Journal of Contemporary Business and Economic Studies Vol.(09) No.(01) (2026)

The Role of Artificial Intelligence in Enhancing Green Finance to Support the Renewable Energy Sector in Saudi Arabia

Loqman Mazouz [1♦] , Naglaa F. Fahim [2]

[1] Imam Abdulrahman Bin Faisal University (Saudi Arabia). lmazouz@iau.edu.sa
ORCID: https://orcid.org/0000-0001-9867-9311

[2] Mansoura University, (Egypt). Naglaa.Alrefaeiii@gmail.com
ORCID: https://orcid.org/0009-0007-9617-7597

Received: 13/07/2025 **Accepted: 09/11/2025** **Published:20/01/2026**

Abstract:

This study aims to analyze the impact of women's empowerment in entrepreneurship on the sustainability of small and medium-sized enterprises (SMEs) during major global economic crises. It focuses on three key cases: the 2008 global financial crisis, the COVID-19 pandemic, and the 2022 energy crisis. This study addresses the role of artificial intelligence in enhancing green finance as a strategy to support the renewable energy sector in Saudi Arabia from 2019 to 2024. Within the framework of Vision 2030, which focuses on environmental sustainability and diversifying energy sources, the study explores how AI technologies contribute to improving the efficiency of green finance and accelerating investments in renewable energy. The study employs an analytical approach based on the least squares methodology to analyze the relationship between relevant variables. The dependent variable is the growth rate of renewable energy, while the independent variables include the growth rate of per capita GDP, the AI readiness index, and average oil prices. The data analysis relies on official sources, such as the International Monetary Fund and the World Bank, as well as Saudi national statistics. The results indicate that artificial intelligence shows a positive relationship with renewable energy development, although its statistical significance remains limited in the short term. The model also demonstrates strong explanatory power, with an R-squared value of 78%. At the same time, oil prices show a modest positive impact, while the growth of per capita GDP exhibits a negative effect, indicating that income increases are still inconsistent with sustainable consumption behaviors in the Kingdom. The study concludes that although artificial intelligence has not yet become a dominant force, it holds significant potential as a tool to enhance green finance strategies. Based on these findings, the study recommends developing a national AI infrastructure dedicated to green finance, integrating AI into regulatory and policy frameworks, expanding green financial instruments, and promoting regional and international collaboration. Future research should also explore the long-term effects of integrating AI into sustainable finance across multiple timeframes and diverse indicators to support effective policymaking in the Kingdom's transition to a green economy.

Keywords: Green finance, renewable energy, artificial intelligence, Vision 2030, sustainable development, environmental sustainability.

♦ **Corresponding author.**

1- Introduction:

Artificial intelligence is considered a new variable that has the potential to bring about a radical transformation in development fields by automating tasks, improving decision-making processes, and enhancing innovation. AI contributes to the development of new technological solutions and provides effective means for environmental preservation and achieving sustainability. Therefore, investing in research, development, and innovation in the field of artificial intelligence is vital for supporting the national economy. The importance of AI and its technologies has increased recently, as its vast potential can impact various sectors of the economy, particularly in the financial sector and the renewable energy sector (Fadly, 2023).

In this context, the International Energy Agency confirms (Energy and AI Report, 2025), that the effectiveness of artificial intelligence technologies primarily depends on the availability of energy. Despite the significant progress made by these modern technologies due to the substantial increase in data and technological advancements, which have made them an integral part of development strategies, artificial intelligence cannot operate without energy. Moreover, artificial intelligence has the potential to bring about radical changes in the energy sector. As part of the focus on using digital technology and modern techniques to support the transition to a diverse, prosperous, and sustainable economy, Saudi Arabia is committed to promoting green technology as a fundamental part of its ambitious Vision 2030. This commitment aims to reduce reliance on oil and fossil fuel sources, while emphasizing environmental issues and enhancing sustainability, thereby creating a favorable environment for innovation and practices that support sustainable development. This is being achieved through the application of environmentally friendly technologies across all sectors, with the goal of attracting green investments and stimulating the growth of the green technology market. In this context, the Saudi Green Initiative, launched by the government in 2021, is a significant step towards achieving these goals. This initiative includes objectives that promote sustainable growth, support energy security, and contribute to reducing carbon emissions, making it one of the most prominent outcomes of the Kingdom's efforts to achieve the sustainable development goals of Vision 2030 (Research and Market, 2025).

The importance of green technology is reflected in its ability to enhance many sustainable development goals, making it present in various fields, most notably in the finance and investment sector. When modern technologies are applied in this area, it becomes essential to integrate financial objectives with environmental goals (Khalaf, 2024). Hence, the significance of using artificial intelligence technology in promoting green finance emerges, contributing to energy security and the development of the renewable energy sector to achieve sustainable development goals. Based on that, the research problem lies in the pursuit of an answer to the question: What is the impact of using artificial intelligence in stimulating green finance and enhancing its efficiency to support the renewable energy sector in Saudi Arabia?

1- Significant of Study

This study gains its significance from addressing three main axes that are considered essential elements for achieving sustainable development in all countries, which represent prominent global trends at present. These axes include: the transition to renewable energy and enhancing energy security to combat climate change, increasing reliance on artificial intelligence technologies across various economic and financial sectors, and finally, green financing through green bonds and its role in supporting sustainable development goals, with a focus on its application in the Kingdom of Saudi Arabia. The study reviews these three axes in the context of green technology and its importance in enhancing green financing tools to support the renewable energy sector, benefiting from the innovations provided by this modern technology.

2- Study Objectives

This study contributes to filling the knowledge gap in the scientific literature, given the scarcity of research addressing the relationship between artificial intelligence and green finance in supporting energy security goals in the Saudi context. Accordingly, the study aims to achieve the following objectives:

1. Analyze the concept of artificial intelligence and its role in developing green finance tools.
2. Examine the status of green finance in the Kingdom of Saudi Arabia and the progress made in supporting the renewable energy sector through it.
3. Explore the applications of artificial intelligence in evaluating and financing green projects, with a focus on the Saudi context.
4. Identify the challenges and opportunities associated with using artificial intelligence to stimulate investment in renewable energy through green finance tools.
5. Propose practical mechanisms to enhance the integration of artificial intelligence technologies and green finance to support sustainable development goals in the Kingdom.

3- Study Hypotheses:

Hypotheses of Study, they are based on testing the following points:

1. There is a statistically significant relationship between the use of artificial intelligence techniques and the increase in the efficiency of green financing. Therefore, artificial intelligence can contribute to improving investment decision-making processes in renewable energy projects supported by green financing. Additionally, AI applications can help reduce the risks associated with financing renewable energy projects compared to traditional methods.

4- Artificial Intelligence and Environmental Sustainability Goals: Concept and Importance

4.1The Concept of AI.

Artificial intelligence is considered one of the most advanced branches of computer science, as it refers to the ability of systems to simulate human intelligent behavior by performing tasks that require cognitive skills such as learning and decision-making. UNESCO defines artificial intelligence as systems that interact with their environment and operate in ways that mimic human intelligence. The Council of Europe also noted that it includes systems that operate independently to perform tasks requiring human intelligence. It is also defined as the ability of programs to execute cognitive functions associated with the human mind. These definitions make it clear that artificial intelligence is an advanced cognitive system that is reshaping the nature of work and human interaction with technology, making it a key element in sustainable development and digital transformation. (UNESCO, 2021; Council of Europe, 2024).

4.2Artificial Intelligence and Green Sustainable Energy.

The International Energy Agency (Energy and AI, 2024) emphasizes the close relationship between artificial intelligence and the energy sector. AI applications are used to enhance energy consumption efficiency, support innovation, and reduce operating costs, thanks to their ability to provide accurate weather forecasts and generate energy quickly without waste. They also contribute to improving solar and hydroelectric power production, as well as developing new battery configurations used in processes. Therefore, artificial intelligence is considered a vital element in optimizing traditional energy systems and promoting innovation in clean energy technologies. According to (Gölnar, 2025), Artificial intelligence is a modern technology that enhances energy production processes by providing accurate analyses of climate forecasts and maintenance operations. It relies on big data and advanced algorithms to improve the management and efficiency of energy networks, predicting patterns of solar and wind energy generation, which facilitates the management of their fluctuations. Both traditional and renewable energy sources benefit from artificial intelligence in identifying shortcomings and forecasting loads, thereby improving production and transmission efficiency. In this context, Saudi Arabia needs to adopt artificial intelligence technologies in the energy sector to enhance economic diversification and reduce reliance on fossil fuels. According to (Al-Harbi, 2025) perspective, the importance of artificial intelligence goes beyond merely improving the efficiency of energy production and consumption and enhancing operational efficiency; its fundamental significance lies in achieving environmental sustainability through the innovative tools it relies on, which include not only big data, machine learning algorithms, and predictive accuracy in climate-related analytics, maintenance, and production, but also geological analytics.

In this regard, a study conducted by Deloitte indicates that artificial intelligence can increase the chances of locating hydrocarbons by 10%, thereby enhancing productivity and reducing environmental impacts. Machine learning can also be used to discover patterns in seismic data, which helps allocate resources more effectively. Furthermore, artificial intelligence technologies can automate drilling operations and inventory management, reducing the need for human labor in routine tasks and allowing workers to focus on more complex activities. This enhances operational efficiency, lowers labor costs, and improves safety outcomes.

4.3 Artificial Intelligence and Green Sustainable Finance.

Sustainable finance has emerged as a response to global trends calling for commitment to initiatives and practices aimed at reducing carbon emissions, within the framework of the Paris Agreement of 2015. A study by (Ali et al. 2024) reveals that developments in technological innovations, which have played a crucial role in the recent emergence of fintech, have significantly contributed to the enhancement of green finance. This is achieved through the use of data analytics to achieve positive environmental outcomes and support sustainable development. Data-driven sustainability in the field of green finance has witnessed a gradual integration of technology, environmental awareness, and financial creativity. In this context, green finance is considered a set of financial instruments whose proceeds are used for sustainable development projects and environmental products. Green bonds have recently emerged as one of the most viable and beneficial options compared to traditional bonds for financing clean and sustainable projects.

On the other hand, (Li et al. 2025) argue that the role of green finance as a key driver for enhancing renewable energy remains insufficiently clear. This is due to the mechanisms through which green finance tools, such as green bonds and investments in energy projects, interact, as well as how carbon markets operate, particularly in emerging countries, where financial markets are often less developed and stable. These countries face greater challenges in understanding the effectiveness and efficiency of green finance in developing sustainable energy alternatives. However, the research emphasizes the effectiveness of green bonds as key financing tools for renewable energy projects, providing investors with a reliable means to support sustainable development goals. It also demonstrated that green investments in renewable energy yield financial and environmental benefits, attract a broader range of capital, and promote sector growth. From this perspective, the importance of integrating artificial intelligence models with financial data emerges to uncover the key factors driving GDP growth by identifying the elements that enhance green finance, improve investment options in renewable energy, and accelerate environmental progress.

Regarding to (Srivastava. V., 2024), it emphasizes that integrating artificial intelligence into the green economy contributes to promoting sustainable business practices by aligning corporate profits with social and environmental responsibilities. Financial institutions can achieve community benefits and create a sustainable environmental impact by using artificial intelligence to enhance data analytics, support risk management, and improve decision-making processes in line with sustainability goals.

(Ramzani, et al, 2025), concluded that artificial intelligence is a fundamental element in enhancing energy security and supporting the green economy, as it contributes to achieving financial and environmental benefits for the national economy. From this perspective, the importance of green investment in addressing climate issues and promoting sustainable financing is increasing. Artificial intelligence is an effective tool for supporting decision-making processes and managing financial risks, which helps accelerate the adoption of sustainable practices by balancing corporate profit motives with social and environmental responsibilities. Furthermore, artificial intelligence enables financial institutions to leverage its capabilities to improve data analytics and enhance risk management related to financing, in addition to developing the necessary decision-making processes to support sustainability goals. Consequently, financial institutions can achieve rewarding returns in parallel with their sustainability objectives.

5- The reality of renewable energy in Saudi Arabia and the need for green financing.

5.1 The evolution of the renewable energy market in Saudi Arabia.

The vision of the Kingdom of Saudi Arabia to support sustainable development goals is primarily based on renewable energy sectors and reducing reliance on traditional energy sources. This aligns with the global transformation in energy markets, which is influenced by international pressures to combat climate change and mitigate the significant increase in carbon emissions. (Saleem et al. 2025) indicate that the Kingdom possesses many important assets and opportunities in the field of renewable energy, such as its desert terrain and abundant solar energy. The Kingdom has placed significant emphasis on electric power, witnessing notable developments since 2010, which have facilitated the transition to a more advanced phase focused on establishing power generation plants from renewable sources, in addition to harnessing wind energy.

According to the General Authority for Statistics, the amount of electricity generated from grid-connected renewable energy projects in 2022 was approximately 2,520 gigawatt-hours annually, with solar energy projects accounting for the largest share at 84.84%, totaling a capacity of 12,313 megawatts. Meanwhile, wind energy projects constituted 15.16% with a total capacity of 2,200 megawatts (GAS, 2022). The annual statistical report on renewable energy also indicated that the contribution of renewable energy to electricity generation is expected to reach about 5% by 2025. In this context, the latest data released by (GAS, 2025) suggests forecasts of an average annual increase in electricity consumption in the Kingdom of 3.3% during the period from 2025 to 2027.As for wind energy capacity, it reached approximately 403 gigawatts, while solar energy capacity increased from 2.286 gigawatts in 2024 to 4.340 gigawatts in 2025 (IRENA, 2025). According to (Attaqa,2024), the Kingdom enjoys one of the highest solar radiation rates in the world, reaching 3,240 hours annually, in addition to significant potential for coastal wind speeds ranging from 6 to 8 meters per second.

According to (Attaqa,2025), despite the dominance of fossil fuels in the electricity generation mix in Saudi Arabia, the share of oil in this mix is expected to decline to 20% by the end of 2027, compared to over 40% in 2023. This is part of the Kingdom's plan to expand its reliance on clean energy sources. The Kingdom also aims to eliminate the use of liquid fuels in the electricity generation mix by the end of 2030, with the mix being divided into 50% gas and 50% renewable energy (Attaqa, 2024), focusing on solar, wind, and hydrogen energy (Islam et al., 2024).Studies by (Ben Jennan & El Kharmany ,2024) indicate that hydrogen energy, particularly green hydrogen, has gained significant attention in the Kingdom, as it is considered one of the key pillars for the transition to renewable energy. Green hydrogen is produced through the process of electrolysis, which primarily relies on renewable energy sources such as solar and wind energy.

Although hydropower is included in the sustainable development plan of the Kingdom's Vision 2030, along with ambitious efforts to transition away from traditional energy sources and increase innovation in the energy sector, it is not widely used in the Kingdom due to the scarcity of freshwater. However, its inclusion in the Kingdom's energy policy is deemed essential to ensure energy storage and sustainability. According to statistics from (Mordor Intelligence ,2024), the size of the renewable energy market in the Kingdom is estimated to be around 8.33 gigawatts in 2024, and this figure is expected to rise to 23.74 gigawatts by 2029, with a compound annual growth rate of 23.30% during the period from 2024 to 2029.Regarding government efforts in renewable energy, the Kingdom has connected renewable energy projects with a capacity of 2,100 megawatts to the national electricity grid since 2022 (Stats, gov. sa, 2022), bringing the total capacity to 2,800 megawatts, which is sufficient to power over 520,000 homes. Studies indicate that the production capacity of renewable energy projects under construction will exceed 8 gigawatts by the end of 2023, with additional projects totaling approximately 13 gigawatts at various stages of development. As part of its efforts to transform the national energy mix, the Kingdom has launched several projects aimed at reducing reliance on liquid fuels and replacing them with gas for electricity generation.

As of December 2023 (SGI, 2023), four high-efficiency gas power plants have been commissioned, with a total capacity of approximately 5,600 megawatts. Carbon capture and storage facilities have also been established, with a total capacity of around 8.4 gigawatts. On December 4, 2023, the Kingdom announced a 300% increase in the share of renewable energy within the energy mix. During the Saudi Green Initiative Forum held concurrently with the 28th Conference of the Parties, it was revealed that over 80 initiatives have been implemented in the public and private sectors, with investments exceeding 705 billion riyals, equivalent to 18 billion US dollars. As part of its sustainability goals, Saudi Arabia aims to reduce carbon emissions by 278 million tons annually by 2030, by decreasing reliance on fossil fuel sources and achieving a balanced energy mix, with the share of renewable energy increasing to 50% by the same year. This will contribute to replacing nearly one million barrels of equivalent fuel currently used, helping to achieve the primary goal of reaching net-zero emissions by 2060.

5.2 The size of green investments in renewable energy projects in Saudi Arabia.

According to (Al-Tamimi et al. ,2023), Saudi Arabia has been focusing on investing in green energy projects and developing renewable energy sources since 2017. The National Renewable Energy Program was announced with the aim of enhancing the local renewable energy market in accordance with the highest international standards. The first step in this program was to activate local sources for the production of renewable and sustainable energy, with a plan to generate 9.5 gigawatts of renewable energy by 2023, in addition to a future goal of producing approximately 200 gigawatts in line with the Kingdom's Vision 2030.The King Salman Renewable Energy Initiative was also launched in 2016, aimed at boosting renewable energy production and supporting the development of solar and wind power plants (SGAVO, 2025). In 2020, the Kingdom inaugurated the Sakaka Solar Power Plant in the Al-Jawf region, which utilizes the latest photovoltaic technology to generate electricity from sunlight, with a capacity of up to 300 megawatts and an investment of 302 million USD (Attaqa, 2024). The plant spans an area of 6 square kilometers and contains over 1.2 million solar panels. The Sakaka Solar Power Plant has achieved record figures in the solar energy sector, with a cost of electricity production at 0.023 USD per kilowatt-hour. The plant also provides clean electricity to approximately 55,000 homes and contributes to reducing carbon emissions by 530,000 tons annually (Vision 2030, Government of Saudi Arabia). The Dumat Al-Jandal Wind Power Project is one of the most prominent renewable energy projects launched by the Kingdom in 2022, as part of the National Energy Program that began in 2019. The total investment cost for the Dumat plant is approximately 1.876 billion USD, and the plant includes 99 turbines with a total capacity of 400 megawatts, contributing to providing energy for around 70,000 homes. The Dumat plant has set a record by achieving the lowest cost of electricity production, at approximately 0.0199 USD per kilowatt-hour. This project is considered an important step towards achieving the Kingdom's goal of increasing the contribution of renewable energy to about 50% by 2030 (Vision 2030, Saudi Government).

In 2021, the NEOM Green Hydrogen Project was launched, a partnership between ACWA Power, Air Products, and NEOM, aimed at establishing the largest green hydrogen plant in the world to produce green ammonia by 2026. The project's estimated value is $8.4 billion, with $6.1 billion in funding from 23 banks and financial institutions. In 2023, NEOM Green Hydrogen Company announced the closure of financing for the project, having signed agreements with Air Products worth $6.7 billion. The project will rely on 4 gigawatts of solar and wind energy to produce 600 tons per day of carbon-free hydrogen. The financing received certification from S&P Global for its commitment to green loan principles (NEOM, 2023).

According to Al Riyadh (Arab News, 2024), the Public Investment Fund allocated approximately $457 million in 2024 for several green projects, including about $19.4 billion for 91 projects in the fields of renewable energy and clean transportation. Regarding the green bonds issued by the fund between 2022 and 2023, it announced in its report released on June 30, 2024, the allocation of an investment portfolio exceeding $19.4 billion for eligible green projects, of which about $8.5 billion is designated for the issuance of green bonds, which will be directed towards several projects, including around 18 ongoing projects in the renewable energy sectors. Saudi Arabia aims to produce 58.7 gigawatts of renewable energy by the end of the decade, including 40 gigawatts from solar energy, 16 gigawatts from wind energy, and 2.7 gigawatts from concentrated solar power, as part of its strategy to diversify energy sources and reduce dependence on fossil fuels (Arab News, 2024). In support of this, the Minister of Energy announced in 2024 plans to launch new projects with a capacity of 20 gigawatts annually, which could raise the total to 100-130 gigawatts by 2030.

In June 2023, the Saudi Electricity Company signed agreements for new solar power projects with a capacity of 5.5 gigawatts, including the Heddan plant and the Al-Muwayh project (each 2000 megawatts) and the Al-Khashabi project (1500 megawatts). Currently, there are operational plants such as the Sakaka plant (300 megawatts), Rabigh plant (400 megawatts), and Jubail 3B plant (45.5 megawatts). There are also future projects in planning, such as the Al-Saadawi plant (2000 megawatts), the Sudair project (1500 megawatts), the Al-Masai plant (1000 megawatts), and the Al-Rass plant (700 megawatts).In 2023, Saudi Arabia achieved a significant milestone by commencing commercial operations for the first phase of the Sudair Solar Power Plant, which is considered one of the largest solar power plants in the world and the largest in the renewable energy sector in the Kingdom. The plant has a production capacity of approximately 1500 megawatts, enabling it to provide clean electricity to around 185,000 residential units, and was established with an investment cost of $924 million. The Jeddah plant is also scheduled to start operations in 2022 with a production capacity of 300 megawatts, in addition to the Al-Qurayyat photovoltaic solar power plant with a capacity of 200 megawatts (Attaqa, 2024).

As part of Saudi Arabia's efforts to increase renewable energy production by 50% by 2030 and achieve the goal of net-zero carbon emissions by 2060, the green financing strategy in the renewable energy sector relies on issuing green bonds as a key means to support clean investments. The Public Investment Fund achieved a remarkable milestone in 2022 by issuing the world's first 100-year green bonds, contributing to the diversification of funding sources and stimulating green investments, thus becoming the first green bond issued for a 100-year term. According to Reuters, the Public Investment Fund received purchase orders worth $17.85 billion for these green bonds. In 2025, the Kingdom achieved a new qualitative milestone in the Middle East and North Africa by issuing the first euro-denominated green bonds worth €1.5 billion, in collaboration with JP Morgan (PIF, 2025; The Saudi Standard, 2025; Morgan, 2025).

Despite the significant progress made by the Kingdom of Saudi Arabia in adopting strategies that support sustainable development goals, in line with Vision 2030—which includes launching major projects and providing substantial investment funding through green financing tools—achieving climate and sustainability goals still faces challenges related to the efficiency of resource allocation and the assessment of environmental and financial risks associated with green projects. The Kingdom still relies on traditional energy sources, such as fossil fuels and coal, in its production and export operations.

In this context, (Al-Tamimi et al. ,2023) clarified that the Kingdom's strategy towards economic diversification, resulting from its heavy reliance on traditional energy sources for decades, has driven it to invest in renewable energy, especially with the increasing demand for it. Consequently, the Kingdom launched the National Renewable Energy Program in 2017, aiming to rely on clean energy sources and achieve the highest international standards. However, the problem persists due to a lack of sufficient studies and research on risk and benefit assessments for investing in renewable energy sectors in the Kingdom, particularly in light of weak infrastructure and high investment costs. (Ben Jennan & El Kharmany, 2024) emphasized that the transition to clean energy in the Kingdom faces a range of challenges at both local and international levels. Among the most prominent of these challenges are the high costs of modern technologies necessary for generating renewable energy, as well as technological difficulties and a lack of specialized technical expertise. Geopolitical changes and the resulting tensions also negatively impact supply chains. Furthermore, there are technological gaps related to technological advancement and financing mechanisms between countries, hindering the Kingdom's ability to adopt and implement innovative solutions in the field of transition and investment in renewable energy. Nevertheless, there are notable efforts from the Kingdom to develop this sector. In this context, the International Energy Agency (iea, 2024) indicated that global investment in energy is expected to exceed $3 trillion for the first time in 2024, with approximately $2 trillion allocated for investment in modern clean energy technologies and infrastructure. It is essential to pay greater attention to green financing mechanisms, especially in light of the significant rise in financing costs that hinder some green investments as the era of cheap financing comes to an end. Therefore, the International Energy Agency suggested alleviating pressures on supply chains for emerging and developing countries, in addition to reducing the costs of solar panels by nearly 30%, a measure that has been implemented since 2022. The prices of essential metals needed for energy transitions have also decreased. The agency warned of imbalances in energy investment flows, particularly given the insufficient investments in clean energy in the markets of emerging and developing countries.

6- Data and Analysis

In this section, the standard model for estimating the impact of artificial intelligence on enhancing green finance as a means to support the renewable energy sector in Saudi Arabia during the period from 2019 to 2024 will be presented. The following hypotheses will be tested:

- H0 hypothesis: There is no significant impact of artificial intelligence on renewable energy in Saudi Arabia.
- H1 hypothesis: Artificial intelligence has a positive and significant impact on renewable energy in Saudi Arabia.

Accordingly, the steps related to the model will be implemented as follows:

1- **Data description,** where Table (1) specifies the model variables, the automatic distributor, and the model designer, as shown below:

Table (1)

Ref.	Definition	Symbol	Variable
)Sharif et all,2023(	Renewable energy (% of primary energy supply)	RGE	Green Energy
IMF Data, 2023	AI Preparedness Index (Index)	AI	Artificial Intelligence
World Bank Data, 2024	Annual percentage growth rate of GDP per capita based on constant local currency	GDP G_t	GDP Per Capita
(Statista, 2025	Crude oil price refers to the cost of a barrel of crude oil, a key global commodity. It's influenced by various factors including global supply and demand, geopolitical events, and the cost of transportation. It is typically quoted in US	Oil price	Average annual Brent crude oil price

	dollars per barrel.		

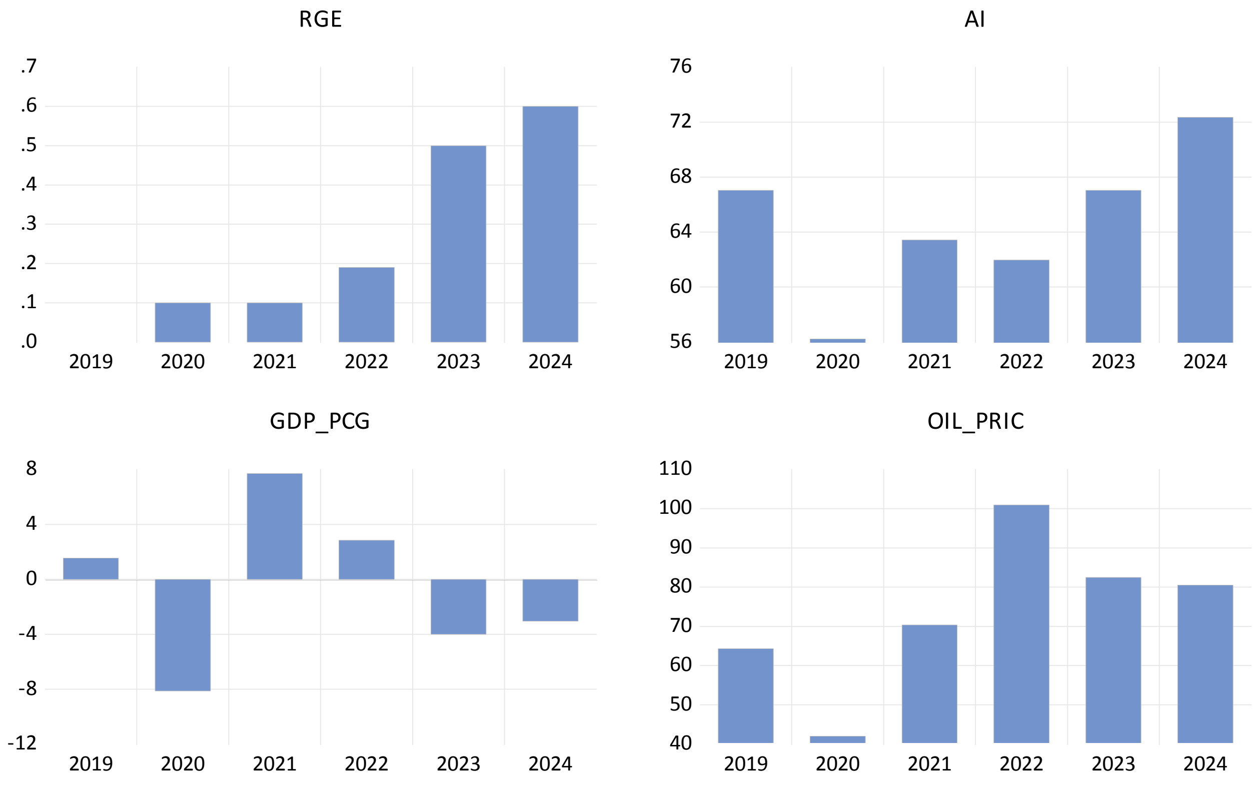
Source: Author's own elaboration based on data from the World Bank, 2023; IMF, 2023; Statista, 2025).

- **Description of the model equation:**

$$RGE_t = \alpha + B_1 AI_t + B_2 GDP\,G_t + B_3 Oil\,Pric_t + E_t.$$

2- The time series chart, where a variation between the study variables is evident; some exhibit volatility while others show an increasing trend, similar to the dependent variable.

Figure (1): The chart of the study variables.



Source: Data compiled and calculated by the researchers using EViews 12 .

3-Descriptive statistics of the model, where statistical characterization of the data is relied upon to understand the nature and characteristics of the study variables; appropriate descriptive statistics will be used here, such as the mean, which is one of the measures of central tendency, and the standard deviation, which represents one of the measures of dispersion, as well as the minimum and maximum values, in addition to graphical representations. This is illustrated in Table (2).

Table (2): Descriptive summary statistics

	RGE	AI	GDP_PCG	OIL_PRIC

Mean	0.248333	64.67500	-0.517515	73.42333
Median	0.145000	65.23000	-0.753380	75.43000
Maximum	0.600000	72.36000	7.696928	100.9300
Minimum	0.000000	56.23000	-8.130752	41.96000
Std. Dev.	0.243345	5.486528	5.648473	19.85679
Skewness	0.568465	-0.190951	0.122753	-0.280480
Kurtosis	1.648670	2.302620	1.944308	2.421722
Jarque-Bera	0.779675	0.158047	0.293690	0.162271
Probability	0.677167	0.924018	0.863428	0.922069
Sum	1.490000	388.0500	-3.105089	440.5400
Sum Sq. Dev.	0.296083	150.5100	159.5263	1971.461
Observations	6	6	6	6

Source: Data compiled and calculated by the researchers using EViews 12 .

The correlation matrix, as shown in Table (3), includes the zero-order correlation analysis between the variables of the study model, utilizing bivariate correlations. These correlations allow us to conduct a preliminary check of the assumed relationships. Upon reviewing the results in the table, several interesting findings can be observed.Regarding the correlations between the independent variables and green renewable energy in Saudi Arabia, it appears that some align with economic theory. For instance, the correlation of the artificial intelligence index with renewable energy is positive, which is consistent with this theory. Additionally, the correlation coefficient of oil prices with renewable energy is also positive, reinforcing the first finding. However, the correlation between growth in real GDP per capita and renewable energy was negative, which contradicts the previous result.

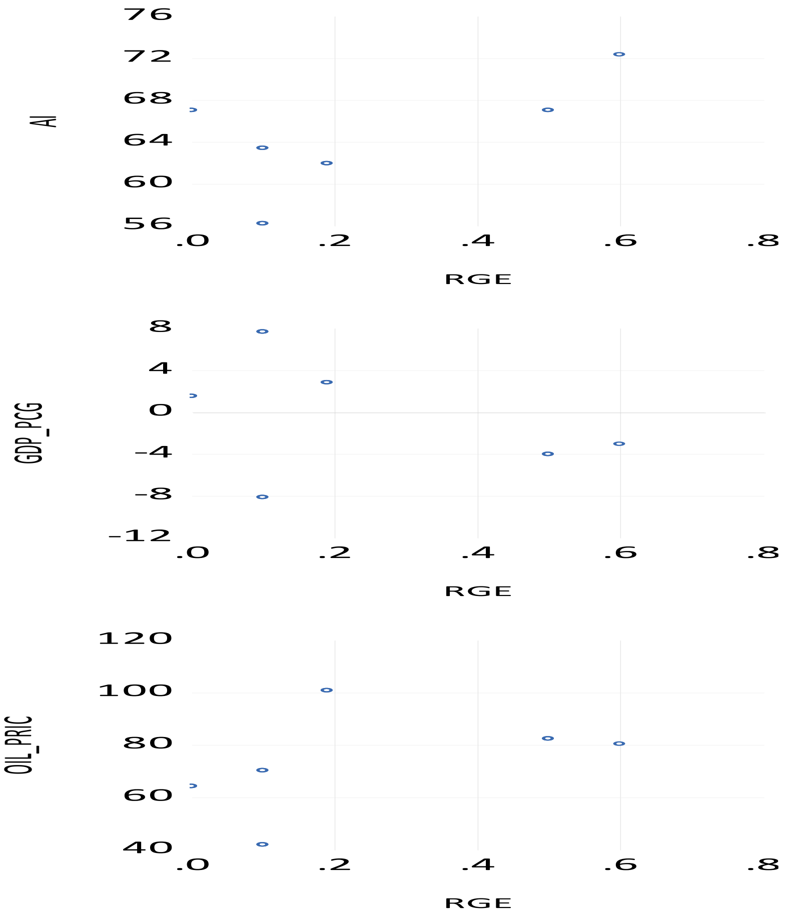
Table (3):Correlation matrix between study variables.

	RGE	AI	GDP_PCG	OIL_PRIC
RGE	1	0.6452838901133448	-0.3731959632286875	0.4367894359314756
AI	0.6452838901133448	1	0.1422077323909087	0.4573358157820995
GDP_PCG	-0.3731959632286875	0.1422077323909087	1	0.4250771935925054
OIL_PRIC	0.4367894359314756	0.4573358157820995	0.4250771935925054	1

Source: Data compiled and calculated by the researchers using EViews 12 .

Accordingly, the form of dispersion can be represented as follows:

Figure (2)



Source: Data compiled and calculated by the researchers using EViews 12 .

4- **Estimation of Ordinary Least Squares (OLS)**: The results showed that the coefficient of determination (R-squared) reached a high percentage of 78%. This means that the independent variables explain about four-fifths of the variations in the dependent variable, while the remaining 22% is attributed to other variables not included in the model. The model also demonstrated insignificance, with a Fisher statistic (F-statistic) value of 2.439451 and a p-value of 0.303997. The Durbin-Watson statistic recorded a value of 1.639515, indicating no serial correlation problem among the errors. It was confirmed that there is no issue of heteroscedasticity among the study variables, as shown in Table 4. Regarding the impact measurement, it was found that there is a positive effect of the Government Readiness for Artificial Intelligence (AI) index, with a parameter value of 0.023087. This means that every 1% increase in government readiness corresponds to a 0.02 increase in renewable green energy. However, the p-value was insignificant, exceeding 5% at 0.2939. The effect of crude oil prices (OIL_PRIC) also showed a positive value of 0.005816, and the p-value was also insignificant, exceeding the significance level of 5% at 0.3607. This indicates that a 1% increase in oil prices leads to an increase in renewable energy, as Saudi Arabia heavily relies on oil to finance its expenditures, and oil wealth is a crucial factor in the development of the Gulf state. These revenues can be used to diversify the Saudi economy and enhance its capabilities in the field of renewable energy. On the other hand, the effect of growth in real GDP per capita (GDP_PCG) was negative, with a value of -0.027958. This means that a 1% growth in per capita income leads to a decline in green renewable energy by 0.02. This inverse effect is attributed to increased consumption and the lack of a culture of transition to renewable energy, in addition to the nature of consumption in Saudi Arabia, which is often considered unproductive, along with fluctuations in global oil prices.

Table (4): Estimation of the Ordinary Least Squares (OLS).

Dependent Variable: RGE				
Method: Least Squares				
Date: 06/19/25 Time: 16:15				
Sample: 2019 2024				
Included observations: 6				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
AI	0.023087	0.016373	1.410066	0.2939
GDP_PCG	-0.027958	0.015625	-1.789346	0.2155
OIL_PRIC	0.005816	0.004947	1.175659	0.3607
C	-1.686314	0.958710	-1.758939	0.2207
R-squared	0.785370	Mean dependent var		0.248333
Adjusted R-squared	0.463424	S.D. dependent var		0.243345
S.E. of regression	0.178253	Akaike info criterion		-0.376502
Sum squared resid	0.063548	Schwarz criterion		-0.515329
Log likelihood	5.129506	Hannan-Quinn criter.		-0.932238
F-statistic	2.439451	Durbin-Watson stat		1.639515
Prob(F-statistic)	0.303997			

Source: Data compiled and calculated by the researchers using EViews 12 .

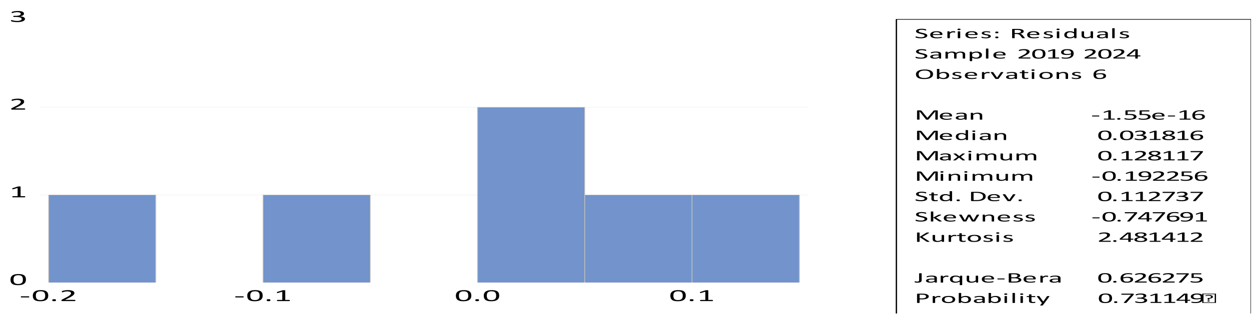
Accordingly, the equation of the current model can be represented as follows:

RGE = 0.0230868006316*AI - 0.0279580361652*GDP_PCG + 0.00581612727149*OIL_PRIC - 1.68631364831

5- The diagnostic tests for the model's quality are as follows:

5.1Normal distribution. The graph in Figure (3) shows that the estimated model follows a normal distribution. Additionally, the results of the Jarque-Bera test yielded a p-value of (0.73), which is greater than the 1% level. Therefore, the hypothesis that the residuals are normally distributed can be accepted.

Figure (3): The normal distribution of the model variables.



Source: Data compiled and calculated by the researchers using EViews 12 .

2.5Heterogeneity Test: The p-value (0.53) was higher than the significance level set at 5%, indicating that there is no issue of heterogeneity in the model. The researchers used several tests to detect the problem of heteroscedasticity, including the Breusch-Pagan-Godfrey test in this study, which recorded a significance level of (0.5327). Therefore, the hypothesis of a serial correlation in the residuals was rejected. Additionally, the calculated values of the F-statistic were lower than the critical values of (1.009149), indicating that the model is free from issues related to heterogeneity, as shown in the table (5), as following:

Table (5): Results of the Breusch-Pagan-Godfrey Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			
F-statistic	1.009149	Prob. F(3,2)	0.5327
Obs*R-squared	3.613102	Prob. Chi-Square(3)	0.3064
Scaled explained SS	0.297361	Prob. Chi-Square(3)	0.9605

Source: Data compiled and calculated by the researchers using EViews 12 .

The ARCH test was also used, which helps ensure that the model is free from heteroscedasticity, as the p-value was greater than 5%, at (0.3170).

Table (6): Results of the ARCH Homogeneity Test

Heteroskedasticity Test: ARCH			
F-statistic	1.434990	Prob. F(1,3)	0.3170
Obs*R-squared	1.617806	Prob. Chi-Square(1)	0.2034

Source: Data compiled and calculated by the researchers using EViews 12 .

Table (7), illustrates the accuracy of the mathematical characterization of the model through the Ramsey RESET test, where the significance level recorded is (0.11), which is higher than the 5% significance level. This indicates that the mathematical characterization of the model is accurate.

Table (7): Mathematical Description of the Model through the Ramsey RESET Test.

Ramsey RESET Test		
Equation: UNTITLED		
Omitted Variables: Squares of fitted values		
Specification: RGE AI GDP_PCG OIL_PRIC C		

	Value	df	Probability	
t-statistic	5.661409	1	0.1113	
F-statistic	32.05155	(1, 1)	0.1113	
Likelihood ratio	20.98841	1	0.0000	

Source: Data compiled and calculated by the researchers using EViews 12 .

Table (8), shows the results of the Variance Inflation Factors (VIF) test, where the values are less than 10 for all study variables (Farrar et al, 1967). This indicates that there is no multicollinearity among the study variables.

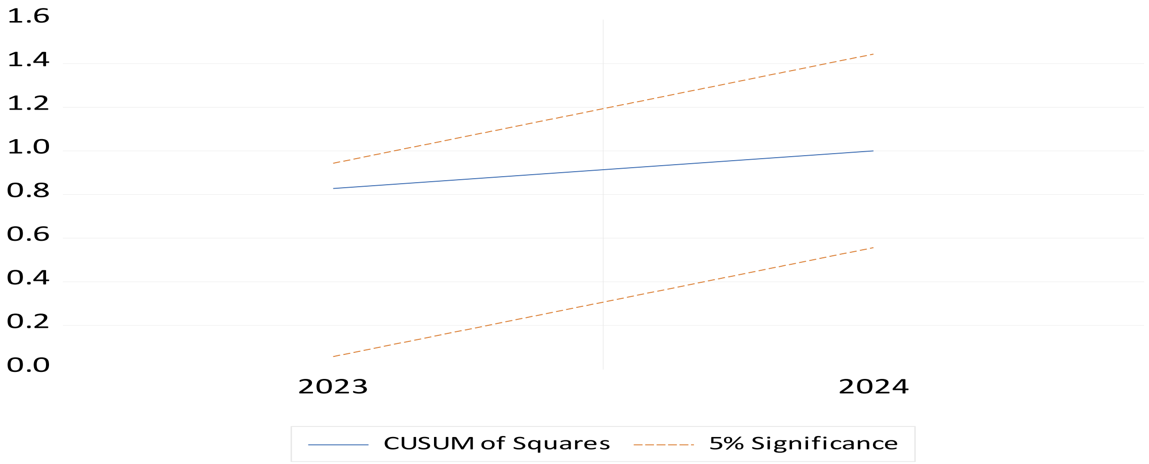
Table (8): Results of the Variance Inflation Factors Test

Variance Inflation Factors			
Date: 06/19/25 Time: 17:53			
Sample: 2019 2024			
Included observations: 6			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
AI	0.000268	213.0074	1.269811
GDP_PCG	0.000244	1.238040	1.225694
OIL_PRIC	2.45E-05	26.43287	1.518513
C	0.919126	173.5607	NA

Source: Data compiled and calculated by the researchers using EViews 12 .

5.3Structural stability test of the model: It is evident from Figure (4), that the estimated coefficients of the model used exhibit structural stability throughout the study period, indicating stability among the research variables and consistency in the model. Additionally, the graphical representation of the test statistic for this model falls within the critical limits at a significance level of 5%.

Figure (4)



Source: Data compiled and calculated by the researchers using EViews 12 .

7- Results

This section aims to estimate the impact of artificial intelligence in enhancing green financing as a mechanism to support the renewable energy sector in Saudi Arabia during the period from 2019 to 2024, using the Ordinary Least Squares (OLS) method. The following are the results:

1. The null hypothesis stating that there is no significant effect of artificial intelligence on renewable energy in the Kingdom was rejected. The alternative hypothesis, which indicates that artificial intelligence has a positive but insignificant effect on renewable energy, was accepted.
2. The results showed a positive correlation between the variables, with the coefficient of determination (R-squared) recorded at 78%. It was also found that crude oil prices have a positive effect, while growth in per capita income was negative.
3. The estimated standard models were found to be free from the problem of serial correlation among the residuals and the issue of heteroscedasticity. Normality tests indicated that the residuals are normally distributed, suggesting that the models are appropriately specified.
4. It was confirmed that there is no multicollinearity issue among the variables of the study models, using the Variance Inflation Factor (VIF) test. The test results for all variables in the study models were below the value of 10, indicating no multicollinearity problem among the study variables.

Conclusion

This study reviewed the role of artificial intelligence in enhancing green finance as a means to support the renewable energy sector in Saudi Arabia from 2019 to 2024. Through a comprehensive literature review, theoretical analysis, and empirical modeling using ordinary least squares, the results showed that artificial intelligence is positively associated with the expansion of renewable energy; however, its statistical significance remains limited in the short term. Nevertheless, the high value of the R-squared index (78%) indicates that artificial intelligence and other independent variables together explain a significant portion of the variance in renewable energy growth. The analysis also demonstrated that oil prices have a positive but modest impact on renewable energy investments, reflecting the Kingdom's reliance on oil revenues to finance green transitions. Conversely, the negative impact of per capita GDP growth suggests that economic development in the Kingdom does not yet adequately reflect environmental awareness or transformative behaviors in the energy sector, highlighting the need for cultural and institutional shifts towards sustainability. In this context, the report (EMBER, 2024) indicated that the contribution of renewable energy, including solar and wind power, to electricity production in Saudi Arabia was approximately 0.2% during 2022. The report also clarified that the Kingdom relies heavily on fossil fuels, which account for 99.8%. According to data from (Worldometers, 2022), carbon dioxide emissions in the Kingdom reached about 607,907,500 tons in 2022, representing an increase of 2.93%, or an increase of 17,325,040 tons compared to 2021, which recorded emissions of 590,582,460 tons. The per capita carbon emissions in the same year were approximately 18.89 tons, based on a population of 32,175,352. This figure reflects a slight increase of 0.04 tons from the recorded figure in 2021, which was 18.85 tons per person, indicating a change of 0.2% in carbon dioxide emissions per capita. Saudi Arabia's share of global carbon emissions is approximately 1.58%. Importantly, diagnostic tests confirmed the robustness of the model, as no issues related to serial correlation, heteroscedasticity, or multicollinearity were found, enhancing the credibility of the results. These findings indicate that while artificial intelligence may not be the primary driver at this stage, it holds significant potential to enhance the effectiveness of green finance tools, especially when integrated with broader strategies that include policy support, public awareness, and institutional alignment with the goals of Vision 2030.In conclusion, artificial intelligence should be considered an enabling force that can significantly support the transition to a green economy. To maximize its impact, Saudi Arabia should continue to invest in AI readiness, infrastructure, and green finance mechanisms such as green bonds, data-driven project assessments, and risk analyses to ensure a sustainable, resilient, and diversified energy future.

Recommendation

Based on the study's findings, there is an urgent need to enhance the institutional and technical frameworks that contribute to the effective integration of artificial intelligence (AI) within the green finance system in Saudi Arabia. To achieve this goal, it is recommended to develop advanced digital infrastructure that aligns with AI requirements by supporting research and innovation centers, strengthening partnerships between the public and private sectors, and implementing specialized training programs in AI technologies related to energy and sustainable finance. Policy integration is also considered a vital element, as national regulatory frameworks should be adopted to ensure data governance and enhance transparency, with a commitment to the ethical use of technology. Financial incentives are also recommended for institutions that apply AI in the areas of assessment, financing, and management of renewable energy projects, aiming to stimulate green innovation and support the market's transition towards sustainable financing models.in this context, the expansion of tools such as green bonds requires the integration of AI technologies in financial and environmental assessment processes, contributing to risk reduction and increasing the efficiency of attracting investments. On the other hand, regional and international cooperation represents a strategic opportunity to enhance the exchange of experiences and successful practices in using AI to support green finance and renewable energy management, especially in the context of emerging markets. In conclusion, the study recommends directing scientific research efforts towards exploring the long-term impact of integrating AI in green economy sectors through future studies that rely on longer time frames and more comprehensive quantitative and qualitative indicators, enabling the provision of accurate insights to support sustainable development policies in the Kingdom.

Regarding the development of digital infrastructure, the research emphasizes the following points:

- Establishing national data platforms for green projects by developing open-source centralized data platforms that integrate environmental, financial, and energy information, providing AI systems with reliable and high-quality datasets essential for modeling, forecasting, and decision-making in green finance.
- Digitizing financial institutions and green investment processes by accelerating the digital transformation of banks, investment funds, and regulatory bodies through the integration of AI-compatible systems, such as blockchain technology, smart contracts, and automated risk assessment tools specifically designed for green finance.
- Developing AI-ready energy infrastructure, which requires updating national energy networks and renewable energy systems using smart sensors, real-time monitoring tools, and Internet of Things devices, enabling AI to optimize energy consumption, track emissions, and assess project performance.
- Establishing specialized centers for AI in sustainable finance by creating research and innovation centers focused on the intersection of AI, green finance, and energy sustainability, while supporting collaboration between universities, financial institutions, and government entities.
- Encouraging public-private partnerships to finance and develop AI-based infrastructure aimed at sustainable financing, such as AI-driven green bond verification systems and carbon footprint monitoring platforms.
- Enhancing cybersecurity and ethical frameworks by establishing a robust cybersecurity infrastructure and ethical oversight to prevent the misuse of environmental data, ensure fairness in investment decisions, and protect sensitive financial and environmental information.
- Integrating AI into national green finance strategies as a core component of national sustainable finance strategies and action plans, ensuring institutional alignment and long-term commitment to smart green transformation.

Bibliography

- Al-Harbi. A. (2025). AI in the Energy Sector: Optimizing Oil and Gas Production and Exploring Renewable Energy Solutions in Saudi Arabia. *International Journal of Innovative Science and Research Technology*. 10(1). P. 1353- 1361. https://doi.org/10.5281/zenodo.14769392.
- AL-Tamimi. KH., Jaradat. M., & Aityassine. F. (2023). Impact of Renewable Energy on the Economy of Saudi Arabia. *International Journal of Energy Economics and Policy*. 13(3). P. 20-27. https://doi.org/10.32479/ijeep.14099.
- Ali. f., Sayal. A., Suri. P, Ahmad. V., Chauhan. A. S., &, Panwar. D. (2025). The emergence of green finance a conceptual framework for environmental sustainability: innovation viewpoint. *F1000Research*. P. 1-18. https://doi.org/ 10.12688/f1000research.157894.1.
- Ben Jennan. H. & El Kharmany. A. (2024). The Impact of Public Investment Fund Financial Behavior on Global Project Management Decisions: A Case Study of Neom. SSRN Paper. P. 1-20. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4996907.
- Council of Europe (CEO). (2024). Council of Europe Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law. Council of Europe Treaty Series. (225). P. 1-12. Available online:

https://www.coe.int/en/web/artificial-intelligence/the-framework-convention-on-artificial-intelligence.

- EMBER. (2024). Electricity Review 2024: World passes 30% renewable electricity milestone. P. 1-191.
- Farrar, D. E., & Glauber, R. R. (1967). Multicollinearity in Regression Analysis: The Problem Revisited. *The Review of Economics and Statistics*. 49(1). P. 92-107. https://doi.org/10.2307/1937887.
- Fadly. M. (2023). 4th Industrial Revolution (Artificial Intelligence... Future Opportunities and Challenges). *Al-Ahram Center for Political and Strategic Studies*, (105). P. 16-21.
- Gölnar. S. (2025). The Effect of Digital Technology Utilization for More Efficient Energy Production, Transmission and Consumption on Energy Policies. Master Thesis, The Graduate School of Natural and Applied Sciences of Middle East Technical University.
- General Authority for Statics (GAS). (2022). Renewable Energy Statics. Available online: https://www.stats.gov.sa/en/statistics-tabs?tab=436312&category=124797.
- General Authority for Statics (GAS). (2025). Renewable Energy Statics. Available online: https://www.stats.gov.sa/en/statistics-tabs?tab=436312&category=124797.
- Gov. Sa, (2025). Green Technology Adoption. Available online: https://my.gov.sa/en/content/110089#section-1.
- International Energy Agency (Iea). (2025). Energy and AI Report. P. 1-304.
- International Energy Agency (Iea). (2024). World Energy Investment. P. 1-219.
- International Renewable Energy Agency (IRENA). (2024). Renewable Capacity Statistics 2024. P.1-72.
- International Renewable Energy Agency (IRENA). (2025). Renewable Capacity Statistics 2025. P. 1-75.
- Khalf, A. A. (2024). Exploring the Effectiveness of Using Green Technology to Enhance Sustainability in Aswan. *Minia Journal of Tourism and Hospitality Research.* 17 (1). P. 158- 172. https://doi.org/10.21608/mjthr.2024.272558.1144.
- Osman, Y., Ellaythy, I., & Daghri, Y. (2024). Investigating the Effect of Digital Transformation on the Energy Sector: Saudi Arabia's Case. *Wseas Transactions on Business and Economics*, (21). P. 328-344. https://doi.org/10.37394/23207.2024.21.29.
- Li. T., Lau. W. T., & Yahya, M. H. (2025). Blockchain Applications in Green Finance for Transparency and Accountability in Sustainable Investments. *Sustainability MPDI journal*. 17(6). P. 1-20. **https://doi.org/10.3390/su17062520**.
- Puplic Investment Fund (PIF). (2025). PIF announces pricing of debut euro-denominated green bond offering. Available Online: https://www.pif.gov.sa/en/news-and-insights/press-releases/2025/pif-announces-pricing-of-debut-euro-denominated-green-bond-offering.
- Ramzani. S. R., Konhaeusner. P., Olaniregun. O. A., Abu-Alkhei. A., & Alsharari. N. Integrating. (2025). AI-Driven Green Finance Strategies for Sustainable Development: A Comparative Analysis of Renewable Energy Investments in Germany and Denmark.

European Journal of Business and Management Research. 9(2). P. 43-55. https://doi.org/10.24018/ejbmr.2024.9.2.2277.
- Research and market. (2025). Saudi Arabia Green Technology Sustainability Market Report. Available online : https://www.researchandmarkets.com/report/saudi-arabia-green-technologymarket?srsltid=AfmBOopBx1F3trIuZq5Kt6HCdPDQ2m1FR2Sbgkj4iIuKhIxjTl_g4kNP.
- Shivangi.S. (2018). An Overview on Green Technology & Its Benefits. (*JETIR*)*Journal of Emerging Technologies and Innovative Research*, *5*(8). P. 164-169.
- Srivastava. V. (2024). Ai Driven Green Finance: Challenges and Opportunities for Banks. ResearchGate. P. 1-11.
- Saleem. M., Bin-Saleem. M. T., in-Saleem. M. A., Ali.m., & Mahrous. E.N. (2025). Energy Transition in Saudi Arabia: Harnessing Solar Solutions for a Sustainable Future Renewable Energy Blend While Navigating Challenges and Capitalizing on Opportunities. *Journal of Renewable Energy and Sustainable Development (RESD)*11(2). P. 190-217. http://dx.doi.org/10.21622/RESD.2025.11.2.1319.
- Sharif A, Kocak S., Khan HHA., & Uzuner G, Tiwari S (2023). Demystifying the links between green technology innovation, economic growth, and environmental tax in ASEAN-6 countries: The dynamic role of green energy and green investment. *Gondwana Research (*115). P. 98–106. https://doi.org/10.1016/j.gr.2022.11.010.
- Saudi Data and AI Authority (SDAID). (2024). Generative Artificial Intelligence Guidelines. P. 1-20.
- SGAVO. (2025). Saudi Green Initiative. Available online: https://scavo.sa/ar/content-hub/the-green-saudi-initiative/.
- Unite Nations. (2020). Artificial Intelligence for Climate Action in Developing Countries: Opportunity, Challenges and Risks. United Nations Climate Change Technology Executive Committee. P. 1-23.
- United Nations Educational, Scientific and Cultural Organization (UNESCO). (2021). Recommendation on the Ethics of Artificial Intelligence. P. 1-44.
- Arab News, (2024). Saudi Arabia’s PIF expands green investments to $19bn across 91 projects. Available online: https://www.arabnews.com/node/2575232/business-economy.
- Arab News, (2024). How investment in solar capacity is powering Saudi Arabia’s sustainable energy future. Available online: https://www.arabnews.com/node/2576806/saudi-arabia.
- Attaqa. (2024). A notable leap in electricity generation capacity from renewable energy in Saudi Arabia. Available online: https://attaqa.net/2024/03/31. (accessed on 26 October 2024).
- Arab News. (2025). Saudi Arabia raises $2.36bn in euro bonds, including inaugural green tranche. Available online: https://www.arabnews.com/node/2591653/business-economy .

- IMF. (2024). Saudi Arabia: 2024 Article IV Consultation-Press Release; and Staff Report. Available online: https://www.elibrary.imf.org/view/journals/002/2024/280/article-A001-en.xml. (accessed on 4 September 2024).
- Morgan J.b., (2025). J.P. Morgan steps up for landmark Saudi Arabia green bond. Available online: https://www.jpmorgan.com/insights/banking/investment-banking/saudi-arabia-green-bond .
- International Monetary Fund (IMF) (2023). AI Preparedness Index. Available at: https://www.imf.org/external/datamapper/AI_PI@AIPI/ADVEC/EME/LIC/SAU?year=2023.
- Mordor Intelligence, (2024). The size of the renewable energy market in Saudi Arabia and market share analysis - trends and growth forecasts (2024 - 2029). Available online: https://www.mordorintelligence.com/ar/industry-reports/saudi-arabia-renewable-energy-market.
- NEOM, (2023). Neom Green Hydrogen Company completes Financial close at Atotal Investment value of USD 8.4 billion in the world's largest Carbon-free Green Hydrogen Plant. Available online:https://www.neom.com/en-us/newsroom/neom-green-hydrogen-investment .
- Our World in Data. (2023). Share of primary energy consumption that comes from renewable. Available online: https://ourworldindata.org/grapher/renewable-share-energy.
- Statista. (2025). Average annual Brent crude oil price from 1976 to 2025. Available online : https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/.
- Stats, gov, Sa. (2022). Renewable Energy Statistics. Available online: https://www.stats.gov.sa/en/statistics-tabs?tab=436312&category=124797.
- The Saudi Standard. (2025). PIF to Issue New 3- and 7-Year Green Bonds. Available online: https://saudistandard.com/2025/10/06/pif-green-bonds/.
- Vision 2030, gov, sa. Sakaka Solar Power Plant. Available online: https://www.vision2030.gov.sa/en/explore/projects/sakaka-solar-power-plant.
- Vision 2030, gov, sa. Dumat Al Jandal Wind Farm. Available online: https://www.vision2030.gov.sa/en/explore/explore-more/dumat-aljandal.
- Vassileve. A., (2024). Saudi Arabia's PIF allocates USD 5.2bn of green bond proceeds. Available online: https://renewablesnow.com/news/saudi-arabias-pif-allocates-usd-5-2bn-of-green-bond-proceeds- .
- WorldOmeter, (2025). Saudi Arabia CO2 Emissions. Available online at: https://www.worldometers.info/co2-emissions/saudi-arabia-co2-emissions/.(accessed on 2025).
- World Bank Data. (2024). Annual percentage growth rate of GDP per capita based on constant local currency. Available online at: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?locations=SA.