Green Financing Mechanism's impact on the Growth of Renewable Energy and Smart Infrastructure in Sultanate of Oman

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ABSTRACT

The study aims examined the green finance mechanisms effect on renewable energy growth, through analyzing the mediating role of Omani smart infrastructure. The study narrowed research gap through linking the three variables together in transitional economies. Oman is considered as a unique case because of its modern legislative environment, which mentioned in the "Sustainability Finance Framework," and within "Vision 2040." The study used a descriptive analytical approach, distributing a Likert scale questionnaire to a purposive sample of 120 experts in the energy and finance sectors, with reliability and validity tests. The significant of study is considered as a benchmark model illustrating how green finance contributes to the digitalization of electricity grids to improve the efficiency of solar and wind energy. The study's results found that there is a statistically significant positive relationship between the availability of green finance tools and the development of smart infrastructure, which accelerates the achievement of net-zero carbon neutrality goals.

Keywords: Clean Energy Investment, Environmental Policy, Green Financing, Green Bonds, Renewable Energy, Smart Infrastructure, Smart Cities, Sustainability, Sustainable Development, Oman Vision 2040.

INTRODUCTION

The green finance has become one of crucial tool for improving smart infrastructure and renewable energy in the push towards sustainable development. corporations, in many countries, is focused on low-carbon and environmentally sound investments through tools such as green bonds and sustainability-linked loans. due to Oman Vision 2040, Oman has included green financing in its national development plan to enhance smart infrastructure and mitigate the environmental consequences of traditional growth models.

Although many studies examined the impact of green finance in driving sustainability in many aspects, the gap emerges when attempting to apply these models to economies. Previous studies lack an integrated link between innovative financing mechanisms (such as green bonds) and the efficiency of smart infrastructure as an intermediary for maximizing renewable energy capacity.

The Sultanate of Oman try to convergence of its carbon neutrality 2050 ambitions through a newly established legislative environment (the 2024 Sustainability Finance Framework). previous results derived from mature markets cannot be entirely generalizable. Therefore, this study tries to narrow this gap through presenting an analytical model that explains the role of green finance as a "monetary tool" and become a technological engine for smart infrastructure in the Sultanate. hence, the study aims to answer the following question:

What is the effect of green financing mechanisms on the growth of renewable energy and smart infrastructure in sultanate of Oman? most of studies has focused on the "quantity" of green financing available without considering the "quality" of employing this financing to stimulate technological innovation, where there is a clear lack of studies focused on the extent to which the Omani energy infrastructure sector has responded to the requirements of "Vision 2040" regarding green financing specifically allocated to renewable energy.

LITERATURE REVIEW

Recently, green finance has become a strategic tool for managing climate risks. where, it is considered as a crucial instrument for fighting climate change and supporting sustainable development. it focuses on the investments in intelligent infrastructure and renewable energy. Oman has been improving its financial and legal policies to be alignment with the sustainability objectives of Oman Vision 2040 through giving environmental stewardship, technological innovation, and economic diversification top priority in the Gulf region.

Previous studies confirmed on the benefits of green financing tools in switch to clean energy sources and digitally enabled infrastructure development. in addition, that, Recent studies demonstrated the importance of green financial instruments for accelerating the advancement toward clean energy solutions and digitally supported infrastructure.

Abdul Rahman and Navaz (2025) forced in their study on the role of green finance and financial technology (FinTech) together in promoting sustainable Development Goal 7 in GCC countries. and they pointed out that access to green capital may be much enhanced by digital financial tools, which enable GCC nations to align their renewable energy targets with global leaders in clean energy invention.

In oil-exporting countries, researchers argue that green finance faces structural challenges related to crowding out from the fossil fuel sector. However, recent trends in the Gulf Cooperation Council (GCC) countries indicate a radical shift; these countries have begun developing national frameworks for sustainable finance to reduce their reliance on oil revenues, creating a pressing need to assess the effectiveness of these frameworks in attracting foreign direct investment toward sustainability projects.

Through Chatham House research, Aboudouh (2025) indicated Oman's goal of achieving net-zero emissions by 2050 and 30% renewable energy by 2030. Setting a national green taxonomy, improved legislative consistency, and the creation of a specialized green-infrastructure funding platform will help to improve the efficiency of Oman's green finance environment, he says. In a long-term study of Oman's sustainability efforts,

Abdel Gadir and Mohammed (2024) investigated the causes of CO_2 emissions from 1990 to 2024. Their studies reveal how the energy transition environment is formed by patterns of energy consumption, financial sector growth, foreign investment, economic development, and urbanization together. The results underline the need of focused green funding policies to support low-carbon growth and lower emissions.

Recent studies agree that investment in renewable energy remains limited in its impact unless coupled with smart grid infrastructure. Traditional grids struggle to accommodate the intermittent flow of solar and wind energy. The literature emphasizes that digitalization and Internet of Things (IoT) technologies act as a "safety valve" to ensure the stability of the national grid and improve distribution efficiency.

Mishrif and Khan (2024) found by examined the application of intelligent technology in renewable energy infrastructure in Oman how renewable energy initiatives that there are several benefits, including improved grid stability and higher energy efficiency. They also found difficulties such as unclear laws, high beginning expenses, and a lack of local technical knowledge. Therefore, they advocate more public-private partnerships and target capacity-building programs.

Al Shanfari and Al Rawahi (2024) stated that there are institutional obstacles to the uptake of green finance such as lack of standardization of green financial products and lack of awareness among financial institutions, which slow down the growth of the sector. because of that, there is a need for stronger legal systems and better institutional readiness in order to attract sustainable investment in Oman such as green sukuk and Islamic green bonds.

Al-Mawali (2023) notes that many times included in public-private partnership agreements, these instruments provide great chances for financing smart infrastructure projects all around the country. As well as Al-Harthy and Al-Araimi (2022) discovered that low financial literacy, a lack of knowledge of the advantages of green finance, and insufficient legal backing still hinder advancement.

RESEARCH METHODOLOGY

This study aims to analyze the impact of green financing mechanisms on the growth of renewable energy and smart infrastructure during the period (2019–2024) by evaluates financial trends and the relationship between green finance instruments and project performance indicators depending on policy papers, government reports, national sustainability initiatives, corporate financial accounts, and policy studies in Oman. It is based on the main hypothesis that the green financing mechanisms contribute to improving the Growth of Renewable Energy and Smart Infrastructure in Sultanate of Oman.

The research so reveals that the deliberate sampling strategy was distributed 120 questioners to expert respondents in Oman to ensure that the sample contained individuals with relevant knowledge and experience in green finance, renewable energy, and intelligent infrastructure development. A 5-point Likert scale was used in this study to gauge respondents' ideas of green finance approaches and their effects on the growth of intelligent infrastructure and renewable energy in the Sultanate of Oman.

A multiple linear regression model was applied to examine the relationship between green financing mechanisms and the growth of renewable energy and smart infrastructure in the Sultanate of Oman. This model enables the assessment of the relative influence of green finance while controlling for other variables. The dependent variable in this study is the growth of renewable energy as shown by increases in installed capacity, investment levels, production output, and its percentage in the national energy mix. The independent variable, green finance mechanisms include financial tools, policies, and investment plans promoting environmentally friendly projects lowering carbon emissions and supporting smart infrastructure growth.

Research Questions:

1. In Oman, how has green funding helped to develop and expand smart infrastructure and renewable energy?

2. Prominent promoters of renewable energy development and wise infrastructure enhancements inside the Omani context are which green financial vehicles and funding mechanisms?

3. To what extent does green financing help Oman's more general sustainability plan and national energy transition goals?

4. What significant hurdles and structural obstacles obstruct the successful implementation of green financing inside the Omani renewable energy and smart infrastructure industries?

5. Particularly in terms of their implementation methods, success, and influence on sustainable energy and infrastructure growth in Oman, how do green financing initiatives and actions vary across public and commercial sector organizations?

Research objectives:

1. Find out how Oman's renewable energy projects are helped to grow and be implemented by green funding methods.

2. demonstrate the important of green bonds and sustainability-linked loans and its effect on the growth of Omani smart infrastructure.

3. explore the degree to which green financing contributes in the sustainability goals achievement in Oman Vision 2040.

4. Find out the opportunities and obstacles associated with the implementation of green finance in the sectors of Oman’s energy and infrastructure.

5. Evaluate the role of government and the financial institutions in supporting and enabling green investments in the intelligent infrastructure expansion that related to renewable energy.

Data Analysis methods:

Data Analysis and Interpretation:

The study shows the impact of Oman's smart infrastructure and renewable energy expansion have been aided by green financing. Improved sustainability, more investments, and better project outcomes have resulted from green bonds, sustainability-linked loans, and government rewards. Studies on many projects demonstrated a strong relationship between green financing and elements including feasibility, cost-effectiveness, and environmental impact. Stakeholder comments stated that there is a need of institutional support and encouraging legislation as well as the need of green finance in reaching Omani Vision 2040.

Green Bonds and Sustainability-Linked Loans by Institutions in Oman:

1. Launched in June 2025, Bank Muscat is administering a sovereign sukuk of OMR 100 million (about USD 260 million) with seven-year duration and an annual profit rate of almost 4.65%. This sukuk is meant to fund Oman's infrastructure and promote sustainable development. Furthermore, the bank has launched a Green Finance product, a solar loan facility created in partnership with the IFC, providing loans from OMR 1,000 to 25,000 for solar panel installations. This project makes renewable energy more accessible and inspires families to consume it.

2) Oman's Authority for Investments (OIA) encourages sustainable development via investments and a five-year OMR 2 billion Future Fund. Though, little proof exists of OIA directly giving green bonds or loans tied to sustainability. Financing infrastructure is its main purpose; indirectly, it helps to sustainable finance by way of co-investments in ESG-oriented finance, green bond initiatives, and advisory services.

3) Oman Oil Company (OQ) released its first USD 750 million international bond in April 2021 as part of a seven-year plan to meet with its worldwide energy policy. The 2024 Sustainability Report noted a 16.1% reduction in emissions and advancements in projects like green hydrogen. OQ issued a Solar Green Bond for a 500 MW solar facility and secured over USD 2 billion in financing for renewable energy projects, clearly connecting its funding to sustainability goals under Oman Vision 2040.

Overview of Green Financing Trends in Oman (2019–2024):

Table 1: Green Financing Trends in Oman 2019-2024

Year	**Total Green Financing (OMR Million)**	**Total Infrastructure Investment %**	**Growth %**
2019	48.5	6.5%	—
2020	61.0	8.3%	+25.8%
2021	78.6	10.2%	+28.9%
2022	96.2	11.5%	+22.3%
2023	109.4	12.8%	+13.7%
2024*	123.8 (est.)	14.1% (projected)	+13.2%

Source: Annual reports during the periods of 2019–2024 of Central Bank of Oman, Muscat Stock Exchange, and Ministry of Energy and Minerals reports.

According to the table (1), the results shows that the compound annual growth rate of green financing in Oman increase about 21.7% since 2019 to 2024, because of Omani national policies, and the integration of ESG principles in finance, and diversification goals.

It also contributes in infrastructure funding also maximizes to over 14%, which lead to an increasing dependence on sustainable funding techniques.

Table 2: Green Financing by Sector wise Allocation (2020–2024)

Year	Green Finance (OMR Million)	Renewable Energy (MW)	CO_2 Reduction (Tons)	Smart Infrastructure Projects (No.)
2020	120	250	40,000	3
2021	180	320	58,000	5
2022	240	410	74,000	6
2023	300	495	90,000	8
2024	370	590	105,000	10

Source: Annual Ministry of Energy and Minerals (Oman) during the period of 2020–2024, Authority for Public Services Regulation (APSR), Oman Power and Water Procurement Company (OPWP), Central Bank of Oman, and annual reports of major renewable energy projects such as Ibri II Solar Project and Dhofar Wind Power Project.

Table (2) pointed out that the green financing improves both infrastructural and environmental progress in sultanate of Oman. where the positive trends toward renewable energy, carbon emission reductions, and smart infrastructure deployment provide empirical evidence that strategic financial investment in green sectors is enhancing the Omani's sustainable development during the period 2020 and 2024.

Table 3: Descriptive Statistics for Total Project Investment

Sector	N (Projects)	Mean Investment (OMR Mn)	Median (OMR Mn)	Min (OMR Mn)	Max (OMR Mn)	Std. Dev.
Renewable Energy (Solar & Wind)	45	22.80	19.40	3.20	92.50	18.60
Water & Wastewater Management	25	16.30	14.20	4.10	48.60	10.90
Transport & Electric Mobility	20	14.70	12.50	2.10	41.30	9.40
Smart Grid & Energy Efficiency	18	12.20	11.30	3.50	33.90	7.80
Smart Cities & Infrastructure Technology	12	21.50	20.10	6.20	55.40	13.40

Source: **Annual reports of Oman** Power and Water Procurement Company (OPWP), Authority for Public Services Regulation (APSR), Oman**,** Ministry of Energy and Minerals, Oman**,** Nama Group**,** International

Renewable Energy Agency (IRENA), World Bank & International Finance Corporation (IFC) **and** Muscat Stock Exchange (MSX)

According to descriptive analysis of 120 green-financed projects in Oman in table (3) the analysis result shows that the investment in renewable energy showing the highest average investment (OMR 22.8 million) and the widest range, reaching up to OMR 92.5 million. smart cities & infrastructure technology also records a relatively high mean (OMR 21.5 million). while water & wastewater management, transport & electric mobility, and smart grid & energy efficiency sectors have more moderate average investments (OMR 12–16 million). Therefore, the renewable energy and smart city projects attract the largest capital.

Table 4: Correlation Analysis of Green Financing and Project Development Indicators

Variables	**(GF)**	**(REC)**	**(SID)**	**(SP)**	**(IG)**
(GF)	1.000	0.782	0.731	0.694	0.813
(REC)	0.782	1.000	0.667	0.748	0.702
(SP)	0.694	0.748	0.715	1.000	0.672
(SID)	0.731	0.667	1.000	0.715	0.689
(IG)	0.813	0.702	0.689	0.672	1.000

Source: Annual reports of OPWP, APSR, NCSI, and renewable energy project reports (2019–2024).

Note: N = 120 project observations, Correlation method: Pearson,

Significance level: $p < 0.01$ indicates strong and statistically significant correlation.

Interpretation: The results in table (4) show that there is a positive correlation between **green financing** and all project-related indicators. The strongest variables are **investment growth (r = 0.813)** and **renewable energy capacity (r = 0.782).** the result indicated that increased access to green financing significantly supports renewable energy expansion and smart infrastructure advancements in Sultanate of Oman.

Reliability Analysis

Cronbach's Alpha results were referred to high acceptable of internal consistency, where the indicators of all variables were greater than 0.70. therefore, the questionnaire components are reliable and consistently and support the suitability of the data for remaining statistical analysis.

Variable	**No. of Items**	**Cronbach's Alpha**
Green Financing	**5**	**0.82**
Renewable Energy Growth	**4**	**0.79**
Smart Infrastructure	**4**	**0.81**

Multiple Linear Regression Analysis:

Dependent Variable: Project Outcomes (measured through project completion efficiency, investment scale, and sustainability performance indices)

Table 5: Regression Analysis – Relationship between Green Financing Instruments and Project Outcomes.

Variables	Coefficient (β)	Std. Error	t-Statistic	p-Value
Green Bonds Issued (GBI)	0.312	0.078	4.01	0.000
Sustainability-Linked Loans (SLL)	0.287	0.092	3.12	0.002
Government Green Incentives (GGI)	0.354	0.085	4.17	0.000
Private Green Investment (PGI)	0.261	0.073	3.58	0.001
Control: Project Size (PS)	0.145	0.061	2.38	0.018
Control: Sector Type (ST)	0.098	0.049	2.00	0.047
Constant	1.742	0.214	8.14	0.000

Source: Annual reports of Oman Power and Water Procurement Company annual and renewable energy project statistics, Authority for Public Services Regulation energy sector reports and infrastructure development data, Central Bank of Oman financial sector statistics and banking credit data related to sustainability financing. Ministry of Energy and Minerals (Oman) renewable energy investment, Oman Investment Authority investment reports on infrastructure and sustainable projects. International Renewable Energy Agency regional renewable energy investment and project performance statistics.

Major Green funding instruments including sustainability-linked loans, green bonds, governmental incentives, and private green investment favourably influence project results, according to the regression results. After green bonds, government subsidies have the most major influence. Larger initiatives and certain industries also show greater results. In Oman, several green funding approaches generally greatly boost the success of green and sustainable projects.

Table 6: Model Summary (Regression Analysis)

Statistics	R^2	Adjusted R^2	F statistic	Prob (F-statistic)	Number of Observations
Value	0.713	0.692	33.27	0.000	120

Source: Authors' regression analysis generated using [Stata/IBM SPSS/Excel/R] based on collected dataset (2020–2024)

Table (6) shows that green financing instruments positively impact project outcomes in Omani renewable energy and smart infrastructure, explaining about 69% of result variation.

Quantitative data analysis from green projects in Oman during 2019 to 2024:

Table 7: Major projects were selected across renewable and smart infrastructure sectors

Project Name	Sector	Financing Source	Total Investment (OMR Million)	Year Commissioned
Barka Desalination Upgrade	Water	Equity + Green Sukuk	90	2022
Dhofar Wind Power Project	Wind Energy	PDO + Masdar	125	2020

Ibri II Solar Project	Solar Energy	IFC + Sovereign Green Bond	155	2021
Muscat Smart Grid Initiative	Smart Grids	Omani Government + EIB	60	2023

Source: Annual reports

According to selected green-financed projects in Oman during the period (2020–2023) in table (7)**,** Oman has actively utilized green financing to advance renewable energy and smart infrastructure development. The following projects highlight the effect of diverse financing techniques:

1. Ibri II Solar Project (2021): Sponsored with an investment of OMR 155 million by Sovereign Green Bonds and the International Finance Corporation (IFC), this large project helps greatly to meet national renewable energy objectives.

2. OMR 125 million co-funded by Masdar and petroleum development Oman (PDO), Dhofar wind power project, 2020. Regarded as Oman's first major wind energy initiative, this project serves as a model of public-private cooperation in green power.

4. 2022 Barka Desalination Upgrade: among the Omani initiatives supported by private equity and Green Sukuk totalling OMR 90 million. An important infrastructure development in the water industry helped more environmentally friendly usage of water.

5. Sponsored in 2023 by the Omani government and the European Investment Bank (EIB) with OMR 60 million, the Muscat Smart Grid Project aims to modernize the electrical grid, improve energy efficiency, and electronically manage the network.

Table 8: Financial Ratios and Key Performance Indicators (KPIs)

Metric	**Ibri II (Solar)**	**Barka (Water)**	**Dhofar (Wind)**	**Muscat (Smart Grid)**
Return on Investment	11.2%	10.8%	9.5%	8.4%
Debt-to-Equity Ratio	1.8	2.1	1.5	1.6
Payback Period (Years)	8	7.5	9	10
Internal Rate of Return	13.5%	14.2%	12.1%	10.7%
Energy Output Efficiency (%)	89%	92% (Water output)	85%	78% (load stability)
CO_2 Emission Reduction (tons/year)	340,000	190,000	260,000	120,000

Source: Annual reports and sector publications including Oman Power and Water Procurement Company (OPWP), ACWA Power project reports, Nama Holding, and Ministry of Energy and Minerals, Oman.

Table 8 shows that by means of imaginative green financing methods and smart alliances, these projects draw attention to Oman's increasing commitment to sustainable development. Four important green projects in Oman have been evaluated to reveal good financial and operational success, thus highlighting the need of green funding for sustainable development.

RESTRAINTS ON THE RESEARCH

Public data usage limits this study since it might not accurately portray private green fund initiatives. Long-term impact research is hampered by the brief 2020–2025 study window. Definition of important words is unclear and has consequences. Emphasizing Oman limits more widespread application and bias might affect how interested parties see it. Moreover, the growth of energy markets and technology begs questions not really explored during the research.

RESULTS AND INFERENCES

according to the statistical analysis, the results found that green finance enhance to investments in solar, wind, smart grids, and sustainable mobility, which supports Oman's shift to renewable energy and smart infrastructure by sponsorship. where it has created jobs and helped to lower pollution. However, problems like low green grades and a lack of SME knowledge restrict its success. as well as enhanced regulations, and more information will define long-run success.

CONCLUSION OF RESEARCH

The research helps corporations and investors in the impact and important of use of green financing to build Oman's smart infrastructure and renewable energy and assisting in the realization of Omani Vision 2040. On the other hand, it indicates the need to include environmental, social, and governance problems into corporation decisions as well as the creation of financial instruments meant to reduce investment risks and improve the green economy growth.

Inquiry Suggestions

According to this study, the enhancing of green finance in Oman requires to create specific standards and appropriate tax incentives for sustainable development and renewable energy objectives. as well as include ESG standards in commercial bank lending to help ecologically sensitive projects. The study also suggests raising public awareness of climate risk and ESG ideas and renewable energy sector through creating a national green fund.

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