ISSN (Print): 2959-4391 ISSN (Online): 2959-4405

JOURNAL OF SOCIAL SCIENCES DEVELOPMENT

www.jssd.org.pk editor@jssd.org.pk

DETERMINANTS OF RENEWABLE ENERGY PRODUCTION: ROLE OF GOVERNANCE AND PATHWAY TO SUSTAINABLE DEVELOPMENT

Seema Ramzan[1], Bakhtawar Ghani[2] & Saba Gulzar[3]

[1]PhD Scholar, Department of Economics, Lahore College for Women University, Lahore, Pakistan

[2]PhD Scholar, Department of Economics, Lahore College for women university Lahore, Pakistan

[3]Scholar, Department of Economics, Lahore College for Women University, Lahore, Pakistan

KEYWORDS

Environmental Sustainability, Climate Change, Renewable Energy Production, Energy Security, Political Instability

ARTICLE HISTORY

Date of Submission: 04-03-2025

Date of Acceptance: 09-04-2025

Date of Publication: 12-04-2025

ABSTRACT

The global shift toward renewable energy (RE) responds to environmental concerns, particularly the excessive use of fossil fuels, which contribute to climate change and energy insecurity. It argues that producing renewable energy is crucial to reducing carbon dioxide (CO_2) emissions and ensuring stable energy supply. Therefore, understanding the key factors influencing renewable energy production (REP) is essential for successfully transitioning to sustainable energy system. This interpretation highlights importance of identifying and analyzing elements that promote the adoption and growth of renewable energy as the solution to environmental and energy security challenges. This study is based on the time series analysis for Pakistan, which uses data from 1980 to 2024. Economic variables such as GDP per capita and trade openness, along with the demographic factors like urban population, environmental variables like ecological footprints, and political variables like governance positively influence REP. The economic and demographic factors support growth of REP, environmental and energy-related variables exert opposing effects. Thus, listing renewable energy projects over other energy sources is vital for achieving stable and environmentally sustainable energy future.

Corresponding Author	Saba Gulzar
Email:	sabagulzar1994@gmail.com

DOI	https://doi.org/10.53664/JSSD/04-02-2025-01-01-12

INTRODUCTION

The worldwide imperious to confront climate change and accomplish sustainable development goals has placed natural energy sources at the forefront of energy policy and investment agendas worldwide (Hayat & Majeed, 2024). The natural energy sources such as photovoltaic energy, air energy, hydropower, Earth heat energy, and bioenergy offer a sustainable alternative to fossil fuels by harnessing natural processes that are refilled over time (IPCC, 2022; IEA, 2021). This transition is critical for minimizing GHG emissions, refining energy security and driving economic expansion while alleviating the environmental influences (REN21, 2020). The scientific consensus on climate change underscores the perseverance of accelerating adoption of renewable energy. IPCC warns Capping global temperature rise at less than 2 degrees Celsius over pre-industrial averages is vital to avoid irreversible environmental damage and mitigate effect of global warming on defenseless ecosystems and societies (IPCC, 2018). Natural energy tools show a crucial part in achieving these ambitious climate targets by displacing fossil fuels and decreasing carbon emissions in the energy zone (IEA, 2021).

Good governance is vital for unlocking the full potential of energy as engine of sustainable growth. Governance encompasses the policies, regulations, institutions, and decision-making processes that shape the deployment, integration, and scaling up of renewable energy technologies (Sovacool & Florini, 2012). The well-designed governance frameworks provide the stability, predictability, and incentives necessary to attract private sector investments, stimulate technological innovation, and enabling environment for renewable energy placement (IRENA, 2021). Governance mechanisms for renewable energy include a range of policy instruments aimed at promoting investment and market growth. These adopt feed-in payments, renewable energy standards, tax rebates, grants, and subsidies are designed to reduce financial risks and enhance the financial sustainability (IEA, 2019; DB Climate Change Advisors, 2011). Transparent and accountable governance practices ensure that renewable energy projects adhere to environmental standards, mitigate social impacts, and engage stakeholders in decision-making procedures (Sovacool & Florini, 2012). International cooperation and agreements significantly contribute to progress of renewable energy deployment on a global scale.

The Paris Agreement, established in 2015 under the UNFCCC, seeks to restrict global temperature increase to significantly below 2 degrees and to strive for the efforts to cap it at 1.5 degrees Celsius above pre-industrial levels (UNFCCC, 2015). By committing economies to NDCs and cooperative environment stroke, agreement provides a framework for scaling up renewable energy investments and accelerating the transition to sustainable energy systems globally (UNFCCC, 2015). Several main determinants influence the production, adoption, and integration of the renewable energy technologies across diverse geographical and socio-economic contexts. These determinants include the technological advancements, economic factors, political and regulatory environments, societal acceptance, and environmental considerations, each shaping the renewable energy landscape in unique ways (REN21, 2020). Technological innovation plays a crucial part in dynamic the evolution and cost competitiveness of renewable energy technologies. The advances in solar photovoltaic (PV) cells, Wind power systems, energy storage devices, along with smart grid innovations have substantially improved the effectiveness, consistency, and scalability of energy measures (IRENA, 2021; NREL, 2021).

Research and development (R&D) investments Persist in reducing the costs of energy technologies to increasingly viable with conventional energy foundations (IRENA, 2020). Economic reflections are central to Implementation and market spread of energy technologies. Financial mechanisms such as feed-in tariffs, power purchase agreements (PPAs), tax incentives, and RECs show a critical part in attracting private sector stashes and reducing financial risks associated with renewable energy projects (IEA, 2021; DB Climate Change Advisors, 2011). The declining costs of renewable energy technologies, coupled with the economies of scale and technological advancements, have bolstered the economic case for renewable energy investments and facilitated their integration into typical energy markets (IEA, 2019). Political will and regulatory frameworks are fundamental enablers of renewable energy deployment. National energy policies, renewable energy targets, and supportive regulatory frameworks provide the policy certainty and long-term planning needed to attract investments and foster market growth (Meckling et al., 2015). Regulatory actions such as emissions trading schemes, carbon pricing mechanisms, and renewable energy standards incentivize renewable energy investments and drive transition towards sustainable energy systems (OECD, 2015).

The public support and societal acceptance are crucial for overcoming barriers to energy transition deployment. The community engagement, stakeholder consultation, and addressing local concerns about visual impacts, land use, and biodiversity are essential for gaining social acceptance and ensuring successful execution of energy transition projects (Devine-Wright, 2005; Wüstenhagen et al., 2007). Building trust, transparency, and inclusiveness in decision-making processes enhance public sureness in energy transition technologies and enable their adoption as viable alternatives to fossil fuels (IRENA, 2021). Environmental sustainability is an ultimate driver of energy transition adoption and minimal water consumption compared to fossil fuels (IPCC, 2011; Gasparatos et al., 2017). However, the environmental impacts associated with energy transition deployment, such as land use changes, habitat disruption, and potential impacts on biodiversity, underline the standing of rigorous environmental assessments and mitigation measures to ensure sustainable outcomes (IPCC, 2022). Pakistan, a country with a burgeoning population and growing energy demand, faces significant challenges in ensuring energy security together with sustainability while addressing environmental concerns.

The nation heavily relies on fossil fuels, particularly natural gas and oil, for its energy needs, leading to issues of energy scarcity, environmental degradation, and economic vulnerability to fluctuating global energy prices (Government of Pakistan, 2021). In recent years, Pakistan has increasingly turned towards energy transition sources as a viable solution to diversify its energy mix, reduce greenhouse gas emissions and achieve sustainable progress goals (ADB, 2020). Geographically blessed with ample sunlight and wind resources, Pakistan holds immense potential for solar and wind energy generation (IRENA, 2021). Government has introduced various policies and initiatives to promote energy transition deployment, including feed-in tariffs, net metering schemes, and incentives for the private sector investment in energy transition projects (Government of Pakistan, 2021). The Pakistan's transition towards energy transition represents a critical pathway to realize sustainable development, addressing energy security challenges, and mitigating climate change impacts that is essential for identifying opportunities and strategies to accelerate the adoption of the energy transition technologies, contributing toward the sustainable and resilient energy future for the country.

Research Objectives

1. Evaluate the effectiveness of Pakistan current policies & regulatory frameworks governing energy transition.
2. Analyse the economic feasibility and financial mechanisms influencing adoption of energy transition projects in Pakistan.
3. Investigate the environmental impact & sustainability considerations associated with energy transition deployment in Pakistan.

LITERATURE REVIEW

The literature reveals several drivers for the deployment of energy transition in various countries, which can be grouped into four main categories: economic, political, social, and population factors. Economic factors are particularly influential. For example, study in the U.S. found that wind power development is driven by consumer demand for green energy, fluctuations in natural gas prices, and wholesale market regulations. Similarly, in China, the energy transition generation has grown exponentially with increasing income and employment levels. Research covering 46 developed & developing countries also shows that rising oil prices and financial development positively affect the share of non-hydro energy transition in electricity generation. Despite this, the impact of GDP per capita on energy transition development is mixed. A study of OECD countries indicates that GDP per capita growth eases energy transition development, which is consistent with findings from study on G7 countries showing economic growth is linked to higher energy transition consumption. Still, other studies present diverse outcomes as research on solar energy generation across countries and on adoption of renewable portfolio standards in the U.S. found the influence of GDP per capita to be insignificant.

Additionally, a study on the transition to non-hydro energy transition reported a negative impact. Political factors play a crucial role in the deployment of energy transition. For instance, a study from the U.S. indicates that the ideology of state governments is linked to the adoption of renewable portfolio standards, with liberal states being likely to implement RPS compared to conservative states. Another study highlights that Democratic control of state legislatures is a significant factor in determining stringency of state RPS policies. Furthermore, research encompassing 112 countries shows that membership in European Union can facilitate adoption of supportive energy transition policies. Government initiatives, such as China's Energy transition Law, have also been shown to positively promote the successful implementation of energy transition projects. The social factors, alongside economic and political influences, play a crucial role in the adoption of energy transition. Research in the U.S. shows that higher involvement in environmental advocacy groups correlates with increased adoption of green electricity policies. Another U.S. study finds that the presence of state-level environmental organizations can forecast the number of energy transition policies state is likely to enact.

In Japan, research underscores the significance of social capital, indicating that cities with stronger community connections are more likely to support the wind power projects. Additionally, a cross-national analysis reveals that a greater number of international NGOs in a country is associated with higher solar energy production. Fourth, population metrics, such as size and density, have been studied in relation to energy transition deployment, but findings are varied. For example, research on energy transition policy adoption in developing nations and Japan's shift to energy transition highlights a positive role of population factors. Moreover, population factors have been observed to negatively affect solar energy production in various countries. According to the review of available literature, numerous studies carried out to determine variables influencing the growth of energy transition sources; however, few studies have been done to precisely define the flow of energy from production and consumption side. The demand side is represented by a number of studies that have examined factors of either deployment or REC (Akintande, Olubusoye, Adenikinju & Olanrewaju, 2020; Alvarado, Deng, Méndez, Bravo, Chamba, Lopez & Ahmad, 2021; Bourcet, 2020; Omri & Nguyen, 2014).

These studies provide an extensive overview of factors that influence the REC and provide context-specific knowledge about nature and implications of RE. These determinants, which offer helpful insight into improving REC, typically comprise socioeconomic, political, policy, regulatory energy, and environmental-related factors. In contrast to REC, fewer authors have empirically investigated the factors influencing REP, and studies that are currently available are restricted to the particular group of the nations (Aguirre & Ibikunle, 2014b; Bayale, Ali, Tchagnao & Nakumuryango, 2021; Przychodzen & Przychodzen, 2020). Even though the factors that scholars took into consideration for production or consumption may be alike, their implications may differ. For example, economies with higher GDPs may benefit from higher production and consumption of energy, but countries' energy security is enhanced when the funds are directed toward development of energy transition projects. In summary, current research has greatly improved our understanding of how economic, political, social, and population factors affect energy transition deployment. Thus, Nonetheless, more investigation is needed to explore whether other variables also influence the adoption of the energy transition.

This study aims to address this gap by exploring the impact of three factors like climate change vulnerability, assessed through ecological footprints; political drivers, evaluated using governance index; and various combined determinants of energy transition production. Despite progress in the energy transition adoption, Pakistan faces challenges like financing constraints, regulatory hurdles & infrastructural limitations that hinder scale-up of energy transition projects (ADB, 2020). These efforts are aimed at enhancing energy security, mitigating climate change impacts, and fostering economic development over job creation & technological innovation. Addressing these challenges requires concerted efforts from policymakers, international partners, and stakeholders to create a conducive environment for sustainable energy development in Pakistan. To tackle this, we draw on theories from the field of environmental issues to formulate theoretical expectations and propose new hypotheses. In public opinion literature, the Objective Problem and Subjective Value (OPSV) theory is extensively utilized to explain environmental concerns. The theory outlines a challenge-response model, proposing that the environmental concern originates from encountering the severe environmental challenges.

According to OPSV, both local issues (air and water pollution) and global threats (ozone depletion and climate change) are pivotal in shaping public environmental concern. Ronald Inglehart, a prominent advocate of theory, argues that environmental concern is primarily driven by significant objective problems. Empirical research supports OPSV theory, signifying that individual who have faced extreme climate events such as floods or heatwaves are more likely to acknowledge the risks of climate change. Moreover, measures of national or regional vulnerability to climate change are found to be positively associated with the public environmental concern and pro-environmental behaviors. OPSV theory posits that exposure to environmental threats can spur a sense of urgency, promoting pro-environmental behaviors among individuals. Countries less susceptible to climate change may perceive the risk as distant and abstract, leading to weaker incentives to reduce fossil fuel consumption and promote renewables. Conversely, countries facing vulnerability to climate-related risks, like severe weather events causing economic and social losses, are likely to prioritize mitigating climate impacts towards transitioning to energy transition sources, vital for combating climate change.

RESEARCH METHODOLOGY

Energy production, representing supply-side factors, is considered the dependent variable under the premise that it accurately depicts the extent of energy transition (RE) integration within each nation's energy portfolio. A comprehensive review of existing literature reveals that the supply-side penetration of RE has been less frequently studied compared to the demand side. Demand-side measures, like energy transition certificates (RECs), may not accurately reflect a country's installed capacity, as RE can be imported from other nations. Bourcet (2020) pointed out that RE deployment is not assessed by its proportion in total installed capacity, emphasizing the importance of selecting appropriate dependent variables. According to Bourcet, the RE production and installed capacity indicate a country's energy and industrial policies, whereas consumption reflects actual utilization of RE sources.

$$REP_t = \beta 0 + \beta 1\, GDP_t + \beta 2\, TO_t + \beta 3\, URBPOP_t + \beta 4\, NGEP_t + \beta 5\, NUCEP_t + \beta 6\, CEP_t + \beta 7\, OEP_t + \beta 8\, CO2 + \beta 9\, GOVIND_t + \beta 10\, ECOFOOT_t + \varepsilon_t$$

Key factors such as economic growth, trade openness, population growth, CO2 emissions, ecological footprints, governance and energy production from oil, coal, natural gas, and nuclear sources are critical to accelerate investment in RE projects and enhance incorporation of green technologies. Based on the above discussion and study by Przychodzen (2020), the following econometric model is developed. Dependent variable, REPt, represents energy transition production. The independent variables include gross domestic product per capita (GDP), trade openness (TO), urban population (URBPOP), electricity production from the natural gas (NGEP), electricity production from nuclear sources (NUCEP), electricity production from coal (CEP), electricity production from oil, carbon emissions (CO2), governance index (GOVIND) and ecological footprints (ECOFOOT). The error term is represented by Ɛt.

Table 1 Description of Variables

Dependent Variables	Definition	Measurement	Data Source
Renewable Energy Production	The proportion of total energy production in gigawatt-hours (GWh) derived from renewable energy sources such as	% Of total final energy production	WDI (2023)

	photovoltaic, geothermal energy, waste conversion, wind turbines, biogas, and hydroelectric		
Independent Variables			
Economic			
GDP per Capita	GDP represents the total gross value added by all domestic producers within the economy. It includes product taxes but subtracts subsidies not factored into the product values. Essentially, GDP accounts for the economic contribution of producers, adjusted by relevant taxes and subsidies.	Current US$	WDI (2023)
Trade Openness	The total value of imports and exports of goods and services is expressed as a percentage of GDP.	% Of GDP	WDI (2023)
Environmental			
Carbon Emission	CO2 emissions resulting from the burning of fossil fuels.	Metric Ton	WDI (2023)
Ecological Footprints	It is a measure that reflects the number of environmental resources needed to sustain a particular lifestyle or business operation.	Global Hectors (GHA)	GEN (2023)
Energy-related			
Oil Source Energy Production	Energy production from oil	% Age	WDI (2023)
Natural gas-based Energy Production	Energy generation from natural gas.	% Age.	WDI (2023)
Nuclear Energy Production	The electricity generated from nuclear power facilities	% Age.	WDI (2023)
Coal-based energy Production	Energy Production from coal.	% Age.	WDI (2023)
Demographic			
Urban Population	People living in urban areas as defined by national statistical offices.	% Of the total population	WDI (2023)
Political			
Governance Index	A governance index is a tool for assessing the quality and effectiveness of governance practices within a country or organization.		Calculated by Researcher

Source: Authors' Compilation

Econometric Analysis

This study is based on the time series data for Pakistan time span is 1980 to 2023. The model of study is tested for normality emphasizing the standing of selecting appropriate dependent variables. The histogram graph shows normality & normal trend of data. Goodness of fit and normal distribution of the residuals is shown by Jarque-Bera (JB) test. If the probability value of JB is greater than 0.05 level of significance then we can conclude that residuals are normally distributed. In our analysis the JB test probability value is 0.1131 which is greater than 0.05 hence, it is concluded that data are normally distributed.

Table 2 Unit Root Tests Results

Variables	ADF Test at the level I (0)	ADF Test at First Difference I (1)	PP Test in level I (0)	PP Test in First difference I (1)
REP	-2.2187	-8.6990***	-2.0794	-16.179***
GDP	0.3388	-6.8975***	-0.2275	-5.3796***
TO	-2.2429	-6.5930***	-2.4142	-6.5924***
CO2	-1.4199	-5.8926***	-1.8735	-6.8536***
ECOFOOT	-1.2349	-6.1615***	-1.3151	-6.1599***
OEP	-2.3490	-4.6191***	-2.3263	-4.5683***
NGEP	-2.2840	-4.8019***	-1.9971	-4.7225***
NEP	-1.2593	-7.6324***	-1.0580	-9.0028***
CEP	-2.4356	-7.9968***	-2.5729	-7.9085
URPOP	0.8263	-2.5924*	3.5288	-1.6497
GOVIND	-1.4871	-5.8286***	-2.1633	-12.8958***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2 shows a unit root analysis of the variables. The augmented ducky filler (ADF) and Phillip-perron (PP) test are applied to check the stationarity of the data We find that all the variables are stationary at first difference. Consequently, the suitable technique for this is to apply cointegration regression analysis.

Table 3 Cointegration Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2PC	-21.66911	5.808210	-3.730773	0.0007
ECOFOOT	34.77493	7.826642	4.443148	0.0001
GDPPCCUR	0.012099	0.002865	-4.223572	0.0002
TO	0.215579	0.093481	2.306135	0.0275
GOVERNANCE_INDEX	7.035292	2.045156	3.439979	0.0016
NEP	0.629127	0.478025	1.316097	0.1972
NGEP	-0.328715	0.117922	-2.787557	0.0087
OEP	-0.546539	0.090459	-6.041832	0.0000
CEP	-2.987713	1.790132	-1.668990	0.1046
URPOP	2.742213	0.264233	10.37802	0.0000
R-squared	0.888075	Mean dependent var		34.14829
Adjusted R-squared	0.857550	S.D. dependent var		6.304085
S.E. of regression	2.379325	Sum squared Resid		186.8192
Long-run variance	2.391233			

DISCUSSION

The findings in Table 3 reveal a significant positive relationship between the GDP per capita and REP. A 1 unit rise in GDP per capita is associated with just a 0.012099 unit increase in REP. The data suggests that although higher GDP per capita positively influences renewable energy projects, impact is minimal, reflecting a potential shortfall in funding for these projects. This small effect hints that renewable energy development is not receiving the focus it might need from many nations. To accelerate the growth of renewable energy projects, a more significant effort and prioritization may be essential. Thus, these findings are similar to studies by Beyale et al. (2021) and Przychodzen and Przychodzen (2020).

Trade Openness

The results presented in Table 3 indicate that trade openness significantly and positively affects REP at 5% level of significance. Specifically, a 1-unit increase in trade openness results in a 0.2155-unit rise in REP. The analysis demonstrates that increased trade openness significantly benefits the development of renewable energy projects. By enhancing transfer of knowledge and technology, open trade channels enable countries to access the expertise needed to advance their renewable energy initiatives. This influx of technology and knowledge stimulates local economic activities and encourages the domestic production of green technologies. As a result, trade openness is a vital factor in rushing transition to clean and sustainable energy solutions. These findings corroborate earlier studies, underscoring the importance of trade openness in the global pursuit of renewable energy development.

Urbanization

The findings in Table 3 show that urbanization has a positive and highly significant impact on REP, with a significance level of 1%. Specifically, a 1 unit increase in urban population results in 2.7422 units in REP. The data suggests that urbanization plays a crucial role in driving growth of renewable energy projects. As the urban population increases, there is a corresponding rise in the demand for energy, which can be met through expansion of renewable energy infrastructure. The significant positive relationship shows that cities, with their concentrated populations and economic activities, are pivotal in adopting and advancing renewable energy solutions. These results are in line with previous studies by Aguirre and Ibikunle (2014), Akintande et al. (2020), Bayale et al. (2021), and Escoffier et al. (2021).

Electricity Production

The results in Table 3 reveal that electricity produced from natural gas and oil energy significantly hinders renewable energy projects (REP) at a 1% significance level. Specifically, a 1 unit increase in electricity generation from natural gas leads to a 0.2387-unit decline in REP, creating an obstacle for renewable energy development. Similarly, a 1 unit increase in oil energy generation results in a 0.5465 reduction in REP. The findings also indicate that coal electricity production also negatively impacts REP. A 1 unit increase in electricity generation from coal reduces REP by 2.9877 units at a 10% significance level. The analysis suggests that business stakeholders invested in conventional energy sources are a significant barrier to the growth of renewable energy projects. Their concern about revenue loss from non-renewable energy and their powerful lobbying to sustain fossil fuel use impedes the progress of renewable energy initiatives. This prioritization of financial interests over environmental benefits delays the shift towards a more sustainable, low-carbon economy. The findings align with previous research Aguirre and Ibikunle (2014), Marques et al. (2010), and Hayat and Tariq (2024).

CO2 Emissions

The results indicate that CO2 emissions, serving as an indicator of environmental degradation, exert a significantly negative effect on the renewable energy projects (REP) at a 1% significance level. Specifically, a 1 unit increase in CO2 emissions corresponds to a 21.66-unit reduction in REP. This suggests that higher CO2 emissions, resulting from bigger electricity production from conventional energy sources, are associated with a decrease in the share of renewable energy projects. As the conventional energy production rises and environmental pollution intensifies, the proportion of REP tends to diminish. These findings are logical and align with research conducted by Aguirre and Ibikunle (2014).

Ecological Footprints

This variable is used as a proxy for environmental vulnerability. Ecological footprints show a significant but positive association with REP. A 1-unit increase in ecological footprints causes a 34.77 units increase in REP at 1% significance level. The positive association between ecological footprint and renewable energy production is influenced by several interconnected factors. High ecological footprints often signal higher energy needs, prompting investments in renewable energy as a strategy to manage environmental impacts. Moreover, governments in high-footprint countries may actively support renewable energy initiatives to offset environmental damage. Therefore, the economic growth further contributes to this trend by providing the financial resources necessary for advancing renewable energy technologies. Consequently, the increase in renewable energy production reflects efforts to address and mitigate the environmental challenges posed by higher ecological footprints.

Governance

The governance index is used as a proxy for political factors. This index is constructed by researcher herself by using 5 indicators control of corruption, regulatory quality, rule of law, transparency, and accountability. The results show positive association amid governance and REP. A 1-unit increase in governance caused a 7.03-unit rise in REP at 1% significance level. Good governance provides a stable and predictable policy framework, which attracts investments in renewable energy projects. International Renewable Energy Agency (IRENA), 2020. Effective governance ensures supportive regulations and incentives, such as tax credits, net metering laws, as well as renewable portfolio standards, which foster the growth of renewable energy. Renewable Energy Policy Network for the (REN) 2020 report.

CONCLUSION

In recent years, researchers have increasingly focused on boosting the share of renewable energy production (REP) in the overall energy production by leveraging supportive factors that drive the adoption of renewable energy. This study, which examines a time series analysis of Pakistan from 1980 to 2023 aims to identify the key factors that contribute to enhancing REP. The analysis of factors affecting renewable energy production, identified several key determinants and economic sustainability. Economic variables like GDP per capita & trade openness along with demographic factors, urban population, environment variables like ecological footprints, and political variables like governance positively influence REP. In contrast, the environmental proxy (CO_2 emissions) and energy-specific variables such as electricity production from oil, natural gas, and coal sources have a negative impact on REP. Thus, while economic and demographic factors support the growth of REP, environmental & energy-related variables exert opposing effects. To boost renewable energy production, policymakers should focus on economic growth and create a supportive environment for the business.

This economic growth will provide the necessary funds for green energy investments. However, it's important to prioritize renewable projects over traditional energy sources. Wealthier countries have the means to invest in renewable energy but may not always prioritize it due to other concerns. In developing countries, income inequality can prevent the adoption of renewable energy. Thus, a balanced approach that considers economic and environmental factors is vital for encouraging investments in renewable energy. The positive link between trade openness and renewable energy production (REP) shows that opening up trade can help spread green technology quickly and easily around the world. Policymakers should consider trade openness as central factor in supporting REP. While richer countries might initially prioritize business profits, wealthy and developing countries will benefit in long run by reducing carbon emissions. Policymakers in developing countries need to communicate the importance of moving towards green energy to their people. The urbanization, as a demographic factor, positively impacts renewable energy production (REP). Offering financial incentives to urban populations to adopt renewable energy solutions will further drive the demand for green energy.

There is also a positive association between governance and ecological footprints with REP, the policy makers establish and empower institutions dedicated to renewable energy. Clear mandates, transparency, and accountability are crucial for effective governance. Integrate renewable energy solutions into urban planning. Promote the use of solar panels, wind turbines, and other renewable technologies in urban development projects. Significant energy production from oil, coal, natural gas, and nuclear sources hinders the progress of renewable energy production (REP). In the presence of substantial energy production from oil, coal, natural gas, and nuclear sources, renewable energy production (REP) will struggle to advance. These measures will drive economic growth, reduce CO2 emissions, and alleviate energy security concerns by decreasing reliance on expensive fossil fuels. However, countries rich in mineral resources might resist renewable energy projects due to fears of losing revenue from resources. While nuclear energy is environmentally friendly, its high costs and proliferation risks make it less favorable compared to renewable energy. Thus, listing renewable energy projects over other energy sources is vital for realizing stable & environmentally sustainable energy future.

REFERENCES

Aguirre, M., & Ibikunle, G. (2014). Determinants of renewable energy growth: A global sample analysis. *Energy Policy*, 69, 374–384.

Akintande, O. J., Olubusoye, O. E., Adenikinju, A. F., & Olanrewaju, B. T. (2020). Modeling the determinants of renewable energy consumption: Evidence from the five most populous nations in Africa. *Energy*, 206, 117992.

Alvarado, R., Deng, Q., Méndez, P., Bravo, D., Chamba, J., Lopez, M., & Ahmad, M. (2021). Do the economic development and human capital decrease non-renewable energy consumption? Evidence for OECD countries. *Energy*, 215, 119147.

Bourcet, C. (2020). The empirical determinants of renewable energy deployment: A systematic literature review. *Energy Economics*, 85, 104563.

Cadoret, I., & Padovano, F. (2016). The political drivers of renewable energies policies. *Energy Economics*, 56, 261–269.

Bayale, N., Ali, E., Tchagnao, A.-F., & Nakumuryango, A. (2021). Determinants of renewable energy production in WAEMU countries: New empirical insights and policy implications. *International Journal of Green Energy*, 18(6), 602–614.

Carley, S., Baldwin, E., MacLean, L. M., & Brass, J. N. (2017). Global Expansion of Renewable Energy Generation: An Analysis of Policy Instruments. *Environmental and Resource Economics*, 68(2), 397–440.

Hao, F., & Shao, W. (2021). What really drives the deployment of renewable energy? A global assessment of 118 countries. *Energy Research and Social Science*, 72.

Hayat, M. Majeed, M. T. (2024). The Determinants of Renewable Energy Production– A Global Study on Panel Data. *Pakistan Journal of Economic Studies*, 7(1), 51-67

Hu, Y., Jiang, W., Dong, H., & Majeed, M. T. (2022). Transmission channels between financial efficiency and renewable energy consumption: Does environmental technology matter in high-polluting economies? *Journal of Cleaner Production*, 368, 132885.

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. *Energy Economics*, 53, 58–63.

Jeon, H. (2022a). CO2 emissions, renewable energy and economic growth in the US. *The Electricity Journal*, 35(7), 107170.

Jeon, H. (2022b). Renewable versus non-renewable: The role of electricity generation to economic growth. *The Electricity Journal*, 35(6), 107140.

Kinab, E., & Elkhoury, M. (2012). Renewable energy use in Lebanon: Barriers and solutions. *Renewable and Sustainable Energy Reviews*, 16(7), 4422–4431.

Luni, T., & Majeed, M. T. (2020). Improving environmental quality through renewable energy: In*ternational Journal of Energy and Water Resources*, 4(3), 335–345.

Marques, A. C., & Fuinhas, J. A. (2011). Do energy efficiency measures promote the use of renewable sources? *Environmental Science & Policy*, 14(4), 471–481.

Marques, A. C., Fuinhas, J. A., & Pires Manso, J. R. (2010). Motivations driving renewable energy in European countries: A panel data approach. *Energy Policy*, 38(11), 6877–6885.

Matsumoto, K., & Matsumura, Y. (2022). Challenges and economic effects of introducing renewable energy in a remote island: A case study of Tsushima Island, Japan. *Renewable and Sustainable Energy Reviews*, 162, 112456.

Omri, A., & Nguyen, D. K. (2014). On the determinants of renewable energy consumption: International evidence. *Energy*, 72, 554–560.

Przychodzen, W., & Przychodzen, J. (2020). Determinants of renewable energy production in transition economies: A panel data approach. *Energy*, 191, 116583.

Renewable Energy Statistics (2019). The Renewable Energy Statistics (2022). World Energy Transitions Outlook 2022: 1.5°C Pathway. (2022).

Tu, Y. X., Kubatko, O., Piven, V., Sotnyk, I., & Kurbatova, T. (2022). Determinants of Renewable Energy Development: Evidence from the EU Countries. *Energies*, 15, 7093.

Wu, L., Kaneko, S., & Matsuoka, S. (2006). Dynamics of energy-related CO2 emissions in China during 1980 to 2002: Relative importance of energy supply-side and demand-side effects. *Energy Policy*, 34(18), 3549–3572.