research, it analyzes policies, institutional frameworks, and outcomes. Comparing successful cases (e.g., Singapore, China) with failures (e.g., Middle East & Central Asia, Latin America) provides key insights.

**Findings:** The findings depict a varied global scenario for green finance. Successes like Singapore's Green Bond Grant Scheme and China's Green Finance Pilot Zones showcase how strong regulations and blended financing boost renewable energy. In contrast, challenges in Africa (weak policies), Southeast Asia (high costs), and Latin America (political instability) emphasize the importance of tailored strategies to overcome structural obstacles.

**Originality:** This study provides a unique comparative analysis of regional green finance initiatives, examining successes and failures. Unlike previous research, it identifies key factors and barriers, offering practical recommendations for policymakers. Addressing region-specific challenges enhances understanding of global green finance and supports sustainable development.

**Implications:** The study underscores the necessity of strong regulations, blended finance, and regional collaboration for green finance success. Addressing weak governance, financing gaps, and political instability is crucial to scaling renewable energy investments and achieving sustainability goals globally.

**Limitations:** Limited quantitative analysis; future research should explore hybrid financing models.

*Keywords:* Green finance, renewable energy investments, sustainable development, Climate Finance.
*JEL: G23, Q01, Q42, Q56.*

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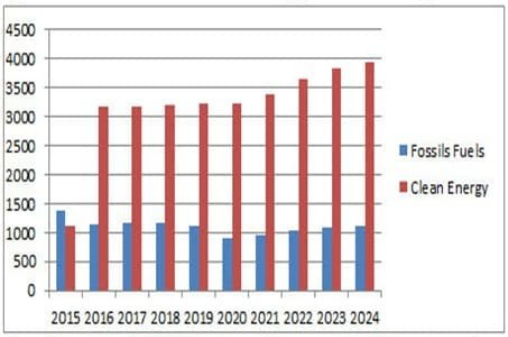
## 1. Introduction

Green finance has emerged as a transformative tool for addressing the substantial global renewable energy investment gap, estimated at $4.5 trillion annually. Instruments such as green bonds, loans, and climate funds are pivotal in channelling financial resources toward renewable energy projects, essential to achieving net-zero emissions by 2050. Despite their potential, significant disparities persist across countries due to unequal access to capital and inconsistent policy frameworks. These disparities hinder the uniform adoption of green finance mechanisms, creating a divide between nations effectively leveraging these instruments and those struggling to attract investments. For example, while developed economies benefit from mature financial markets that facilitate green finance initiatives, emerging and developing economies (EMDEs) face structural barriers such as high capital costs and limited long-term financing options, particularly for solar energy projects (Sareen, Prakash Jena 2022; Akash, Atharva 2022; Cian et al. 2024). As seen in the Figure 1 which illustrates a significant shift in global investment trends between 2015 and 2024, showcasing a growing divergence between clean energy and fossil fuel investments. While clean energy investments have demonstrated a robust and consistent upward trajectory, nearly doubling from $2200 billion in 2015 to $4000 billion by 2024, fossil fuel investments have shown only marginal growth, increasing from $1100 billion to $1200 billion over the same period. This stark contrast has led to a widening gap between the two sectors, with clean energy investments more than tripling their fossil fuel counterparts by 2024, compared to being just double in 2015. This trend underscores a major reorientation of global investment priorities towards clean energy technologies and infrastructure, reflecting an increasing focus on sustainable and renewable energy sources.

Figure 1: Global Investment in clean energy and fossil fuels (in Billion USD), 2015-2024




SourceFigure1 to 4: IEA, World Energy Investment 2024, https://www.iea.org/reports/world-energy-investment-2024/overview-and-key-findings.

Existing research highlights success stories in green finance implementation, such as in China and Singapore. China has established green finance pilot zones and implemented feed-in tariffs to attract private investments. At the same time, Singapore has introduced targeted financial mechanisms like green bonds and government-backed guarantees to support renewable energy development. These cases demonstrate how effective policy frameworks and institutional support can drive renewable energy investments. However, this narrow focus on successful examples neglects the systemic challenges developing economies face. For instance, many African nations with significant solar potential cannot secure adequate financing due to fragmented market structures, regulatory uncertainties, and the high cost of capital (Akash, Atharva 2022; Pradnyaswari et al. 2024; Cian et al. 2024).

This study aims to synthesize recent advancements in green finance research by evaluating how institutional, economic, and policy factors influence renewable energy investment outcomes across different national contexts. By adopting a comparative approach, the research seeks to identify the drivers of success and the barriers contributing to failures in leveraging green finance for renewable energy development. This comprehensive analysis aims to provide a more nuanced understanding of the global green finance landscape and offer actionable insights for policymakers and stakeholders (World Bank 2024; Henry, North 2024; Segal et al. 2024).

Green finance has emerged as a crucial mechanism for promoting sustainable development and addressing environmental challenges. It aims to increase financial flows from various sectors towards sustainable development priorities, focusing on better management of environmental and social risks while seeking opportunities that provide both financial returns and environmental benefits (UNEP 2025).

Recent research highlights the growing role of investment funds in financing green companies in emerging markets (EMs). Despite a global surge in sustainable investing, companies involved in carbon solutions in EMs still make up a small portion of reported sustainable investments. Key characteristics driving green investments include younger funds, retail investor funds, funds with domestic mandates, and sustainable funds, which are more inclined to invest in green companies and less in fossil fuels (Lepers, De Crescenzio 2024).

The field of green finance research has seen significant growth, with a surge in publications from 2018 to 2023. This increase reflects the growing academic interest and the global momentum of investing in green finance as an economic driver. Environmental activists' demand and the availability of information to capitalize on ecological and sustainability opportunities have contributed to this rise in interest (Ali et al. 2024).

While emerging markets and developing economies (EMDEs) currently rely mainly on domestic public sector financing for green investments, private financing will need to cover a large share of future needs due to shrinking fiscal space in both EMDEs and advanced economies. Cross-border private capital flows, including foreign direct investment, bank lending, and portfolio equity and debt flows, will be significant for markets with few domestic investors (Lepers, De Crescenzio 2024).

However, EMDEs face unique challenges in implementing green and sustainable finance initiatives. These include higher reliance on fossil fuels for domestic energy consumption and financial, institutional, and capacity gaps compared to advanced economies. These factors create higher hurdles for financial firms in moving toward green and sustainable finance, while climate policy frameworks in EMDEs are generally less advanced (World Bank 2023).

Despite these challenges, green finance is crucial in harmonizing economic and environmental objectives. For instance, studies examining the relationship between

green finance and sustainable development in countries like Morocco have focused on its dual impact on economic growth and environmental protection (Dahhou et al. 2024). As the field of green finance continues to evolve, addressing the specific needs and characteristics of emerging markets will be essential for its successful implementation and contribution to global sustainability goals.

## 2.Theoretical framework

The theoretical foundation linking green finance to renewable energy investments is anchored in interdisciplinary frameworks integrating financial mechanisms with environmental objectives. The innovative approach of the Data-Driven Sustainable Finance Framework integrates sustainable finance principles with advanced analytics to optimize renewable energy investments. It employs a multifaceted strategy encompassing comprehensive risk assessment, considering financial and non-financial factors to evaluate project viability (Adeyoe et al. 2024). The method also quantifies positive impacts, such as carbon reduction and job creation, to ensure alignment with sustainability goals (Adeyoe et al. 2024). Furthermore, it harnesses the power of artificial intelligence and machine learning to analyze extensive datasets spanning energy production, environmental metrics, and geopolitical factors. This data-driven approach enables the identification of high-potential projects (Ali et al. 2024) ultimately enhancing the effectiveness and sustainability of investments in the renewable energy sector.

Building on this data-driven approach, the Institutional-Policy Synergy Theory emphasizes the role of policy frameworks in facilitating private sector participation in renewable energy investments. This theory highlights how green finance policies, such as China's green bond guidelines, lower investment barriers through tax incentives and risk-sharing mechanisms. It also incorporates the double dividend hypothesis, which suggests that environmental taxes and green investments can simultaneously drive economic growth and reduce emissions, as demonstrated by initiatives like the European Union's carbon markets (Schöb 2003; Bayer, Aklin

2020). These institutional arrangements create an ecosystem that channels capital into sustainable energy initiatives.

Complementing these policy-focused insights is the STIRPAT Environmental Impact Model, which examines how societal factors and technological advancements interact to drive renewable energy adoption. This model identifies two primary pathways: the technology channel, where green finance accelerates R&D and deployment of wind and solar technologies (Yunpeng et al. 2023; Bingfeng, Zhihao 2024; Subramaniam, Loganathan 2024) (2) and affluence modulation, where wealthier economies use green financing to decouple economic growth from emissions (Yunpeng et al. 2023; Zhao, Ellisha 2024). These pathways illustrate how financial mechanisms can align technological progress with economic development patterns.

The risk-return optimization theory further advances this discussion, exploring how structured financial instruments balance profitability and sustainability in renewable energy projects. Tools like green bonds and blended finance demonstrate how public and private resources can be strategically combined to reduce risks while ensuring measurable returns. For example, Peru's $164M green bond for hydroelectric grid upgrades exemplifies how these instruments achieve financial viability and environmental impact (Adeoye et al. 2024; UNEP and the People's Bank of China 2015).

Finally, the Ecological-Economic Harmonization Theory bridges economic growth with environmental protection by emphasizing circular investment flows and social cost internalization. Circular flows reinvest profits from renewable projects into further innovations (Dahhou et al. 2024; Hailiang 2023), while mechanisms like carbon credits make renewables more competitive by accounting for environmental externalities (Xing et al. 2024). Together with earlier frameworks, this theory underscores how green finance catalyses renewable energy transitions by addressing scalability challenges through policy coordination and financial innovation.

Collectively, these interconnected theories present a comprehensive perspective on how green finance fosters a sustainable energy landscape by aligning economic incentives with environmental goals.

## 3. Methodology

The methodology for this study is structured to systematically evaluate the impact of green finance on renewable energy investments across successful and failed cases. It employs a literature review strategy, thematic analysis, and case study selection to ensure comprehensive insights into the factors influencing project outcomes.

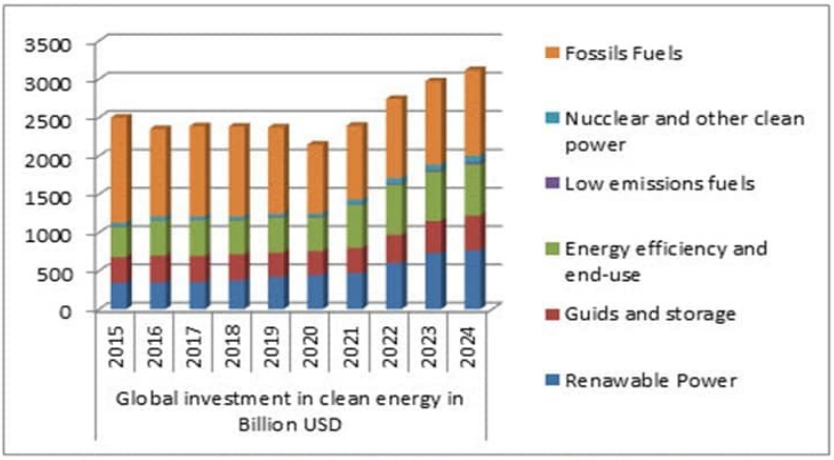
### 3.1. Literature review strategy

The field of green finance has seen significant growth, driven by its potential to address environmental challenges and promote sustainable development. Investments in clean energy have become a cornerstone of global decarbonization strategies, with renewable power emerging as a dominant focus. Figure 2 comprehensively summarizes global investments in clean energy and fossil fuels by sectors from 2015 to 2024. The data reveals that renewable power consistently attracts the largest share of clean energy investments, underscoring its pivotal role in reducing carbon emissions. Additionally, significant growth is observed in investments in grids and storage infrastructure, which are crucial for integrating renewable energy sources into existing power systems.

The diversification of clean energy investments is evident, with funding allocated to energy efficiency, low-emission fuels, and nuclear power. This diversified approach highlights the multifaceted nature of green finance, aiming to build a sustainable and varied energy landscape. In contrast, fossil fuel investments remain relatively consistent but are overshadowed by the rapid expansion of clean energy sectors, particularly renewable power.

Existing research supports these trends by emphasizing the importance of robust regulatory frameworks and institutional support in driving sectoral investments. For example, countries like China have implemented green finance pilot zones to attract private-sector participation in renewable energy projects. At the same time, Singapore's Green Bond Grant Scheme has incentivized issuers to adopt sustainable financing.

Figure 2: Global Investment in clean energy and fossil fuels by Sectors (in Billion USD), 2015-2024




SourceFigure1 to 4: IEA, World Energy Investment 2024, https://www.iea.org/reports/world-energy-investment-2024/overview-and-key-findings.

The research methodology for this study on green finance and renewable energy investments employs a systematic approach to literature review, ensuring a comprehensive and up-to-date analysis of the field.

The search criteria focus on peer-reviewed articles published between 2015 and 2025, using keywords such as “green finance,” “renewable energy investments,” and “case studies.” This timeframe captures recent developments in green finance mechanisms and their global application to renewable energy projects (Betul, Yaşar 2024; Subramaniam, Loganathan 2024). By concentrating on this period, the study ensures relevance to current market conditions and policy landscapes.

Regarding inclusion and exclusion criteria, the research prioritizes non-econometric studies that qualitatively assess national policies, institutional frameworks, and project outcomes. This approach allows a deeper understanding of contextual factors influencing success and barriers in green finance initiatives. Conversely, articles emphasizing econometric modelling or purely quantitative analyses were excluded to maintain focus on rich, contextual insights (Betul, Yaşar 2024; Chang 2019).

The study employs thematic coding to analyze the selected literature and identify recurring patterns in success factors and barriers. This method enables a structured approach to synthesizing diverse case studies and policy analyses.

Success factors identified through this process include robust regulatory support (e.g., feed-in tariffs, green bond standards), effective risk mitigation strategies (such as government-backed guarantees), and institutional partnerships that foster private-sector involvement (Subramaniam, Loganathan 2024; Chang 2019). For instance, Singapore's Renewable Energy Funding Scheme exemplifies how targeted policies can reduce financial risks while attracting investments in the renewable energy sector.

Conversely, the analysis highlights common barriers to green finance and renewable energy investments. These challenges include high capital costs, weak regulatory environments, political instability, and limited institutional capacity. African nations, for example, often face significant financing barriers due to fragmented markets and geopolitical instability, which deter private investment in renewable energy projects (Africa Policy Research Institute 2025; Khoffash, Subhi Awwad 2024; Cai et al. 2024). This research methodology provides a comprehensive framework for understanding the complex landscape of green finance in renewable energy investments by systematically examining success factors and barriers across diverse contexts. This approach enables policymakers and investors to draw valuable lessons from global experiences, potentially informing more effective strategies for accelerating the transition to sustainable energy systems.

### 3.2. Successful cases of green finance by regions

Analysing successful green finance initiatives across various regions reveals innovative approaches to promoting renewable energy investments and sustainable development. These cases demonstrate how tailored strategies can effectively address regional challenges while accelerating global progress toward sustainable energy transitions.

In Asia, Singapore has emerged as a leader in green finance through its Green Bond Grant Scheme and regional energy partnerships. The scheme, introduced by the Monetary Authority of Singapore (MAS), subsidizes external review costs for green bonds, encouraging sustainable financing practices. For example, Sunseap Group

secured a $50 million green loan for rooftop solar installations, significantly boosting the country's solar energy capacity. Singapore's participation in the Laos-Thailand-Malaysia-Singapore Power Integration Project further diversified its energy sources and reduced carbon emissions (Zhang et al. 2023; IFC 2017).

China's implementation of Green Finance Pilot Zones in provinces like Jiangsu, Zhejiang, and Guangdong has been equally impactful. These zones offer concessional loans, tax incentives, and land-use benefits to attract private-sector participation in clean energy projects. By 2024, China had mobilized approximately $4.5 trillion in green loans, enabling it to meet its renewable energy targets ahead of schedule (Zhang et al. 2023).

Kenya has leveraged innovative financing models in Africa to expand renewable energy access. The M-KOPA Solar initiative uses a pay-as-you-go model to provide affordable solar home systems to over one million households. Additionally, the Lake Turkana Wind Power Project, Africa's largest wind farm, supplies 17% of Kenya's electricity needs (CIF 2024; IFC 2017). South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has attracted over $13 billion in investments and added 6 GW of renewable energy capacity to the national grid (IFC 2017).

Europe showcases successful initiatives such as Germany's KfW Renewable Energy Programme, which has financed thousands of solar photovoltaic systems and wind turbines through low-interest loans. Croatia's Citizen-Led Energy Renovation Fund demonstrates the power of community engagement in financing energy-efficient building renovations (IFC 2017). Croatia has implemented a crowdfunding initiative for energy-efficient building renovations through its Citizen-Led Energy Renovation Fund. This fund supports approximately 250 households annually, reducing thermal and electrical usage by up to 1,300 kWh per year per household. Croatia has successfully scaled up small-scale renewable energy adoption by engaging local communities directly in financing efforts while fostering public participation in sustainability initiatives (Mestri-CE 2024).

In Latin America, Chile's Cerro Dominador Solar Thermal Plant, financed through blended finance, generates 580,000 MWh annually while avoiding 235,000 tons of $CO_2$ emissions (Groves et al. 2020; UNFCCC 2018). Costa Rica's National

Decarbonization Plan (NDP) aims to achieve net-zero emissions by 2050 through transportation, agriculture, and forestry sectoral reforms. The plan attracted nearly $1 billion in international funding from institutions like the International Monetary Fund (IMF) and Inter-American Development Bank (IDB). Early achievements include deploying electric buses and reducing agricultural emissions through composting initiatives. The NDP demonstrates how robust policy frameworks can attract large-scale investments while ensuring long-term sustainability goals are met (Elliott et al. 2024; Groves et al., 2020).

These successful cases highlight key lessons for effective green finance strategies: strong regulatory frameworks, public-private partnerships, blended finance models, community engagement, and regional collaboration. By adapting these approaches to local contexts, countries can overcome barriers and leverage green finance to achieve sustainability goals.

### 3.3. Failure cases of green finance by regions

The failure cases of green finance across various regions highlight significant challenges in implementing sustainable financial practices and reveal systemic vulnerabilities that hinder progress toward environmental goals.

The Middle East and Central Asia (ME&CA) region faces significant challenges in implementing green finance due to climate-related risks and systemic vulnerabilities in its financial sectors. Countries like Afghanistan, Pakistan, and Iran are particularly susceptible to climate-induced financial risks, as they heavily rely on climate-sensitive industries such as agriculture and tourism. Climate disasters amplify these vulnerabilities, causing substantial credit losses and increasing systemic risks for banks. The region also grapples with transition risks, especially for oil-exporting nations, as the global shift towards renewable energy threatens to create stranded assets. Low carbon pricing and continued reliance on subsidies for energy-intensive sectors exacerbate these challenges. Furthermore, the ME&CA region suffers from significant insurance gaps, with only 16% of insurance protection needs met between 2005 and 2019. This lack of coverage has resulted in a mere $2 billion of the $44 billion in climate-related economic losses being insured during this period, placing a

substantial financial burden on governments and impeding the adoption of green finance initiatives (Radzewicz-Bak et al. 2024).

Despite its significant renewable energy potential, Latin America faces substantial hurdles in scaling up green finance initiatives due to limited access to long-term financing and insufficient technical capacity. A European Investment Bank survey revealed that 55% of the region's Public Development Banks (PDBs) identified inadequate green investment knowledge among clients as a significant obstacle. In comparison, 45% cited clients' lack of awareness of green finance opportunities. Funding constraints compound these challenges as PDBs struggle to secure the long-term capital necessary for climate investments (European Investment Bank 2025). The region requires an estimated $2.1–$2.8 trillion by 2030 to address climate change effectively, but persistent financing gaps stemming from insufficient international cooperation and weak domestic financial systems hinder progress (Omori 2024).

Furthermore, the vulnerability of critical sectors like agriculture to climate change impacts exacerbates food insecurity and economic instability, further impeding the adoption of green finance solutions in Latin America (European Investment Bank 2025; Omori 2024).

Southeast Asian countries face significant challenges in implementing green finance initiatives due to regulatory uncertainty, resource constraints, and greenwashing concerns. In Indonesia, for example, unclear power purchase agreement (PPA) regulations have led to delays in renewable energy projects, with investors struggling to navigate inconsistent policies that fail to provide long-term stability for green investments (World Bank 2023). Across the region, allegations of companies misrepresenting their environmental credentials have eroded trust and deterred private-sector participation in green bond markets. Additionally, the high upfront costs associated with renewable energy projects pose a substantial barrier for local companies, particularly those without access to concessional financing or government support. These interrelated factors collectively undermine investor confidence and hinder the growth of green finance in Southeast Asia despite the region's significant potential for sustainable development (World Bank 2023).

Although Europe has historically been a global leader in green finance, recent developments reveal mounting challenges driven by political resistance, economic

pressures, and unequal financing distribution. Opposition to the European Green Deal has introduced uncertainty about long-term sustainability commitments, with countries like Poland continuing to rely heavily on coal subsidies despite receiving EU funding for renewable energy transitions. Economic pressures, including rising inflation and higher interest rates, have further increased the debt issuance cost for renewable energy projects, making green bonds less appealing to investors. Additionally, financing remains disproportionately allocated, with fossil fuel companies receiving five times more funding than green initiatives, undermining efforts to meet net-zero targets. These factors collectively hinder Europe's progress in maintaining its leadership in green finance and achieving its climate goals (IFC 2017).

The failure cases in green finance across various regions reveal several key contributing factors hindering sustainable investment progress. Weak regulatory frameworks, exemplified by inconsistent policies like Southeast Asia's power purchase agreements, discourage private-sector participation. Limited access to long-term financing creates funding gaps that prevent large-scale investments, particularly in regions like Latin America. A lack of technical capacity, especially among financial institutions in the Middle East, Central Asia, and Latin America, impedes the development and implementation of green finance initiatives. Political instability, such as resistance to sustainability policies in Eastern Europe, creates uncertainty and undermines long-term commitments. Additionally, insurance gaps, particularly evident in the Middle East and Central Asia, amplify financial risks associated with climate disasters. These interconnected challenges underscore the critical need to address structural barriers, enhance regulatory clarity, promote international cooperation, and build institutional capacity to scale up green finance on a global scale effectively.

## 4. Results

### 4.1. Results: successful cases of green finance by regions

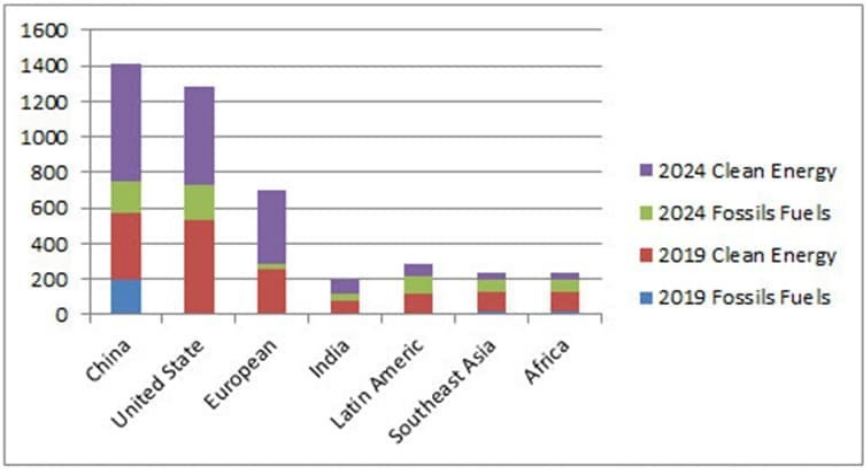
The analysis of green finance initiatives reveals significant regional disparities in clean energy investments between 2019 and 2024. Figure 3 illustrates the global landscape of clean energy investments during this period, highlighting China's leadership in renewable energy funding. China consistently maintains its dominant position due to strong policy support, such as its Green Finance Pilot Zones and extensive renewable energy projects. The United States also shows notable growth in clean energy investments, driven by federal incentives and private-sector participation.

In contrast, Europe experienced a decline in clean energy investment between 2019 and 2024, reflecting challenges such as political resistance to sustainability policies and unequal financing allocation. Other regions, including India, Latin America, Southeast Asia, and Africa, demonstrate modest but consistent increases in clean energy funding. These trends underscore varying levels of commitment and progress across different regions.

Notably, fossil fuel investments remain relatively stable across all regions but are significantly overshadowed by the growing clean energy sector. This shift highlights a global reorientation toward renewable energy technologies and infrastructure, particularly in leading economies like China and the United States.

Singapore has established itself as a regional leader in green finance, mainly through the Green Bond Grant Scheme, which subsidizes the costs of external reviews for green bonds. This initiative has encouraged issuers to adopt sustainable financing practices, resulting in significant investments in renewable energy projects. Between 2016 and 2020, Singapore led the ASEAN region with 47 green finance deals, amounting to approximately $9.6 billion in green loans. The country's leadership is further reflected in its Singapore Green Plan 2030, which integrates green finance as a key pillar to achieve sustainable development goals (Climate Bonds Initiative 2021).

Figure 3: Annual investment in clean energy by selected country and region (in Billion USD), 2019 and 2024




SourceFigure1 to 4: IEA, World Energy Investment 2024, https://www.iea.org/reports/world-energy-investment-2024/overview-and-key-findings.

China's success in green finance is exemplified by its Green Finance Pilot Zones, particularly in cities like Huzhou. These zones allow local governments to test innovative green finance policies and products before scaling them nationwide. Huzhou developed its green finance taxonomy, focused on industries such as textiles and batteries, and introduced financial products to support small and medium-sized enterprises (SMEs) in adopting sustainable practices. By 2024, China had mobilized $4.5 trillion in green loans, accelerating renewable energy adoption (Eiff 2025).

Chile has emerged as a leader in Latin America's green finance landscape, being the first country to issue sovereign green bonds. By 2021, Chile had issued $3.8 billion worth of sovereign green bonds, which have been used to fund large-scale renewable energy projects such as solar and wind farms. These efforts have positioned Chile as a key player in advancing sustainable energy transitions (Climate Bonds Initiative, 2021; European Investment Bank 2024).

Brazil has leveraged green finance to support sustainable agriculture and renewable energy projects. In 2023, Brazil issued $2 billion in national sustainable bonds to fund initiatives to reduce deforestation and promote clean energy solutions. Corporate issuers such as Klabin have also utilized green bonds to finance biomass

energy production and other eco-friendly industrial practices (Climate Bonds Initiative 2021; European Investment Bank 2024; Climate Investment Funds 2024).

Colombia issued its first domestic green bond worth $70 million to fund renewable energy projects and later launched a biodiversity-focused bond of similar value.

These initiatives highlight Colombia's efforts to integrate environmental sustainability into its financial markets (Climate Bonds Initiative 2021; European Investment Bank 2024).

Germany's success in green finance is primarily attributed to the KfW Renewable Energy Programme, which provides low-interest loans for renewable energy projects. Through this program, thousands of small-scale solar photovoltaic (PV) systems and wind turbines have been installed across Germany, significantly contributing to the country's transition toward a low-carbon economy (Ecofy Finance Private Limited 2023).

Croatia has implemented a citizen-led crowdfunding initiative for energy-efficient building renovations through its Citizen-Led Energy Renovation Fund. This fund supports approximately 250 households annually, significantly reducing thermal and electrical energy usage—up to 1,300 kWh per household per year (Ecofy Finance Private Limited 2023).

The analysis of successful green finance cases across various regions reveals several key lessons for effective implementation. Strong regulatory frameworks, exemplified by China's pilot zones, are crucial for attracting private-sector investments. Public-private partnerships, such as Singapore's Green Bond Grant Scheme, have proven effective in reducing risks for investors while scaling up renewable energy projects. Blended finance models, combining public subsidies with private capital as seen in Chile's sovereign green bonds, ensure financial viability for large-scale initiatives. Community engagement through localized approaches, like Croatia's citizen-led fund, fosters trust and encourages public participation in sustainable projects. Additionally, regional leadership, demonstrated by countries like Singapore and Chile, shows how proactive policies can position nations as hubs for sustainable finance. These diverse strategies illustrate how tailored approaches can

address specific regional challenges while contributing to global sustainability goals, offering valuable insights for policymakers and investors worldwide.

### 4.2. Results: failure cases of green finance by regions

The Middle East and Central Asia (ME&CA) region faces significant obstacles in implementing green finance due to systemic vulnerabilities, limited institutional capacity, and climate-induced risks. Many countries in the region, particularly low-income and developing economies like Afghanistan, Pakistan, and Iran, rely heavily on climate-sensitive industries such as agriculture, fishing, and tourism. These sectors are highly susceptible to climate disasters, exacerbating poverty, unemployment, and food insecurity. Notably, seven of the region's ten most significant climate disasters since 2000 occurred in low-income countries, highlighting the fragility of their economic drivers and limiting investments in climate-resilient infrastructure. Additionally, oil-exporting nations face transition risks as the global shift toward renewable energy reduces demand for fossil fuels. This challenge is compounded by low carbon pricing and reliance on fossil fuel subsidies, with the banking sector in 30 ME&CA countries projected to incur cumulative loan losses of $11 billion by 2030 and over $50 billion by 2050 due to stranded assets.

Furthermore, the region has one of the lowest levels of insurance resilience globally; only 16% of insurance protection needs were met between 2005 and 2019. Climate-related disasters caused $44 billion in economic losses during this period, but only $2 billion was insured. This lack of coverage increases financial burdens on governments and deters private-sector investments in green finance initiatives (Radzewicz-Bak et al. 2024).

Despite its growing energy demand and vast renewable potential, Southeast Asia faces significant challenges in implementing green finance initiatives. The region grapples with regulatory uncertainty, exemplified by unclear power purchase agreement (PPA) regulations in countries like Indonesia, which have delayed renewable energy projects and created an unstable environment for long-term green investments (IFC 2023). However, current sustainable financing levels meet only one-sixth of this requirement. Greenwashing concerns have further eroded investor confidence, with allegations of companies misrepresenting their environmental

credentials undermining trust in green bonds across the region (Cai 2023). Small and medium-sized enterprises (SMEs), which form a significant portion of Southeast Asia's economy, face additional barriers, including high costs, limited knowledge of sustainability practices, and restricted access to concessional financing. Despite recognizing the importance of sustainability, only 40% of SMEs in the region have adopted such measures, highlighting the need for targeted support and capacity building to drive green finance adoption across all sectors of the economy.

Latin America faces significant challenges in scaling green finance due to its dependence on fossil fuel revenues, weak financial systems, and sectoral vulnerabilities. Many countries, such as Brazil, rely heavily on fossil fuel exports, making the transition to renewable energy difficult. For instance, Brazil's Amazon Fund experienced setbacks due to political changes that eroded international donor confidence (Climate Investment Funds 2024). Public Development Banks (PDBs) in the region also struggle with limited access to long-term capital, essential for financing renewable energy projects. A survey revealed that 55% of PDBs identified inadequate client awareness about green finance opportunities as a significant barrier, further hindering progress (IFC 2023). Additionally, agriculture—a critical sector for many Latin American economies—is highly vulnerable to climate change impacts. The lack of adaptation investments exacerbates food insecurity and economic instability across the region, further constraining efforts to implement effective green finance initiatives.

Although Europe has long been a global leader in green finance, it now faces mounting challenges from political resistance, economic pressures, and unequal financing distribution. Countries like Poland depend heavily on coal subsidies in Eastern Europe despite receiving EU funding for renewable energy transitions. Political opposition to the European Green Deal has further created uncertainty about long-term commitments to sustainability goals (IFC 2023, 2017). Economic pressures, including rising inflation and higher interest rates, have increased the debt issuance cost for renewable energy projects, making green bonds less appealing to investors (IFC 2017). Additionally, financing remains disproportionately allocated, with fossil fuel companies receiving five times more funding than green initiatives,

undermining Europe's efforts to meet its net-zero targets and maintain its leadership in global green finance (IFC 2023).

Analysing failure cases in green finance reveals several critical lessons highlighting the structural barriers impeding progress globally. Weak regulatory frameworks, such as inconsistent power purchase agreements (PPAs) in Southeast Asia, discourage private-sector participation. At the same time, limited access to long-term financing creates significant funding gaps, particularly in regions like Latin America. A lack of institutional capacity, especially among financial institutions in the Middle East, Central Asia, and Latin America, further hinders the effective implementation of green finance initiatives. Political instability, including resistance to sustainability policies in regions like Eastern Europe, generates uncertainty and undermines long-term commitments. Additionally, insurance gaps, particularly in the Middle East and Central Asia, exacerbate financial risks from climate disasters and deter private-sector investments. These challenges underscore the urgent need for stronger regulatory frameworks, expanded concessional financing, enhanced institutional capacity building, and increased international cooperation to overcome these barriers and scale green finance globally. Table 1 summarizes and compares the key metrics across several countries to highlight influential factors in green finance and renewable energy investments:

The analysis of green finance and renewable energy investments across various countries reveals several key factors driving success in this sector. Robust policy frameworks and regulatory support, exemplified by initiatives like China's Green Finance Pilot Zones and Singapore's Green Bond Grant Scheme, are crucial in attracting investments. Government-led programs, such as Germany's KfW Renewable Energy Programme and Chile's sovereign green bonds, significantly contribute to project implementation and investment growth. International collaboration and adherence to global standards, as demonstrated by France's partnership with Sweden and the adoption of EU initiatives, further enhance a nation's green finance ecosystem. Countries focusing on specific sectors, like Brazil's emphasis on sustainable agriculture and deforestation, can channel investments more effectively. Developing innovative financial instruments, including green bonds and sustainability-linked loans, also increases investment volumes and diversifies

projects. Collectively, these factors underscore the importance of combining strong policy support, innovative financial mechanisms, and targeted sector approaches to create successful green finance and renewable energy investment strategies across different national contexts.

**Table 1.** Comparative analysis of green finance initiatives and renewable energy investments across selected countries

| Country | Total Investment (USD) | Policy Frameworks | Outcomes |
|---|---|---|---|
| China | 4.5 trillion | Green Finance Pilot Zones, strong regulations | Mobilized $4.5 trillion in green loans, 35.75 trillion yuan in outstanding green loans by Q3 2024 |
| Singapore | 9.6 billion | Green Bond Grant Scheme, subsidies for green bonds | 47 green finance deals, significant solar capacity increase |
| Germany | 13 billion | KfW Renewable Energy Programme, low-interest loans | Thousands of solar PV systems installed |
| Chile | 3.8 billion | Sovereign green bonds, National Decarbonization Plan | Large-scale renewable energy projects funded |
| Brazil | 2 billion | National sustainable bonds, focus on deforestation | Support for sustainable agriculture and clean energy |
| United Arab Emirates | Not specified | Dubai Declaration on Sustainable Finance | Framework for identifying contributions to green economy |
| France | Not specified | EU-level initiatives, partnership with Sweden | Stronger disclosure obligations, climate stress testing for banks, new green bonds |

Source: prepared by the researcher based on the data in paragraph number 4.1.

## 5. Discussion

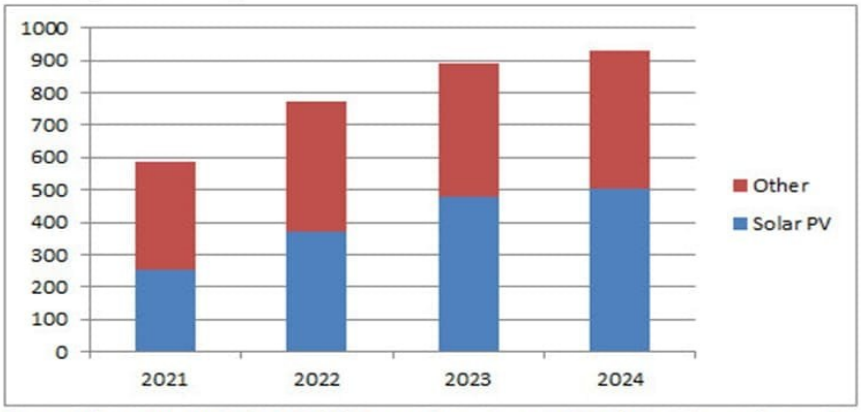
The theoretical analysis of green finance and renewable energy investments reveals a complex interplay of frameworks that explain successes and challenges across different regions. The Data-Driven Sustainable Finance Framework has proven effective in countries like China and Singapore, where comprehensive risk assessment and impact quantification have optimized renewable energy investments. China's Green Finance Pilot Zones exemplify how data-driven approaches can identify high-potential projects. However, this framework's efficacy is limited in regions with systemic vulnerabilities, such as the Middle East and Central Asia, where inadequate

data infrastructure and climate risk modelling capabilities hinder advanced analytics applications.

The Institutional-Policy Synergy Theory supports successful initiatives like Germany's KfW Renewable Energy Programme, demonstrating how well-crafted policies can encourage private investment in renewable energy. Conversely, this theory helps explain setbacks in Southeast Asia, where regulatory uncertainty has deterred private sector participation. The STIRPAT Environmental Impact Model offers insights into regional variations, highlighting China's strong technology channel effect in accelerating renewable technology R&D and deployment while revealing challenges in Latin America, where fossil fuel dependence impedes the renewable transition.

Risk-Return Optimization Theory is evident in successful blended finance models, such as Chile's sovereign green bonds, which effectively balance profitability and sustainability. However, this theory also illuminates challenges in regions like Africa, where high perceived risks and limited risk mitigation tools hinder investment. The Ecological-Economic Harmonization Theory is exemplified by initiatives like Croatia's Citizen-Led Energy Renovation Fund, which creates circular investment flows at the community level while also highlighting the persistent challenges in fossil fuel-dependent regions.

Figure 4: Global annual investment in Solar PV and other generation technologies from 2021 to 2024 (Billion USD)




SourceFigure1 to 4: IEA, World Energy Investment 2024, https://www.iea.org/reports/world-energy-investment-2024/overview-and-key-findings.

In the global context, a stark divide exists between regions successfully leveraging green finance and those struggling with structural barriers. This disparity is evident in the concentration of clean energy investments in countries like China and the United States, contrasting with the lag in Africa and Southeast Asia. As seen in the figure 4, the global shift towards renewable energy, particularly in solar PV investments, underscores green finance's potential to drive sustainable development. However, persistent challenges in scaling up these investments in developing economies highlight the need for targeted international cooperation and capacity-building efforts.

Critical examination of successes and failures raises questions about the replicability and scalability of green finance initiatives. China's success in mobilizing green loans, partly due to its unique political and economic structure, may not be easily replicated elsewhere. Failures in regions like the Middle East and Central Asia underscore the critical role of underlying economic structures and institutional capacities in determining the effectiveness of green finance initiatives.

This analysis reveals several areas for future research and policy development, including tailoring green finance strategies for resource-dependent economies, enhancing climate risk modelling and data infrastructure in vulnerable regions, designing innovative risk mitigation tools for high-risk environments, and accelerating technology transfer and capacity building in developing economies. By addressing these areas, policymakers and researchers can work towards more effective and equitable green finance solutions that drive global progress in renewable energy investments.

## 6. Policy implications and recommendations

Analysing green finance initiatives and their impact on renewable energy investments yields several critical policy implications and recommendations. These strategies aim to create a more favourable environment for green finance and accelerate the global transition to renewable energy.

Strengthening regulatory frameworks should be a primary focus. This involves implementing robust and consistent policies that provide long-term certainty for

investors (Azhgaliyeva et al. 2018), developing sector-specific decarbonization roadmaps (Griffa 2025), and establishing transparent accountability mechanisms. These measures will help maintain integrity in green finance markets and clarify pathways for different industries.

Enhancing financing mechanisms is equally crucial. Policymakers should prioritize blended finance models that combine public and private capital, expand access to concessional financing (especially for emerging markets and developing economies) (Criscuolo et al. 2014), and promote innovative financial instruments like green bonds (Griffa 2025). These strategies can effectively mobilize capital for renewable projects.

Supportive legal frameworks for research and development in renewable energy should be created to foster innovation and technology advancement. Collaboration with international organizations can accelerate technological progress and reduce costs. Additionally, implementing differentiated support for emerging versus near-competitive renewable technologies can drive further advancements (Criscuolo et al. 2014).

Improving policy design is another key area. This includes designing feed-in tariffs to compensate for cost differences between renewables and fossil fuels, using renewable energy certificates to incentivize innovation in near-competitive technologies, and considering upstream R&D support alongside output-based incentives (Criscuolo et al. 2014).

Promoting international cooperation is vital for sustainable development. Establishing bilateral and multilateral agreements can mobilize resources while harmonizing green finance standards and practices across jurisdictions and facilitate cross-border investments in renewable energy projects (Criscuolo et al. 2014).

Addressing regional challenges requires tailored strategies to overcome structural barriers such as high capital costs and weak governance. Providing targeted support and capacity building for small and medium enterprises and developing region-specific risk mitigation tools can attract private investment.

By implementing these recommendations, policymakers can create a more conducive environment for green finance and accelerate the transition to renewable energy globally. Success will depend on consistent political commitment, innovative

financing approaches, and international collaboration to overcome persistent barriers and scale up sustainable investments.

## 7. Conclusion

The comprehensive analysis of green finance initiatives for renewable energy reveals a nuanced global landscape with promising successes and persistent challenges. The study highlights that effective implementation of green finance mechanisms depends on tailored strategies addressing specific regional contexts. Key success factors include strong regulatory frameworks, innovative blended finance models, and community engagement, which have proven effective in driving renewable energy adoption, particularly in Asia, Europe, and Latin America. However, persistent barriers such as weak regulations, limited access to long-term financing, political instability, and insufficient institutional capacity impede progress in regions like Africa, Southeast Asia, and parts of Europe. The analysis underscores the critical importance of addressing these structural barriers through enhanced international cooperation, capacity building, and policy innovation to achieve a sustainable, low-carbon future globally. Moving forward, concerted efforts from governments, financial institutions, and the private sector will be essential to develop context-specific solutions that can effectively mobilize green finance for renewable energy across all regions, ultimately accelerating the transition to a more sustainable energy landscape worldwide.

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