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The Multifaceted Impact of Solar Energy on Pakistani Society Economic, Geographic, Sociological, Political, Environmental, and Urban Planning Perspectives

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ABSTRACT:
This review paper highlights the broad perspective of solar energy on Pakistani society, detailing its applicability in economic, geographic, sociological, political environment solidarity, and urban planning. With the world energy map changing to renewables, solar power offers a beacon of light for Pakistan, which is suffering from a severe fuel import-based energy crisis. The paper outlines the promise of solar energy to improve rural livelihoods, help alleviate energy poverty and encourage sustainable agricultural techniques. This paper examines how government policies can support foreign direct investment in the deployment of solar technologies and identifies barriers to implementation, such as financial constraints and technology awareness. With this, environmental benefits that it yields, such as attenuation of carbon emissions and ecological footprints, are laid strong while solar energy is made a part of urban planning initiatives besides smart city projects. The paper also highlights the importance of effective governance, financial assistance, and a creative policy framework to tap Pakistan's renewable potential efficiently. This paper is a call for necessary integrative thinking in long-term solar energy adoption that validates local agendas and achieves global development goals advocated on authoritative levels.

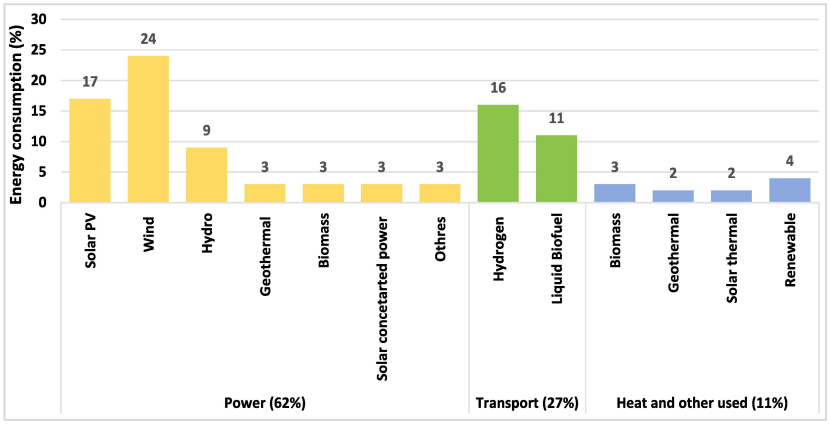
KEY WORDS:
Solar Energy, Renewable Energy, Economic Impact, Policy Framework, Sustainable Development, Energy Crisis

Introduction

Renewable energy is playing an increasingly important role in the global energy transition; it has the potential to supply up to two-thirds of global primary energy supplies by 2050 (Hassan et al., 2024). The European Union aims to increase renewable energy share to 55% by 2030 while reducing greenhouse gas emissions (Androniceanu & Sabie, 2022). Global low-carbon energy sources accounted for 15.7% of primary energy supplies in 2019, with hydropower, wind, and solar power having grown significantly over the past decade (Gan et al., 2023). Renewable energy adoption varies from region to region, with European countries such as Denmark and Germany leading the way in Asia. It is showing rapid growth, especially in China and India (Hassan et al., 2024). North America is also making progress, with opportunities for large-scale and distributed renewable energy configurations (Azarpour et al., 2022). But challenges remain. Including problems with scaling up financing mechanisms and implementation strategies (Gan et al., 2023), continued investment and policy support are critical to accelerating the global transition to renewable energy.

Figure 1

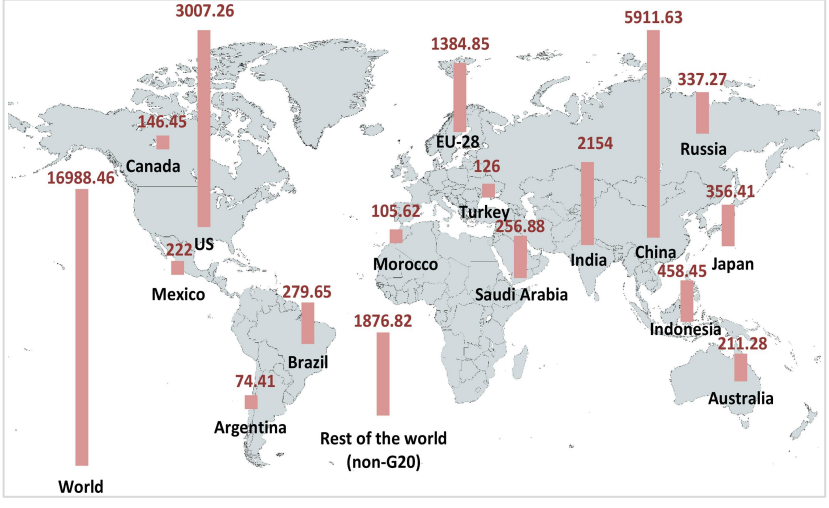
Analysis of renewable energy utilization in final energy consumption: REM perspective for 2050



Source: Hassan et al., 2024

Figure 2

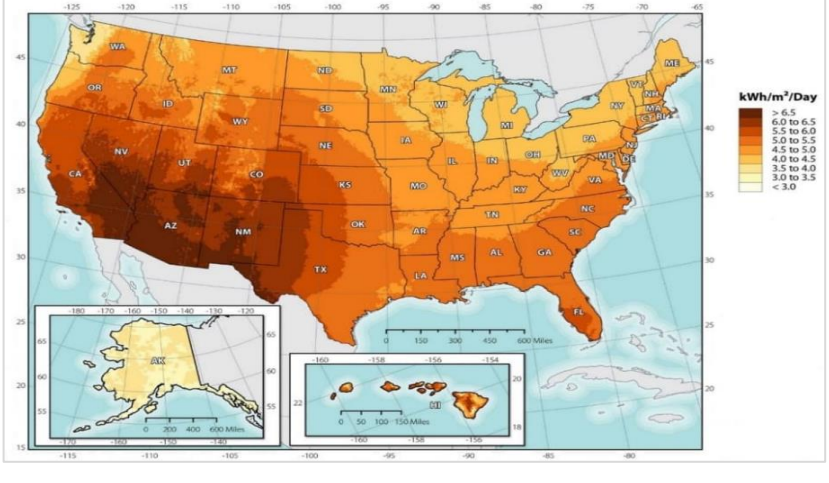
Regional distribution of added renewable energy production capacity from 2020–2050



Source: Hassan et al., 2024

Figure 3

Solar Resources in North America



Objectives

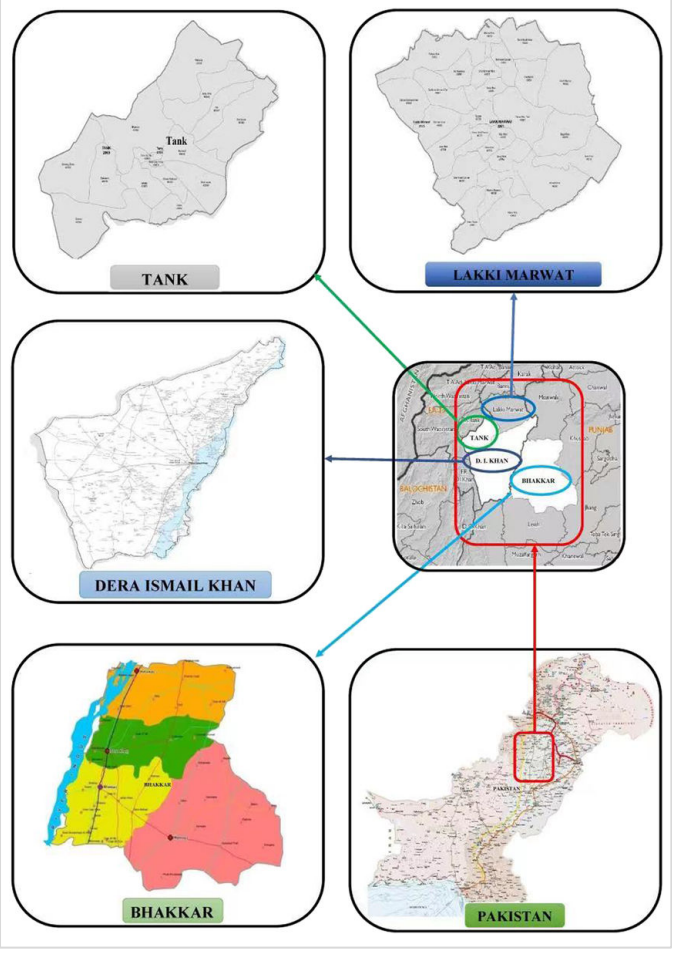
- To evaluate the Economic Impact
- To analyze Geographic Potential
- To examine Sociological Effects
- To evaluate the Political Framework
- To investigate Environmental Benefits
- To identify Barriers to Adoption
- To promote Awareness

Solar Energy in Pakistan: A Background

Pakistan has been grappling with an electricity crisis for decades. This is mainly due to reliance on fossil fuels and inadequate energy policies (Khatri et al., 2022). However, the adoption of photovoltaic (PV) systems in rural areas is still low (Ahmar et al., 2022). Factors affecting the adoption of solar energy include age, education, income, availability of credit, and system prices (Ahmar et al., 2022). Recent policies aim to increase the share of renewable energy, but implementation is still lacking (Haq et al., 2022). Also, under the current policy, solar power is expected to contribute less than 2% to the grid by 2030 (Haq et al., 2022). Import tariffs and fiscal measures have been identified as effective policy tools for attracting FDI (foreign direct investment) in the field of solar energy (Ahmar et al., 2022). Good governance and financial support, as well as developing sustainable energy policies based on robust demand forecasts and assessments of renewable energy, are critical to resolving Pakistan's energy crisis (Ahmar et al., 2022; Khatri et al., 2022).

Figure 4

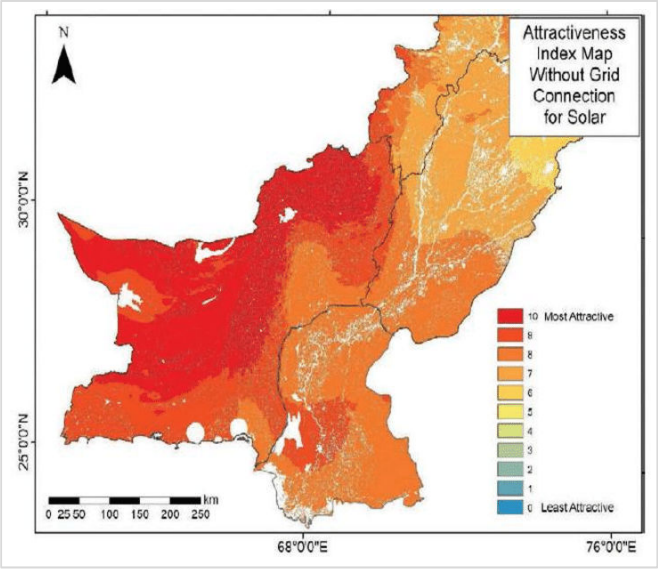
Rural areas of Pakistan with adoption of photovoltaic (PV) systems



Source: Ahmar et al., 2022

Figure 5

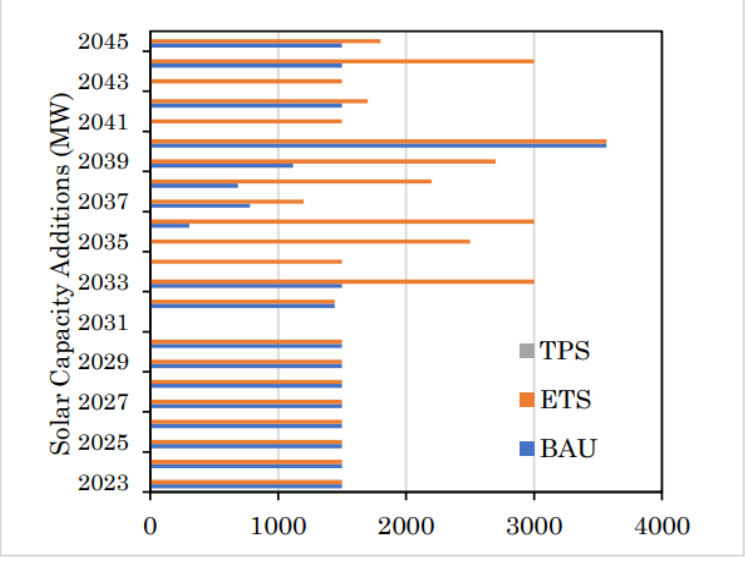
Financial attractiveness of solar PV potential, excluding



Source: Haq et al., 2022

Figure 6

Capacity additions of solar power under different scenarios under the current policy



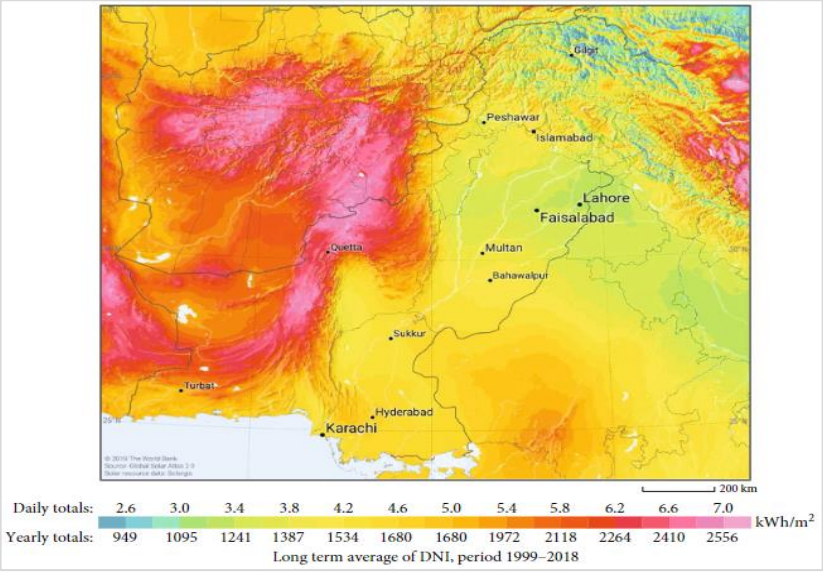
Source: Haq et al., 2022

Economic Impact

The adoption of solar energy in Pakistan has shown signs of economic growth and rural development; also, related studies indicate that photovoltaic (PV) systems are more cost-effective than concentrated solar power, with fixed costs as high as 5.95 cents/kWh in suitable locations (Orangzeb et al., 2023). The adoption of solar power by income-producing farmers has had a positive effect, highlighting the need for subsidies from the government and credit to promote access (Khan et al., 2024). The hybrid energy systems that combine solar, wind, and biomass resources offer practical solutions for power generation in remote areas by providing 24-hour electricity with low carbon emissions (Rehmani et al., 2023). However, the barriers to implementing solar energy projects in developing countries are financial conditions as well as policy and technology awareness (Mustafa et al., 2024). Through effective policies and financial stability, addressing these challenges with institutional support can increase solar energy adoption. And contribute to sustainable economic development in Pakistan.

Figure 7

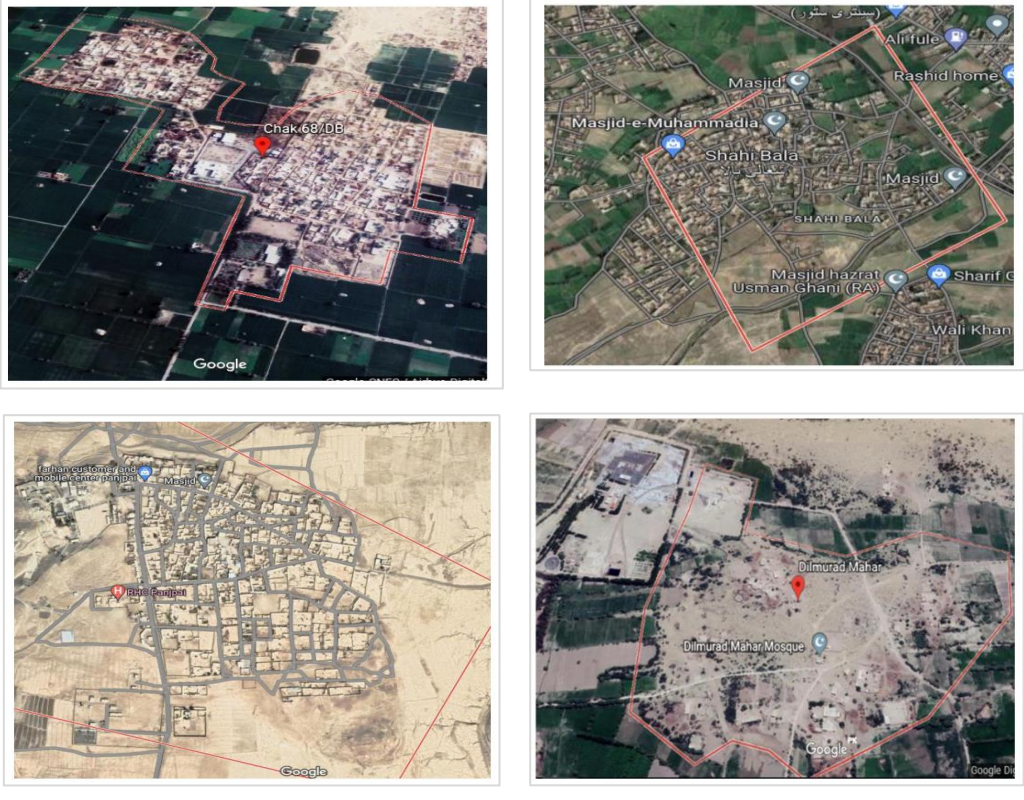
DNI map of Pakistan with suitable locations (Multan, Bahawalpur, Rahim Yar Khan, Hyderabad, Quetta, and Toba)



Source: Orangzeb et al., 2023

Figure 8

Remote areas chosen by Rehmani et al., 2023



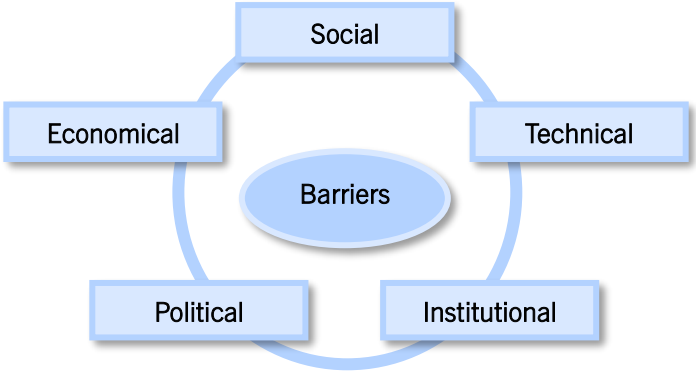
Geographic Considerations

The diverse geography and landscapes of Pakistan have significant and unseen potential for renewable energy, especially solar energy and wind energy. Both Sindh and Baluchistan regions are commercially promising for wind energy installations (Turi et al., 2022). The energy produced by solar PVs has been identified as the most suitable renewable energy source for rural areas of Pakistan due to various factors such as cost, age, and maintenance (Habib et al., 2024; Batool et al., 2022). Pakistan's

geography also provides better opportunities to deploy solar and wind energy in different locations (Turi et al., 2022). However, challenges remain still there in the implementation of these energy generation technologies, including energy poverty in rural areas, such as areas far away from cities as well as villages, and the need to improve policies to promote the adoption of renewable energy (Batool et al., 2022; Turi et al., 2022). Solar energy efficiency optimization approaches focus on reducing costs and greenhouse gas emissions while increasing system reliability (Soomar et al., 2022). To achieve these Sustainable Development Goals (SDGs) by 2030, Pakistan should work on challenges associated with these technologies and harness its renewable energy potential (Turi et al., 2022; Izam et al., 2022).

Figure 9

Barriers led to energy poverty



Source: Batool et al., 2022

Figure 10

Improve policies by Batool et al., 2022

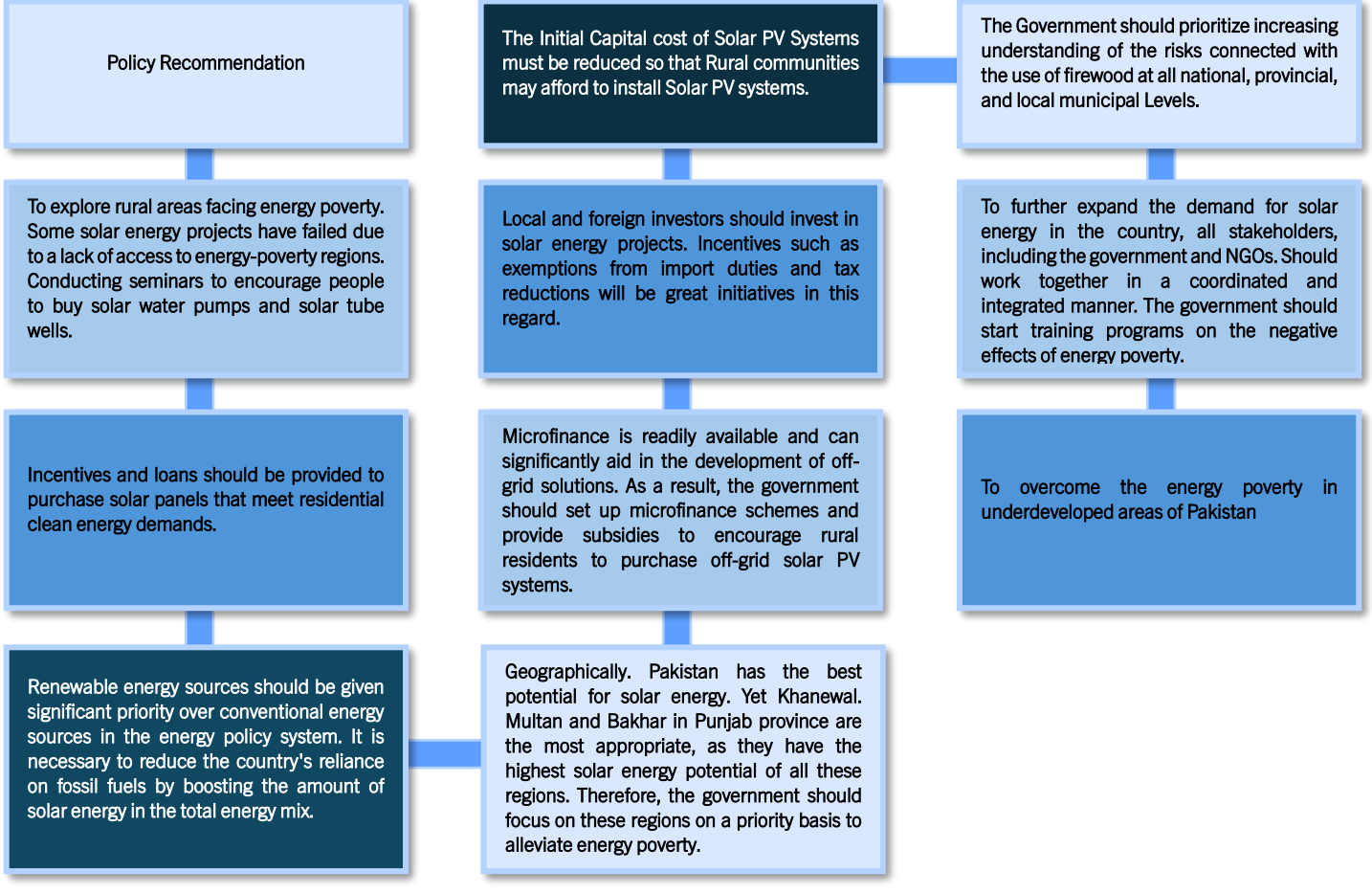
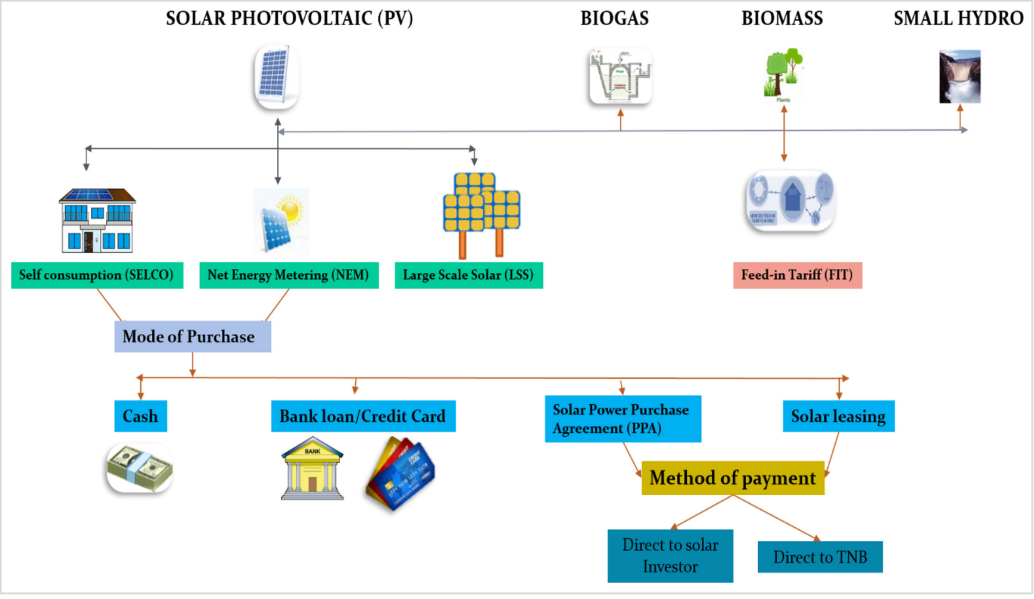


Figure 11

Implementation of the program using different technologies to improve renewable energy



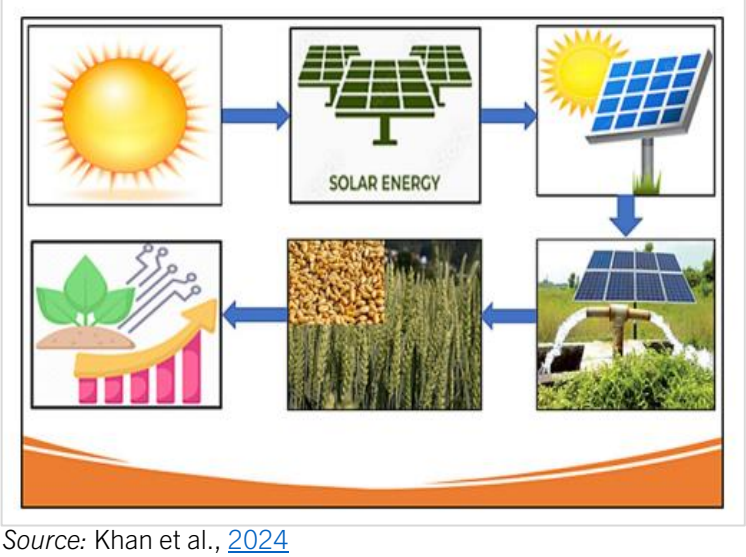
Source: Izam et al., 2022

Sociological Impact

The installation of solar power plants in Pakistan unhide and shows promise for improving rural livelihoods and alleviating energy poverty. Studies show that solar energy technology can increase farmers' incomes and promote agricultural development (Khan et al., 2024). Public perception of renewable energy is generally positive, especially among educated people who are ready to pay for green energy (Din et al., 2023). However, barriers to implementation still exist, including financial obstacles, Lack of technological awareness, and insufficient institutional support (Mustafa et al., 2024). Hybrid energy systems that combine all power sources, solar, wind, and biomass resources offer practical solutions for power generation in remote areas and provide a 24-hour electricity supply with low carbon emissions compared to conventional energy sources (Rehmani et al., 2023). Subsidies to accelerate adoption, credit and knowledge dissemination, etc. Interventions at sea. The Caribbean matters. This is especially true for resource-poor farmers who face challenges in procuring technology (Khan et al., 2024).

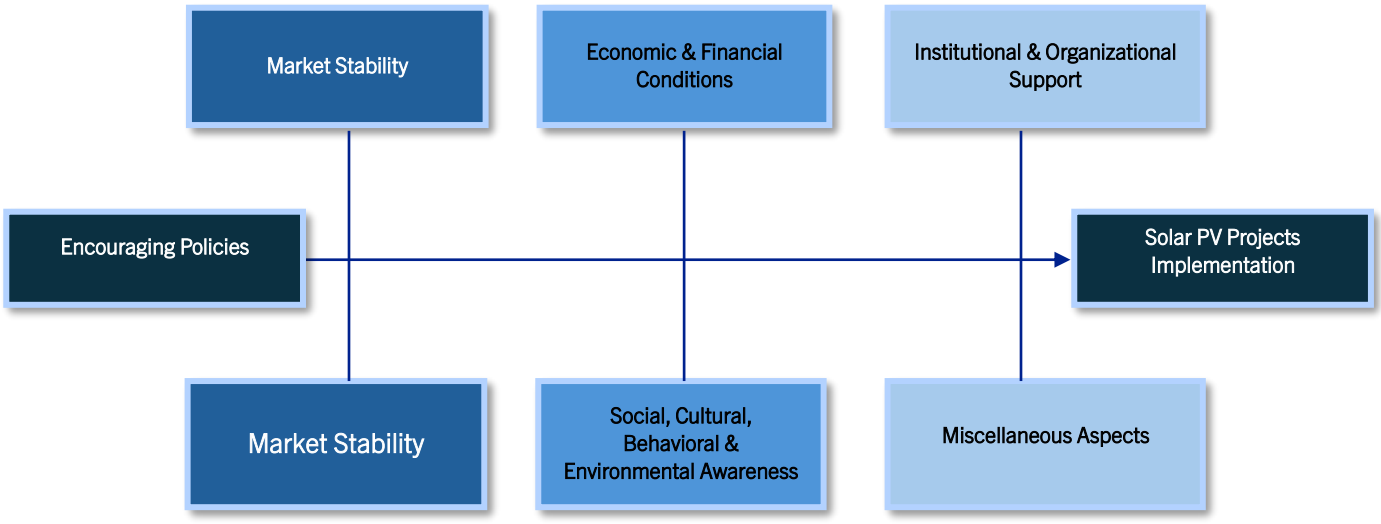
Figure 12

Agricultural development using renewable energy



Source: Khan et al., 2024

Figure 13
barriers impacting solar PV projects



Source: Mustafa et al., 2024

Political Implications

Government policies play an important role in the promotion of the adoption of solar energy in Pakistan. Import tariffs and fiscal measures are effective policy tools to attract foreigners for FDI (foreign direct investment) in the solar energy sector (Ali et al., 2022). However, the implementation of renewable energy plans faces challenges (Xin et al., 2022). Factors affecting the adoption of solar cell technology include perceived benefits, ease of use, and consumer attitudes to government policies and promotions that drive purchase intention (Ali et al., 2020). The solution to solve Pakistan's energy shortage problem, such as dependence on imported fuels, renewable energy, especially solar energy, has great potential to reduce dependency (Xin et al., 2022). The green energy scenario focusing on renewable energy sources shows promise in reducing energy demand, reducing greenhouse gas emissions, and reducing operating costs compared to other energy options (Asim et al., 2022). For the promotion of solar energy adoption to achieve clean and green energy, policymakers should focus on improving governance, providing financial support, and implementing advanced renewable energy policies (Ali et al., 2022).

Figure 14
Conceptual framework of (Ali et al., 2022)

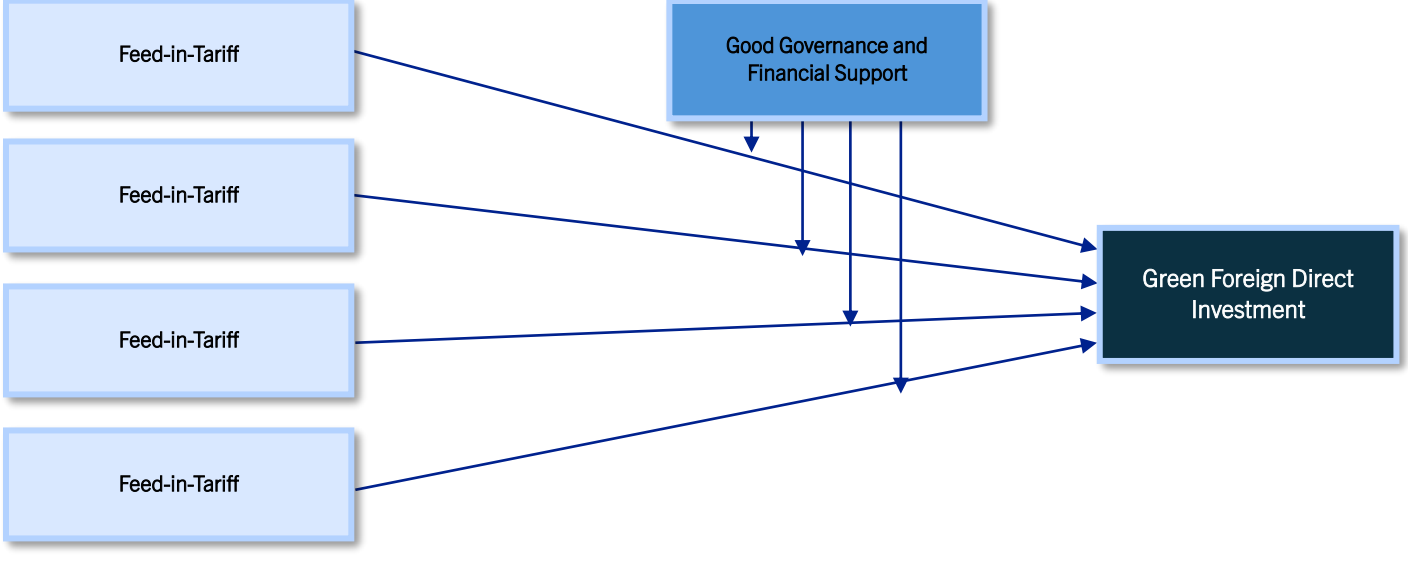
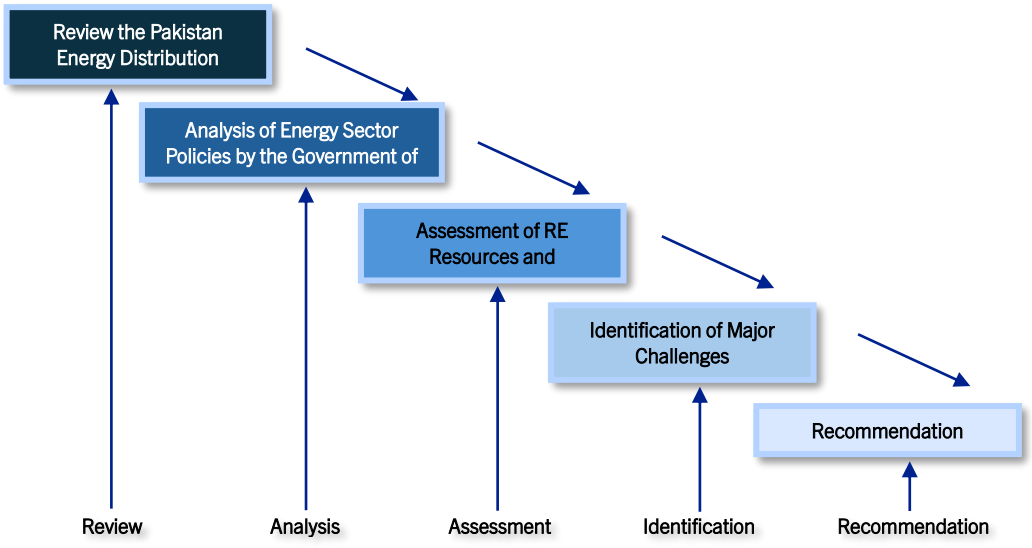


Figure 15

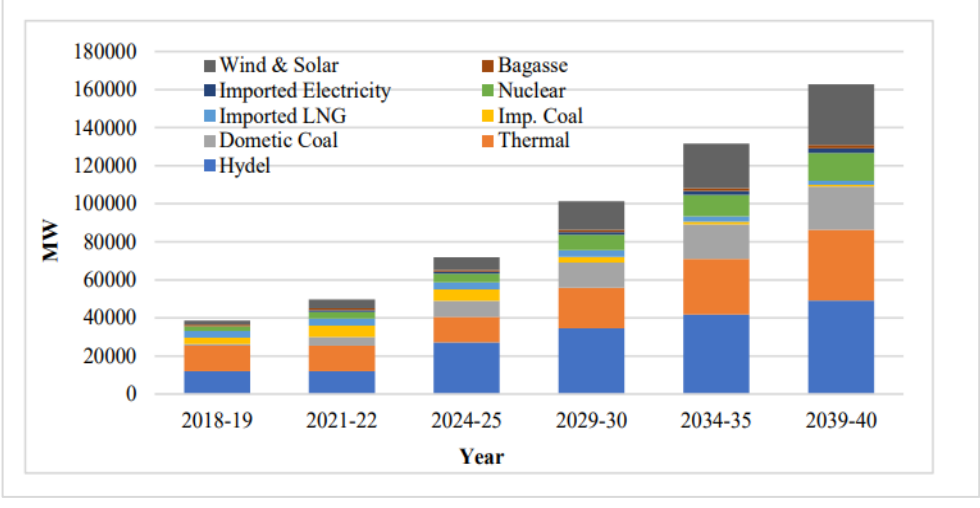
Renewable energy Methodology and plans face challenges



Source: Xin et al., 2022

Figure 16

Projection of Pakistan Energy Utilization 2040



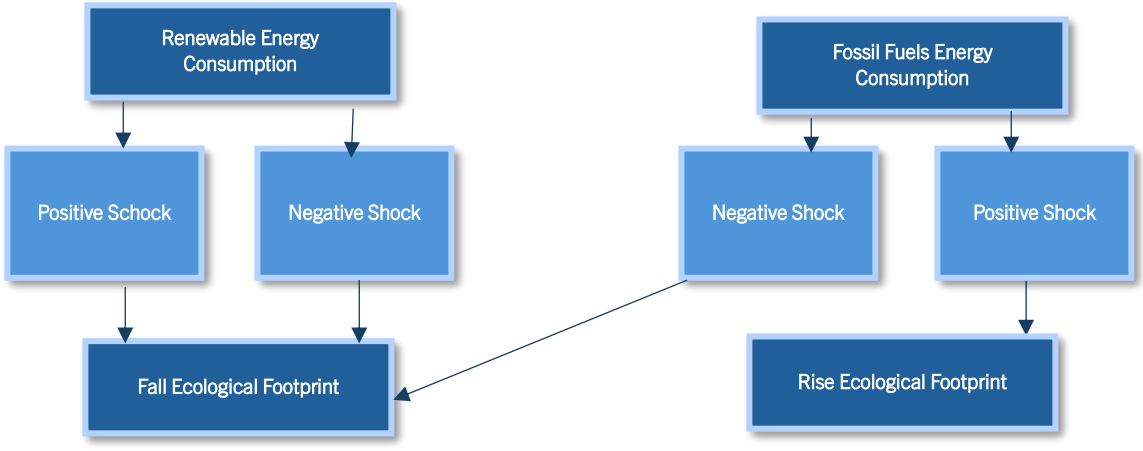
Source: Asim et al., 2022

Environmental Impact

Recent studies have illuminated the real potential of renewable energy, especially solar and nuclear energy. To reduce Pakistan's ecological footprint and carbon emissions, solar panels in Pakistan have a short energy turnaround time of 2.5-3.5 years, making them an attractive option for sustainable energy production (Shah et al., 2023). Both positive and negative changes in the use of renewable energy have occurred and helped in the reduction of the ecological footprint in Pakistan (Asghar et al., 2023). Similarly, environment-relevant technologies and renewable energy planning will significantly reduce long-term pollution levels (Usman et al., 2022). However, remaining challenges and issues related to urban sanitation and energy consumption continue to increase carbon emissions (Khalil et al., 2022). The Pakistani government should work and focus on the improvement of health-related services as well as renewable energy promotion to address these challenges perfectly. These efforts combined with the increased availability of clean drinking water and improved air quality, as well as the country's climate change (Khalil et al., 2022).

Figure 17

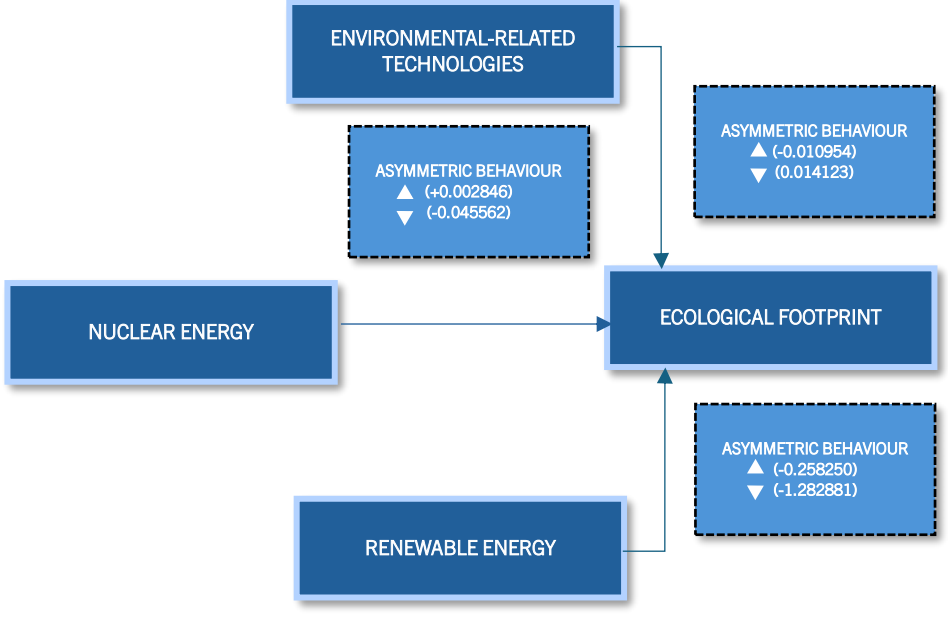
Conceptual framework



(Asghar et al., 2023)

Figure 18

Graphical presentation of empirical findings



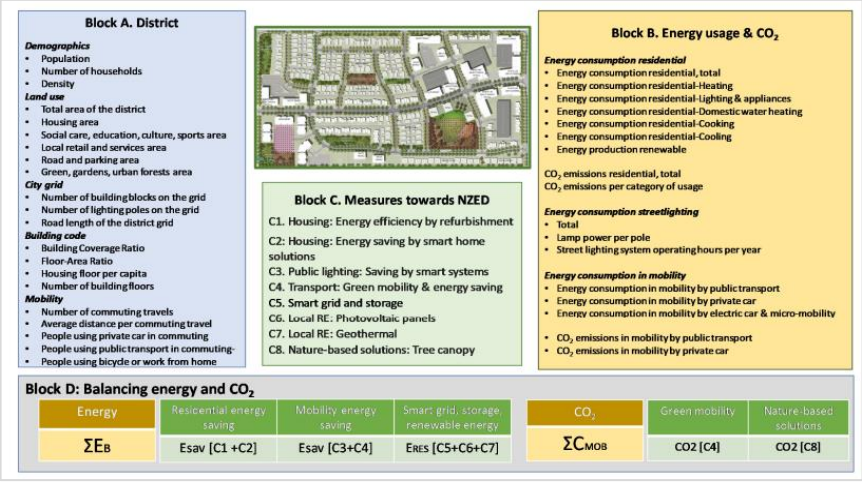
Source: Usman et al., 2022)

Urban Planning and Development

Integrating solar energy into urban infrastructure and smart city projects is gaining momentum as a sustainable solution to energy needs. Net Zero Energy Districts (NZED) are becoming a key component of smart green cities. Using smart technology and renewable energy to achieve carbon neutrality (Komninos, 2022), solar panels are being integrated into innovative infrastructure applications such as building design. Urban planning parking lot canopies and noise barriers (Vijayan et al., 2023). However, they still have spatial and aesthetic limitations in densely populated urban areas. Despite these limitations, solar power also shows great potential for decentralized energy grids and rooftop initiatives. Especially in developing countries such as Pakistan, smart integrated decentralized solar energy systems can produce low-cost electricity through cooperative sharing mechanisms (Shah et al., 2022). Solar energy has been identified as a renewable energy source that is most suitable for addressing energy poverty and related problems in rural areas (Batool et al., 2022).

Figure 19

Building blocks of the NZED model



Source: Komninos, 2022

Figure 20

Utilization of solar panels in smart cities (Vijayan et al., 2023)

Figure 21

Experimental procedure

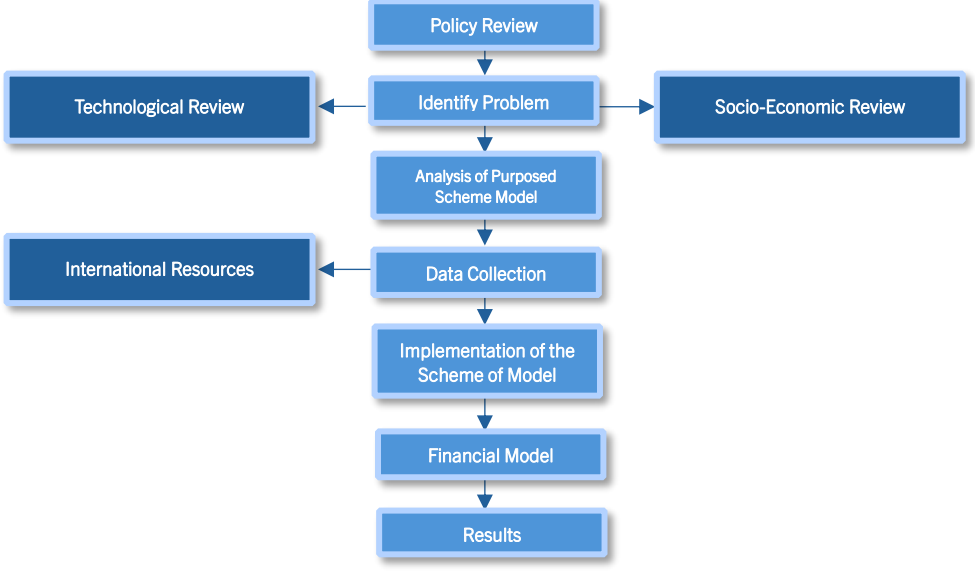
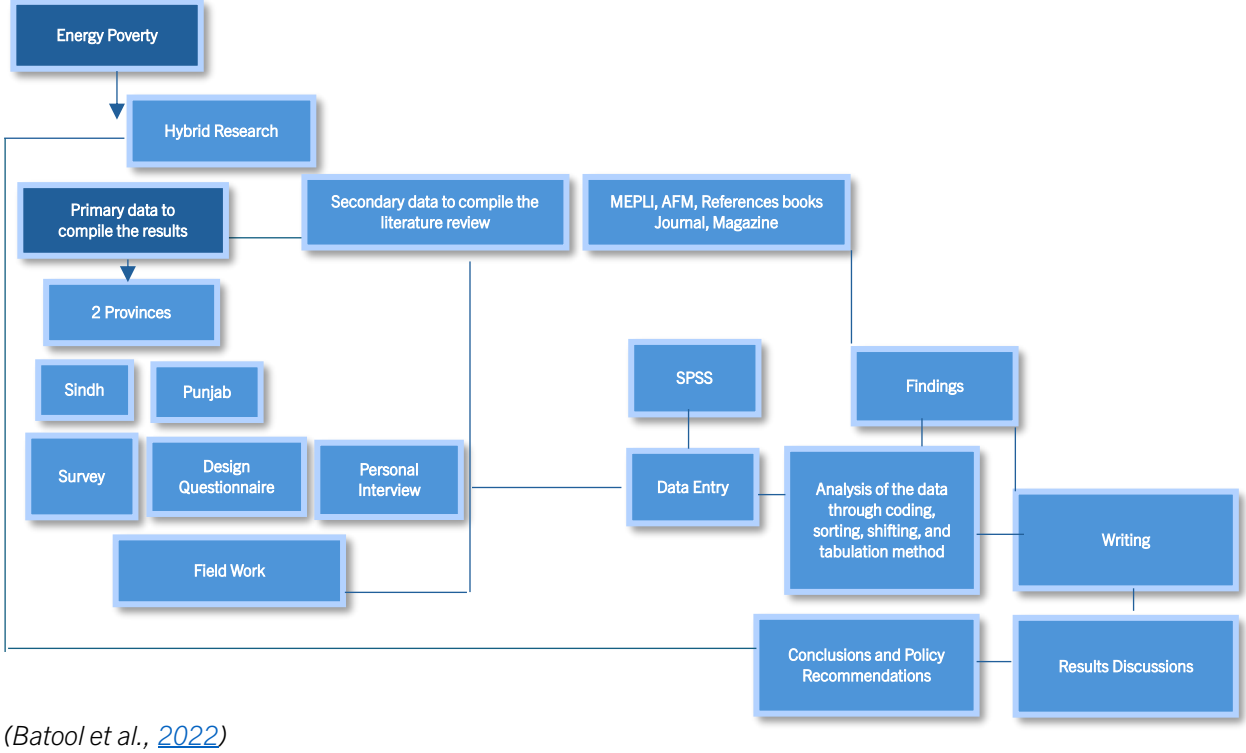


Figure 22

PV Installation on the rooftop

Figure 23

Research process



(Batool et al., 2022)

Table 1

Key figures illustrating the impact of solar energy on various aspects of Pakistani society

Aspect	Key Points	Figures
Environmental Impact	Solar panels have a short energy turnaround time. Reduction of ecological footprint and carbon emissions through renewable energy.	2.5-3.5 years energy turnaround time.
Economic Impact	Cost-effectiveness of photovoltaic (PV) systems compared to concentrated solar power.	Fixed costs as high as 5.95 cents/kWh in suitable locations.
Sociological Impact	Increase in farmers' incomes due to solar energy technology. Positive public perception of renewable energy among educated individuals.	
Political Implications	Effective policies and financial stability can increase solar energy adoption.	

Table 2

Key Themes and findings on the impact of solar energy on Pakistani society

Aspect	Key Themes	Findings
Economic Impact	Economic growth and rural development.	Solar energy adoption leads to increased income for farmers and rural communities.
	Cost-effectiveness of solar technologies.	Photovoltaic systems are more cost-effective than other solar technologies.
	Need for government subsidies and credit.	Financial support is crucial for wider adoption.
Geographic Considerations	Diverse geography offers potential for renewable energy.	Sindh and Baluchistan are promising for wind and solar installations.
	Suitability of solar PV for rural areas.	Solar PV is identified as the best option for rural electrification.
Sociological Impact	Improvement of rural livelihoods.	Solar energy can alleviate energy poverty and enhance quality of life.
	Public perception of renewable energy.	Generally positive, especially among educated individuals.
Political Implications	Role of government policies in promoting solar energy.	Effective governance and supportive policies are essential for adoption.
	Challenges in implementing renewable energy plans.	Barriers include financial conditions and policy awareness.
Environmental Impact	Potential for reducing ecological footprint.	Solar energy contributes to lower carbon emissions and sustainable energy production.
	Short energy turnaround time of solar panels.	Solar panels have a quick payback period, enhancing their attractiveness.

Challenges and Future Directions

Challenges

The transition to solar energy in Pakistan faces several challenges that must be addressed to realize its full potential. Key obstacles include:

Financial Barriers

The high capital investment in solar energy systems makes them unaffordable, especially for low-income households and small farmers. Affordable financing options and government subsidies are crucial to drive adoption.

Technological Awareness

Much of the knowledge about solar technologies is missing among their least technical potential users, especially in rural areas

where functional facilities are most lacking. Information for opening public awareness and comprehension of the benefits of solar energy systems is to be designed through educational programs and outreach initiatives.

Policy and Regulatory Framework

Heavy dependence on policies and regulations makes the solar energy sector slow-growing. A stable policy framework that includes well-structured incentives for investment in renewable energy provides investors, both local and international, with certainty around their return on investment.

Infrastructure Limitations

Energy infrastructure in Pakistan may not be well-suited to integrate solar power efficiently. Upgrades to the grid and building systems for decentralized generation are also important.

Public Perception and Acceptance

Even when people have a relatively high opinion of renewable power, misinformation, and distrust can be barriers to regular uptake. The next step is to engage communities and show that solar projects can work.

Future Directions

To meet challenges and disseminate solar power very broadly, we need to think of several strategic directions. Pay-as-you-go systems and microfinancing are innovative financial mechanisms that can significantly expand access to the underserved. It also provides on-the-job training as well as capacity building of local technicians and engineers for correct installation & maintenance, which in turn will support more jobs. Policymakers should, therefore, pursue a consistent, long-term renewable strategy that is based on objectives and includes the goals for solar as well as incentives and support to realize projects. Additionally, investment in the research and development (R&D) of new technologies would enable more efficient solar systems to be developed and thus reduce costs to increase competitiveness. Second, harnessing local community input into the decision-making around solar project planning and execution would ensure that solutions are adapted to their needs and most likely be accepted by locals.

Conclusion

Pakistan's energy challenges have led to an exploration of a sustainable and affordable resource. Solar energy is the most appropriate alternative for sustaining the country's growth, as it is considered to be "an environmentally clean" source of energy. This review paper illuminates the numerous advantages of solar power not only in the economic sense but also in issues of rural development and green energy. While the future looks bright, solar power continues to face renewable energy challenges in its shift. Financial barriers, technological awareness gaps, inconsistent policy frameworks, and infrastructure limitations are some of the non-neglectable factors that act as significant hurdles to its widespread use. Strategic intervention, improved financial mechanisms, and capacity building supported by strong political support could mitigate these challenges in a very effective manner. The trajectory of solar energy in Pakistan can only be achieved when the public, the private sector, and the local communities work together and create an environment that encourages innovation and investment. It unlocks the country's renewable energy potential. This further opens opportunities for the realization of cleaner and sustainable energy in the country. The successful integration of solar energy into the national energy mix would also benefit the country's economic development while keeping the global sustainable development goals (SDGs) in perspective. This guarantees a brighter future for all sections of society.

References

Ahmar, M., Ali, F., Jiang, Y., Wang, Y., & Iqbal, K. (2022). Determinants of Adoption and the Type of Solar PV Technology Adopted in Rural Pakistan. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/fenvs.2022.895622

Ali, S., Poulova, P., Akbar, A., Javed, H. M. U., & Danish, M. (2020). Determining the Influencing Factors in the Adoption of Solar Photovoltaic Technology in Pakistan: A Decomposed Technology Acceptance Model Approach. *Economies*, *8*(4), 108. https://doi.org/10.3390/economies8040108

Ali, S., Yan, Q., Irfan, M., Ameer, W., Atchike, D. W., & Acevedo-Duque, Á. (2022). Green Investment for Sustainable Business Development: The Influence of Policy Instruments on Solar Technology Adoption. *Frontiers in Energy Research*, *10*. https://doi.org/10.3389/fenrg.2022.874824

Androniceanu, A., & Sabie, O. M. (2022). Overview of Green Energy as a Real Strategic Option for Sustainable Development. *Energies*, *15*(22), 8573. https://doi.org/10.3390/en15228573

Asghar, N., Amjad, M. A., Rehman, H. U., Munir, M., & Alhajj, R. (2023). Causes of Higher Ecological Footprint in Pakistan: Does Energy Consumption Contribute? Evidence from the Non-Linear ARDL Model. *Sustainability*, *15*(4), 3013. https://doi.org/10.3390/su15043013

Asim, M., Qamar, A., Kanwal, A., Uddin, G. M., Abbas, M. M., Farooq, M., Kalam, M. A., Mousa, M., & Shahapurkar, K. (2022). Opportunities and Challenges for Renewable Energy Utilization in Pakistan. *Sustainability*, *14*(17), 10947. https://doi.org/10.3390/su141710947

Azarpour, A., Mohammadzadeh, O., Rezaei, N., & Zendehboudi, S. (2022). Current status and future prospects of renewable and sustainable energy in North America: Progress and challenges. *Energy Conversion and Management*, *269*, 115945. https://doi.org/10.1016/j.enconman.2022.115945

Batool, K., Zhao, Z., Atif, F., & Dilanchiev, A. (2022). Nexus Between Energy Poverty and Technological Innovations: A Pathway for Addressing Energy Sustainability. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/fenvs.2022.888080

Din, S. U., Wimalasiri, R., Ehsan, M., Liang, X., Ning, F., Guo, D., Manzoor, Z., Abu-Alam, T., & Abioui, M. (2023). Assessing public perception and willingness to pay for renewable energy in Pakistan through the theory of planned behavior. *Frontiers in Energy Research*, *11*. https://doi.org/10.3389/fenrg.2023.1088297

Gan, K. E., Taikan, O., Gan, T. Y., Weis, T., Yamazaki, D., & Schüttrumpf, H. (2023). Enhancing Renewable Energy Systems, Contributing to Sustainable Development Goals of the United Nations, and Building Resilience Against Climate Change Impacts. *Energy Technology*, *11*(11). https://doi.org/10.1002/ente.202300275

Habib, M. I., Ghazi, H. M., Sajjad, S., Khan, M., Aslam, F., Mushtaq, M. A., Hussain, S. K., Bhatti, H. A., Naeem, I., & Nadeem, M. A. (2024, June 1). *Design, Development, and Deployment of an IoT-Enabled Solar Energy Meter*. https://www.jcbi.org/index.php/Main/article/view/522

Haq, F. U., Rashid, T. U., & Zia, U. U. R. (2022). Socio-Economic Prospects of Solar PV Uptake in Energy Policy Landscape of Pakistan. *International Journal of Renewable Energy Development*, *11*(4), 936–949. https://doi.org/10.14710/ijred.2022.46082

Hassan, Q., Viktor, P., Al-Musawi, T. J., Ali, B. M., Algburi, S., Alzoubi, H. M., Al-Jiboory, A. K., Sameen, A. Z., Salman, H. M., & Jaszczur, M. (2024). Renewable energy's role in global energy Transformations. *Renewable Energy Focus*, *48*, 100545. https://doi.org/10.1016/j.ref.2024.100545

Izam, N. S. M. N., Itam, Z., Sing, W. L., & Syamsir, A. (2022). Sustainable Development Perspectives of Solar Energy Technologies with Focus on Solar Photovoltaic—A Review. *Energies*, *15*(8), 2790. https://doi.org/10.3390/en15082790

Khalil, L., Abbas, S., Hussain, K., Zaman, K., Iswan, N., Salamun, H., Hassan, Z. B., & Anser, M. K. (2022). Sanitation, water, energy use, and traffic volume affect environmental quality: Go-for-green developmental policies. *PLoS ONE*, *17*(8), e0271017. https://doi.org/10.1371/journal.pone.0271017

Khan, N., Elhindi, K. M., Kassem, H. S., Kazim, R., & Zhang, S. (2024). Unveiling the nexus between solar energy adoption and crop farmer income: evidence from Pakistan. *Frontiers in Sustainable Food Systems*, *8*. https://doi.org/10.3389/fsufs.2024.1364040

Khatri, S. A., Mirjat, N. H., Harijan, K., Uqaili, M. A., Shah, S. F., Shaikh, P. H., & Kumar, L. (2022). An Overview of the Current Energy Situation of Pakistan and the Way Forward towards Green Energy Implementation. *Energies*, *16*(1), 423. https://doi.org/10.3390/en16010423

Komninos, N. (2022). Net Zero Energy Districts: Connected Intelligence for Carbon-Neutral Cities. *Land*, *11*(2), 210. https://doi.org/10.3390/land11020210

Mustafa, M., Malik, M. O. F., & Maqsoom, A. (2024). Barriers to Solar PV Adoption in Developing Countries: Multiple Regression and Analytical Hierarchy Process Approach. *Sustainability*, *16*(3), 1032. https://doi.org/10.3390/su16031032

Orangzeb, S., Qaisrani, M. A., Shafiq, M. B., Ahmed, N., Sahar, M. S. U., Ullah, S., Farooq, M. U., & Jiabin, F. (2023). Potential Assessment and Economic Analysis of Concentrated Solar Power against Solar Photovoltaic Technology. *International Journal of Energy Research*, *2023*, 1–26. https://doi.org/10.1155/2023/3611318

Rehmani, A. M., Kazmi, S. a. A., Altamimi, A., Khan, Z. A., & Awais, M. (2023). Techno-Economic-Environmental Assessment of an Isolated Rural Micro-Grid from a Mid-Career Repowering Perspective. *Sustainability*, *15*(3), 2137. https://doi.org/10.3390/su15032137

Shah, H. H., Bareschino, P., Mancusi, E., & Pepe, F. (2023). Environmental Life Cycle Analysis and Energy Payback Period Evaluation of Solar PV Systems: The Case of Pakistan. *Energies*, *16*(17), 6400. https://doi.org/10.3390/en16176400

Shah, S. M. K., Rasheed, T. U., & Ali, H. M. (2022). Smart Integrated Decentralization Strategies of Solar Power System in Buildings. *International Journal of Photoenergy*, *2022*, 1–14. https://doi.org/10.1155/2022/9311686

Soomar, A. M., Hakeem, A., Messaoudi, M., Musznicki, P., Iqbal, A., & Czapp, S. (2022). Solar Photovoltaic Energy Optimization and Challenges. *Frontiers in Energy Research*, *10*. https://doi.org/10.3389/fenrg.2022.879985

Turi, J. A., Rosak-Szyrocka, J., Mansoor, M., Asif, H., Nazir, A., & Balsalobre-Lorente, D. (2022). Assessing Wind Energy Projects Potential in Pakistan: Challenges and Way Forward. *Energies*, *15*(23), 9014. https://doi.org/10.3390/en15239014

Usman, M., Jahanger, A., Radulescu, M., & Balsalobre-Lorente, D. (2022). Do Nuclear Energy, Renewable Energy, and Environmental-Related Technologies Asymmetrically Reduce Ecological Footprint? Evidence from Pakistan. *Energies*, *15*(9), 3448. https://doi.org/10.3390/en15093448

Vijayan, D. S., Koda, E., Sivasuriyan, A., Winkler, J., Devarajan, P., Kumar, R. S., Jakimiuk, A., Osinski, P., Podlasek, A., & Vaverková, M. D. (2023). Advancements in Solar Panel Technology in Civil Engineering for Revolutionizing Renewable Energy Solutions—A Review. *Energies*, *16*(18), 6579. https://doi.org/10.3390/en16186579

Xin, Y., Dost, M. K. B., Akram, H., & Watto, W. A. (2022). Analyzing Pakistan's Renewable Energy Potential: A Review of the Country's Energy Policy, Its Challenges, and Recommendations. *Sustainability*, *14*(23), 16123. https://doi.org/10.3390/su142316123