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Determinants of Green Energy Use: Household Level Comparative Analysis of Southern Khyber Pakhtunkhwa

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Abstract: *In recent times, the utilization of renewable energy sources has gained significant traction and garnered widespread attention across diverse social segments. The prominent driver behind this surge in popularity is its cost-effectiveness and long-term durability. Notably, even individuals with limited financial means are increasingly drawn toward various forms of renewable energy. This research endeavor aims to draw comparisons between users and non-users of green energy and their corresponding household behaviors. Upon conducting a rigorous data analysis, the study will present a comprehensive and well-founded conclusion, along with offering pertinent recommendations. This study is slated to take place in the rural regions of Southern Khyber Pakhtunkhwa, Pakistan. The study employed random sampling to select a sample from the population and focused on examining the relationship between the utilization of green energy, its characteristics, conventional green energy use, and the quality of solar energy. The primary objective of the study was to explore the choices made by individual households concerning green energy consumption and the factors that influence this choice. The analysis was carried out using Ordinary Least Squares (OLS) regression. This research gap presents a significant opportunity for advancing the promotion and adoption of renewable energy sources.*

Key Words: Green Energy Use, Determinants, Household Level Analysis, Khyber Pakhtunkhwa, Pakistan

Introduction

Southern Khyber Pakhtunkhwa (KP) in Pakistan grapples with challenges related to household energy systems. The region faces a lack of proper infrastructure and access to reliable energy sources, impacting the socio-economic dynamics within households. The absence of a robust energy system significantly affects daily life, economic activities, and overall development prospects. This research aims to conduct a comparative analysis of household energy systems in Southern Khyber Pakhtunkhwa, shedding light on the disparities, limitations, and potential solutions.

Understanding the dynamics of household energy systems in Southern Khyber Pakhtunkhwa is crucial for policymakers, NGOs, and relevant stakeholders. This research will provide valuable insights into the pressing energy needs of households, aiding in the development of targeted interventions and policy frameworks to improve energy access, enhance living standards, and promote sustainable development.

In recent decades, renewable energy has garnered significant attention from policymakers, researchers, and the international community, particularly in developing nations. It is evident that renewable energy has emerged as a crucial component in the transition toward cleaner economies and the fight against climate change. Renewable energy now holds a vital role in national and regional energy supply. Moreover, it plays a pivotal part in curbing environmental degradation by reducing pollution. The inherent importance of both the consumption and production of renewable energy for the environment, societal well-being, and addressing climate change urges economies to prominently feature renewable

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energy-related policy initiatives in their political and social agendas. At the global level, the demand for renewable energy is becoming increasingly imperative(Iqbal, Wang, Ali, Haider, & Amin, 2023).

Over the past two decades, Pakistan has grappled with a severe energy crisis, leaving more than 145 million people without reliable access to electricity. Shockingly, 60.29 million individuals in Pakistan still lack any access to electricity. In 2018, the electricity deficit reached an alarming 6500 MW, resulting in an average of 6 to 9 hours of daily power outages. This issue is particularly acute in rural areas, where daily power cuts lasting 12 to 14 hours have had devastating consequences for the country's economic growth. To illustrate the gravity of the situation, nearly five million daily wage earners have been forced out of work due to this ongoing calamity(Rauf et al., 2022).

In Pakistan, approximately half of the population resides in remote rural areas without access to electricity, leading to heavy dependence on energy imports, which places a significant economic burden. Therefore, it is imperative for the government to implement Renewable Energy Technologies (RETs) to reduce this dependency. However, there are several formidable barriers that must be overcome to effectively deploy RETs, encompassing economic, technical, market-related, institutional, political, environmental, and social challenges. Addressing these multifaceted obstacles is essential for the successful development of renewable energy technologies, as the attainment of development targets would be otherwise unattainable. These barriers are particularly intricate and crucial, particularly for developing nations seeking to enhance energy access and security by increasing the proportion of renewable energy in their energy mix(Solangi, Longsheng, & Shah, 2021).

Pakistan, like many other developing nations, requires a consistent, sufficient, cost-effective, and sustainable energy source to catalyze broader economic development, elevate living standards, and foster socio-economic prosperity. Nevertheless, the country faces a critical electricity deficit that obstructs economic progress. Despite a 99% accessibility rate to electricity, citizens still struggle to access dependable and adequate power. Widespread and extended power cuts lasting 8 to 10 hours in urban areas and 18 to 22 hours in rural regions are causing significant disruptions. This nationwide major power outage is causing substantial financial losses in key economic sectors, which are grappling with unreliable and insufficient energy supplies(Solangi et al., 2021).

Sustainable energy is a crucial factor for the continuous economic growth of any society. Currently, developing countries are grappling with substantial challenges in meeting their energy needs. Despite the efforts of policymakers to address these issues, they have struggled to bridge the gap between energy demand and supply. Shockingly, 11% of the global population still lacks access to various forms of energy. Over time, various policies have been introduced to promote renewable energy, particularly in remote areas where access to gas and electricity is limited. This research project seeks to identify the most significant renewable energy source for Pakistan's economy, emphasizing the economic advantages it can bring, such as job creation in the energy sector. The primary goal of this study is to discover ways to ensure a stable energy supply while also reaping economic benefits. The research ultimately recommends embracing renewable energy technologies that offer the lowest operational and externality costs, making them the most viable choice for the future. From a policy perspective, the Pakistani government should take decisive actions to support renewable energy and technological innovation, which may require sustained investments in biomass resources that are not environmentally harmful(Ahmad, Usman, Hussain, Jahangir, & Abrar, 2022).

Research Objective

The overall objective of the current study is to investigate household behaviors towards usage or otherwise of various forms of green energy. Therefore, the objectives of the study are;

The study aims to first discern the drivers behind increased green energy adoption within households, seeking to enumerate specific factors that encourage its consumption. This involves compiling a comprehensive list of attributes characterizing user households, essential for effectively distinguishing non-users and enabling precise targeting for potential future governmental or non-governmental interventions. Secondly, the focus lies on unraveling the nuances in preferences regarding green energy consumption. This entails understanding the distinctive choices made by users versus non-users

concerning their utilization and preferences for various types of green energy sources. By delving into these differences, the research endeavors to provide insights crucial for devising tailored strategies aimed at promoting sustainable energy consumption among households, thereby fostering a more environmentally conscious and energy-efficient society.

Literature Review

There is a growing recognition of the significance of climate change and environmental issues on a global scale. A burgeoning area of research has begun to explore the perspectives of households concerning the utilization of green energy and environmental concerns (Du et al., 2017). The detrimental impact of industries on the environment is widely acknowledged, primarily due to unsustainable production and consumption practices (Tseng et al., 2018).

Global economies are engaged in a race to rapidly revive fossil fuel production to meet growing energy demands, often with limited regard for environmental concerns. This excessive exploitation of natural resources is resulting in ecological degradation, emphasizing the urgent need to raise awareness about environmental issues and promote sustainable consumption (Alhaj et al., 2016).

Many nations and international institutions are placing significant emphasis on advancing environmentally sustainable progress (Song et al., 2015a). Some experts contend that the surge in energy consumption from sustainable sources and the shift towards converting to renewable energy, such as solar panels (Gençer and Agrawal, 2018), is occurring at a rapid pace.

Qureshi et al. (2017) have emphasized the significant role of information exchange among consumers in driving the adoption of solar photovoltaic technology. Many individuals are motivated to embrace eco-friendly innovations, drawing inspiration from innovative approaches to address current challenges. For instance, India has prioritized the utilization of solar systems for household lighting, cooking, and heating purposes, and this emphasis directly impacts the installation of solar equipment in residential settings. Solar equipment, including systems for water heating, lighting, and cooking, is readily accessible to Indian households (Upadhyay & Chowdhury, 2014).

The installation of lighting systems, including garden lights, various torches, and security lights, is designed to be straightforward and hassle-free, requiring no electrical work. Solar panels are placed on rooftops or buildings, initially incurring an installation cost for households. However, once installed, these systems come with minimal ongoing expenses for an extended period, making them economically viable over their usage duration (Borah et al., 2014). Furthermore, solar panels contribute to lower monthly bills by eliminating the need for gas and oil consumption, ultimately resulting in reduced pollution and a cleaner environment.

Renowned scholars and the International Energy Agency (IEA) acknowledge that the availability of clean, sustainable, and efficient energy sources is increasingly being regarded as an essential requirement for ensuring and promoting sustainable development (Zhu et al., 2017).

There is a growing emphasis on making it more accessible and cost-effective to address the essential energy and basic needs of low-income households in developing countries through performance-based approaches. These strategies serve as a cornerstone for income-generating activities and offer business opportunities for individuals with limited resources. Furthermore, they play a pivotal role in promoting greater social equity and contribute to the provision of innovative services such as communication, education, healthcare, and water management. Additionally, these approaches support sustainable economic growth and financial development with an environmental focus (Guta et al., 2017).

This revelation underscores the fact that indoor air pollution has emerged as a significant global health hazard. Likewise, the heavy reliance on traditional bioenergy sources such as dung cakes, crop residues, fuelwood, and charcoal is a major contributor to the alarming depletion of forests due to ecological disruptions caused by rural households, as well as losses in agricultural productivity. Consequently, there is a widespread agreement that transitioning to modern energy sources is essential for creating a cleaner environment, elevating living standards, and fostering the kind of green economic development that numerous countries aspire to achieve (Campbell et al., 2019).

Nelson and Starcher (2018) argue that solar and wind energy technologies offer superior environmental benefits compared to hydroelectric energy and do not encounter the challenges associated with nuclear energy or storage issues. These renewable sources generate direct current (DC) electricity, which is commonly converted into alternating current (AC) using AC/DC inverters.

Kapoor and Dwivedi (2020) delved into the various determinants that influence households' decisions to embrace solar energy equipment. They underscored that the adoption choices made by households are not solely influenced by factors such as the physical environment and economic aspects. Instead, they emphasized that a complex interplay of lifestyle choices, signals from household situations, and access to information also play pivotal roles. Furthermore, a Bangladeshi study shed light on how distinct factors contribute to the acceptance and satisfaction levels regarding the utilization of solar panel systems in homes. This study revealed that the adoption of home solar systems can bring about lifestyle changes, such as an increase in children's study time, among other benefits. Numerous studies have explored the idea that the adoption of household solar systems can exhibit a peer effect, as exemplified by (Rai et al., 2016).

Enhancing rural development through the utilization of renewable energy requires concerted efforts to mobilize resources effectively. In 2015, the Millennium Development Goals (MDGs) outlined approximately eight specific objectives and targets. The primary focus of these MDGs was poverty reduction through rural development. Another critical MDG objective aimed to alleviate energy poverty while promoting environmental sustainability. In 2002, the Sustainable Development Summit made a commitment to align clean energy initiatives with sustainable development goals. This commitment was subsequently embraced by the United Nations General Assembly, emphasizing the provision of affordable and eco-friendly energy solutions. A significant portion of the Indian population still relies on traditional energy sources. The United Nations is dedicated to reducing this heavy dependence on conventional energy and aims to minimize the escalating demand for renewable energy solutions. It is important to note that the world's rapidly increasing population will inherently drive greater demand for clean and cost-effective energy sources (Bhattacharyya, 2006).

Garniwa andHerdiansyah (2021) research delved into the potential of solar power as a crucial component in shaping energy policies aimed at addressing the energy challenges faced by remote regions. Notably, countries like India and China, both of which are still grappling with underdevelopment, have emerged as significant players in the adoption of solar power solutions. This transition to solar power isn't merely an alternative; it also aligns with the seventh goal of modern and sustainable development. An illustrative instance of this transition is the provision of dependable, cost-effective, contemporary, and sustainable energy to remote populations that are unable to access the national electrical grid. Solar power stands out as a prime example of off-grid solutions implemented in underdeveloped nations, facilitating the delivery of electricity to communities that have long-awaited integration with the national power network. Nevertheless, it is essential to acknowledge the challenges in the renewable energy sector, such as instances of system failure, like the case of Guatemala, where 45% of solar power systems have become defunct, and Laos experiencing a 65% failure rate.

Zhan et al. (2020) discuss the utilization of renewable solar energy as a sustainable, long-term solution for space heating. Solar heating systems have found widespread applications worldwide, with notable adoption in Europe, particularly in Germany, where rural homes have harnessed solar energy for heating. This adoption has led to substantial energy savings and improved thermal comfort. Many countries have made significant efforts to introduce solar heating systems into rural households. In China, the world's largest technology market, there is a high demand for advanced solar heating systems in rural areas owing to a well-established solar industry. Additionally, alternative energy sources have been explored in conjunction with solar power. Various energy sources, including gas, coal, and electricity, have been considered for heating purposes alongside solar power. Conventional coal-fired boilers have been a common choice due to their ability to reduce environmental pollution and enhance indoor air quality. Electric heaters and heat pumps have also been considered, with electric heaters being less efficient due to their heavy reliance on the electrical grid. However, the cost of heat pumps has posed a challenge for farmers looking to invest in these systems. Solar power emerges as a supplementary energy system that is not only eco-friendly but also contributes to the rural economy by encouraging the cultivation of biofuel crops.

The government of Pakistan is actively promoting the widespread adoption of affordable solar energy across the nation. Their efforts encompass various measures, including incentives, financial support, and regulatory frameworks. To entice investors, the government is offering fiscal and financial incentives. Notably, the federal government has allocated a substantial sum of 23 billion rupees to facilitate the conversion of tube wells to solar power in Balochistan.

Additionally, in Khyber-Pakhtunkhwa, an investment of approximately 400 million rupees is earmarked for the installation of solar photovoltaic systems in off-grid households across 200 rural villages. Furthermore, in Punjab, there are plans to solarize approximately 1100 government schools. In KPK, the government will shoulder 90% of the cost of solar photovoltaic systems, with households contributing the remaining 10%. These systems will include a 200-watt solar panel, two batteries, and associated accessories. Furthermore, non-profit organizations are collaborating with the government to provide solar panels to economically disadvantaged individuals living in hilly regions. Some of these non-profit organizations have introduced financial schemes that allow impoverished individuals to pay for these installations in installments based on their financial capabilities. Currently, the country relies heavily on fossil fuels for electricity generation, which places a significant economic burden. Hydropower serves as a secondary source of electricity. Approximately 40,000 villages lack access to electricity, and solar panels offer a viable alternative to address this electricity deficit. Previous research suggests that effective coordination among various institutions can bridge the existing gaps in this endeavor (Shah et al., 2018).

The literature overview delves into the topic of rural electrification, with a primary focus on mini-grids within the Indian context. In rural regions of Asia and sub-Saharan Africa, approximately one million individuals still lack access to electrical power. Addressing this deficiency can be achieved by harnessing solar energy, as emphasized by the International Energy Agency (IEA) in 2017. Renewable energy stands as a viable solution for delivering affordable electricity to rural populations. Advancements in technology and cost reductions have made it increasingly feasible to transition to solar energy. Solar energy not only offers lighting solutions but also facilitates mobile device charging services. The growing popularity of mini-grids and solar power plants can be attributed to their affordability and easy accessibility, as noted by the IEA in 2017. According to a survey conducted in 2018 by the International Renewable Energy Agency (IRENA), approximately 9 million individuals have already benefited from mini-grids. Looking ahead to the future, Vision 2030 sets an ambitious target, aiming to serve 100 million people through mini-grids and provide 65% of new electricity connections by the year 2030, as outlined by (Sharma et al., 2020).

Akintande et al.(2020) argued that renewable energy represents a highly favorable choice. This form of sustainable and eco-friendly energy is deemed a practical solution to combat global warming and address climate change. Consequently, renewable energy has garnered significant attention in global energy discussions aimed at resolving problems and promoting sustainability. In 2014 and 2015, renewable energy made substantial contributions, accounting for 19.2 percent of global energy consumption and 23.7 percent of electricity generation.

Recent research indicates a growing focus on environmental pollution among stakeholders, who increasingly perceive it as a primary contributor to global warming and climate change. The adverse impacts of global warming and climate change are seen as detrimental to the quality of life and economic prosperity, particularly in industrialized nations. Developing countries are striving to enhance their economic growth and living standards by increasing their production output. However, many countries have inadvertently prioritized output expansion over reducing CO2 emissions, leading to a misallocation of energy resources. Numerous studies have delved into this subject, employing econometric methods to explore the intricate relationship between energy consumption, economic growth, and carbon emissions (Rjoub et al., 2021).

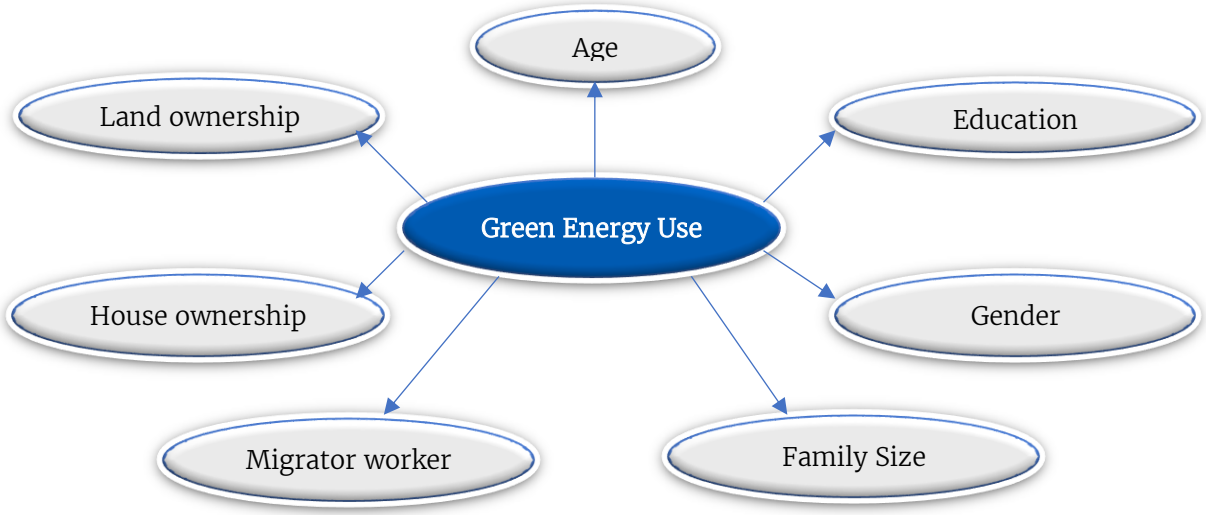
Global energy consumption is on the rise owing to factors such as a growing population, expansive agricultural practices, industrialization, and the proliferation of automobiles (Jan et al., 2020). These challenges are closely linked to the utilization of non-renewable energy sources, prompting nations worldwide to transition towards renewable energy alternatives (Raheem et al., 2016). Among the various renewable energy sources, solar energy stands out as the most promising option due to its abundant availability, economic viability, and perpetual nature (Kabir et al., 2018).

Research Methodology

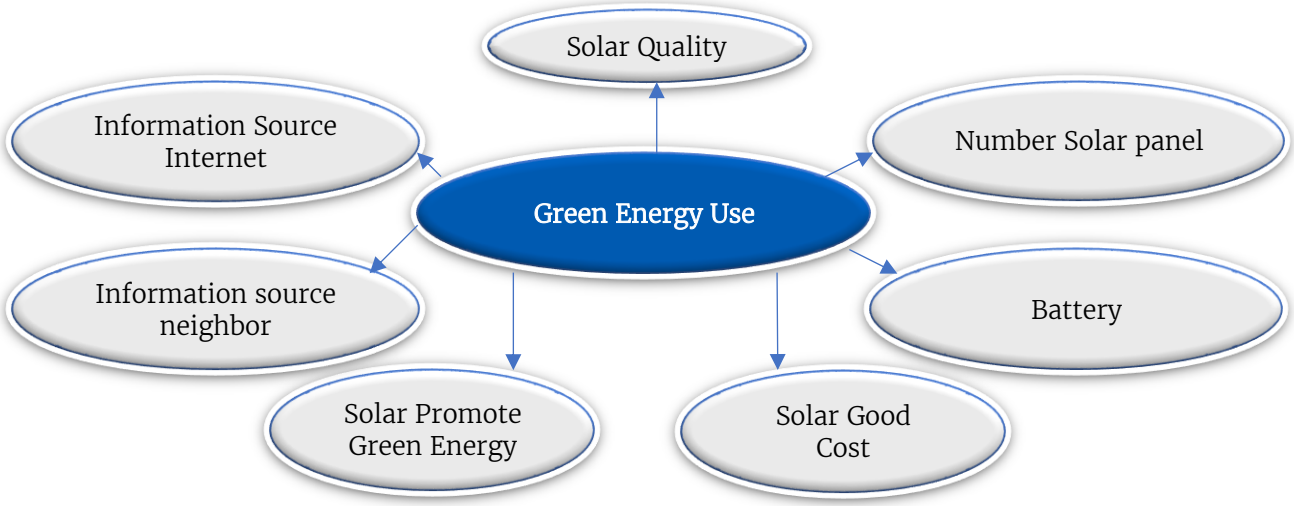
Theoretical Framework

In this study, we have embraced a specific theoretical framework that centers on the concept of green energy values. This framework employs a multi-dimensional construct encompassing various facets. These facets are expounded upon in accordance with the descriptions provided by (Sangroya and Nayak, 2017).

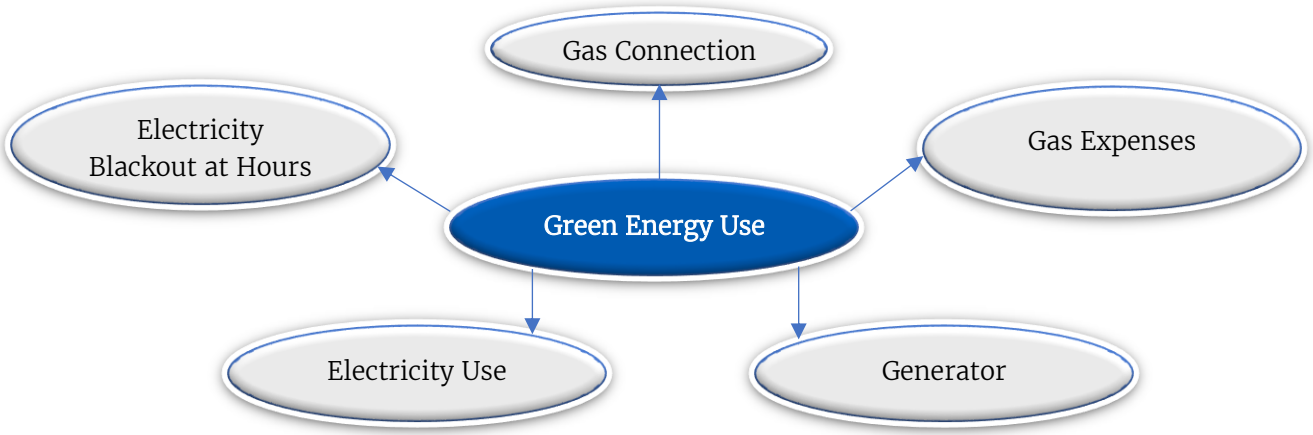
Attributes of Renewable Energy



The Caliber of Renewable Energy



Traditional utilization of renewable energy sources



Study Area

This study encompasses the five districts located in the southern region of Khyber Pakhtunkhwa: Karak, Kohat, Bannu, Lakki Marwat, and Dera Ismail Khan. These underdeveloped regions in less developed countries face significant challenges, such as the lack of access to electricity and natural gas, which are essential for human needs and integral to daily life.

Karak

Karak, with a total population of approximately 706,299 residents, is characterized by a demographic distribution of roughly 51 percent female and 49 percent male. The district spans an area of 3,372 square kilometers. However, it faces a multitude of pressing issues, including challenges related to water supply, gas provision, and electricity access. In terms of gas supply, there is a notable absence of legal connections, prompting many residents to resort to unauthorized connections, exacerbating the problem. The water situation is equally troubling, with inadequate access for many inhabitants, as well as concerns related to uranium contamination that has led to instances of cancer in areas like ShnawaGodikhel. Additionally, certain areas grapple with the issue of saline water. The electricity supply in Karak is plagued by various issues, including an unclear billing system that has resulted in power shortages in some regions. Even in areas with connections, frequent and prolonged blackouts lasting between 12 to 20 hours within a 24-hour period have become a common occurrence. The dominant occupations in Karak primarily revolve around government and private-sector employment.

Kohat

Kohat has a total population of approximately 1,627,132 people, with females comprising roughly 52 percent and males around 48 percent. The district spans an area of 2,545 square kilometers. The overall literacy rate in the district stands at 44.1 percent. In Kohat, the urban areas enjoy a reliable and efficient electricity system, while the situation in rural areas varies. The billing system in rural areas is functional, ensuring electricity availability, but there are challenges in ensuring consistent power supply. Regarding water supply, Kohat boasts a well-functioning system. However, access to gas is primarily limited to the main city and the Kohat Development Authority (KDA) area. Kohat District is considered relatively advanced in Khyber Pakhtunkhwa (KP) due to its active participation in hydrocarbon extraction, robust mining activities, a thriving horticulture sector, and a prosperous agriculture industry.

Bannu

The overall population of Bannu stands at approximately 1,167,892 individuals, with females making up approximately 49 percent and males approximately 51 percent of the total. The district covers a total area of 1,227 square kilometers. The literacy rate for the entire district is relatively low, at 32.11 percent. In rural areas of Bannu, there is a severe shortage of electricity, resulting in a blackout for approximately 20 out of 24 hours due to inadequate billing systems. However, the urban areas have a more reliable electricity supply. The primary issue with water supply in some specific tehsils of Bannu is the presence of salty water. The major occupations in the district include business, overseas employment, and agriculture, with an annual milk production of around 540 million liters. Unfortunately, there is no access to natural gas throughout the entire district. In rural regions, electricity access is limited, and even when available, there are extensive power outages lasting 18 to 20 hours in a 24-hour period. In contrast, urban areas experience shorter power outages, typically ranging from 4 to 6 hours within a 24-hour timeframe.

Lucky Marwat

Lucky Marwat is a district with a total population of approximately 876,182 people, with roughly 51 percent being female and 49 percent being male. The district spans an area of 3164 square kilometers and has an overall literacy rate of 59 percent. According to data from the statistical bureau, the uncultivated land in the district exceeds the cultivated land, and the primary crops grown include rice, maize, bajra, and sugarcane. Some rural areas in Lucky Marwat experience frequent power outages lasting between 12 to 18 hours within a 24-hour period, while access to gas is limited to the city.

Dera Ismail Khan

Dera Ismail Khan, a district in Khyber Pakhtunkhwa situated along the western bank of the Indus River, boasts a substantial population of 1,627,132 residents spread across an expansive area of 7326.4 square kilometers. The literacy rate in the entire district stands at 31.2 percent. Dera Ismail Khan exhibits significant potential for business and economic development, given its vast tracts of land that support the cultivation of various fruits and crops, benefiting numerous households. Furthermore, the availability of natural gas extends not only to the city but also to select village councils. However, it is important to note that rural areas experience power outages ranging from 8 to 12 hours within a 24-hour period, while urban areas face electricity lasting from 3 to 5 hours to 5 hours of blackout.

Sampling Strategies and Sample Size

To achieve our stated objectives, we will employ a structured questionnaire to gather data from a sample of 257 individuals. This sample will be drawn randomly from two groups: the treatment group (users of green energy) and the control group (non-users). Our study will be conducted in the Southern Khyber Pakhtunkhwa region.

Our sampling process will involve three stages:

In the initial stage, we will include all districts within Southern Khyber Pakhtunkhwa, specifically Bannu, Karak, Kohat, LakiMarwat, and D.I Khan.

In the second stage, we will randomly select Tehsils from these districts. The chosen Tehsils will be Domel, TakhtiNusrati, Kohat, SariaNaurang, D.I Khan, and Paroa.

Table 1

Sample distribution by districts

District Name	Tehsil Name	Frequency	Percent
Bannu	Domel	51	19.84
Lucky Marwat	SariaNaurang	49	19.07
Kohat	Kohat	52	20.23
Karak	Takhtinusrati	55	21.40
Dera ismail khan	Dera ismail khan	27	10.51
Dera ismail khan	Paroa	23	8.95
Total		100	100

Table 2

Village-wise distribution of sample

Village Name	Population	Frequency	User	Non-user
Kamarkalla	3646	51	50	1
Narmuhammad khan ghaznikhel	3331	49	49	0
Jarma	4884	52	52	0
Bogara	4165	55	55	0
Muriali	6120	21	0	21
Qayumnagar	5550	29	23	6
Total		257	229	28

Research Tools

A meticulously structured survey questionnaire, encompassing both open-ended and closed-ended questions, has been meticulously crafted for the purpose of data collection in this research study. The administration and oversight of this questionnaire are conducted subsequent to a comprehensive assessment of the research team's qualifications and with the involvement of experts in the relevant field.

Research Questions

Respondent's Age, Respondent's Education Illiterate=0 Literate=1 primary=5 middle=8 matric=10 intermediate=12 B.A/BSC=14 b.s=16 M.A/M.sc=17 M.phil=18 P.H.D=23, Respondent's Gender

Male=1/female=0, Family Size, If one of more family member(s) is/are working outside the country? Yes=1/No=0, Do you have your own house? Yes=1/No=0, Do you have land? Yes=1/No=0.

Do you have batteries to save solar energy? Yes=1, No=0, Do you use electricity (from WAPDA)? Yes=1/No=0, If electricity blackout (load shedding) is yes, then duration in hours per week, Electricity bill (monthly), Do you have a generator? Yes=1/No=0, Do you have a generator? Yes=1/No=0.

Type of solar panel: mono-crystalline=1, polycrystalline=2, number of solar panels. Green energy is a good source of energy based on its cost (installation and running?yes=1/No=0. For green energy, the solar panel is a good source in terms of its lower cost (installation and operational cost); Yes=1/No=0? I am using solar power to promote green energy. Yes=1/No=0 (only for current users of solar power). If yes, then what is the source of this information? Neighbor and internet.

Econometric Model

In this study, we will use the following model for analysis;

Model 1

$$Status=\beta_0+\beta_1\sum \text{User Characteristics}+\beta_2\sum\text{Characteristics of Energy Used}+ \beta_3\sum\text{Decision Making Process}+\mu$$

Model 2

$$\text{Decision Making Process}=\beta_0+ \beta_1\sum \text{User Characteristics}+\beta_2 \sum\text{Characteristics of Energy Used}+\mu$$

Where;

Status= Treatment Group (User) =1, Control Group (Non-user)=0

Decision-Making Process Source of information: Media (TV, Newspaper, Internet), Individual (Friend, Relative, Neighbor), and Organization (NGO, Local Government) that led to decision-making of using green energy.

User Characteristics= Age, Education, and Profession of Respondent

Characteristics of Energy Used = Type, Cost, and Perception of Energy Used.

Result and Discussion

Data

Table 3

Summary statistics

Description	Variable	Observation	Mean	Std. Dev.	Min	Max
Age of respondent (in a year)	age_resp	257	30.35	9.017	19	55
Education of respondent, Illiterate=0 Literate=1 primary=5 middle=8 matric=10 intermediate=12 B.A/BSC=14 b.s=16 M.A/M.sc=17 M.phil=18 P.H.D=23	edu_res	257	12.89	4.073	0	23
Gender respondent, (Male=1 female=0)	gender_res	257	.97	.151	0	1
Household size	total_family	257	12.48	10.744	2	95
Overseas worker, (yes=1 No=0)	mig_wrkr	257	.10	Dummy	0	1
House ownership, (Yes=1/No=0)	Own house	257	.96	Dummy	0	1
Land ownership, (yes=1 No=0)	Land	257	.52	Dummy	0	1
Gas connection, (yes=1 No=0)	gas_conction	257	.15	Dummy	1	0

Description	Variable	Observation	Mean	Std. Dev.	Min	Max
Gas expenditure in rupees (per month)	gas_exp	257	163.67	564.644	0	5000
Electricity use, (yes=1 no=0)	Elect use	257	.97	Dummy	0	1
Electricity blackout (per week) at hours	elect_blckouthh	257	99.68	40.701	28	161
Generator, (yes=1 No=0)	genrtr_have	257	.13	Dummy	0	1
Solar quality (mono-crystalline=1, polycrystalline=2)	solar_qty		1.18	.589	0	2
Number of solars	sp_no	257	3.89	4.793	0	40
Battery, (yes=1 no=0)	Battery	257	.828	Dummy	0	1
The solar panel is a good source in terms of its lower cost (Yes=1/No=0?	solargood_~t	257	3.89	Dummy	0	1
I am using solar power to promote green energy. Yes=1/No=0 (only for current users of solar power)	green_ener~r	257	.89	Dummy	0	1
Use of solar information from neighbor	Infosrce neighbor	257	.20	Dummy	0	1
Use of solar information from the internet	Infosrce internet	257	.15	Dummy	0	1

Table number 3 provides an overview of key statistics for various variables used in the regression analysis. The dataset includes 257 observations, with the dependent variable being green energy usage. Here are the summary statistics for the independent variables:

- The age of the respondent has a mean value of 30.35, with a minimum of 19 and a maximum of 55.
- The education level of the respondent has a mean value of 12.89, ranging from 0 for illiterate to 23 for those with a Ph.D.
- The gender of the respondent has a mean value of 0.97, indicating that 97% of the respondents are male.
- Household size has a mean value of 12.48, with a minimum of 2 and a maximum of 95.
- The percentage of respondent families with migrant workers is 10%, with a mean value of 0.10.
- House ownership is prevalent, with a mean of 0.96, indicating that 96% of respondents own their houses.
- Land ownership has a mean value of 0.52, with 52% of respondents having land.
- Gas connection is possessed by 15% of respondents, with a mean value of 0.15.
- Gas expenditure has a mean value of 163.67, with a minimum bill of 564.44 and a maximum of 5000.
- Electricity usage is widespread, with a mean value of 0.97, indicating that 97% of people have electricity connections.
- On average, there are 99.68 hours of electricity blackout per week, ranging from a minimum of 28 to a maximum of 161 hours.
- Generator usage is relatively low, with a mean value of 0.13, indicating that only 13% of people use generators.
- Mono-crystalline solar panels are favored, with a mean quality score of 1.18.
- The average number of solar panels used per household is 3.89, with a minimum of 0 and a maximum of 40.
- Battery usage for solar energy storage is prevalent, with 83% of people using batteries and a mean value of 0.826.
- Solar panels are considered cost-effective, with a mean value of 0.89, indicating that 89% of respondents believe that solar energy costs are low.
- 89% of people use solar power to promote green energy, with a mean value of 0.89 for this variable.

Result Estimation and Discussion

Attributes of Renewable Energy

Table 4

Independent Variable	Dependent Variable: Green Energy Use	
	Coefficient	Level of Significance
gender_res	0.6179924	*
Age_resp	-0.0028045	
edu_res	-0.0170552	*
Land	0.2003311	*
own_house	-0.0044453	
mig_wrkr	0.021265	
total_family	0.0003905	
_cons	0.4845743	

Notes

R-squared	0.2714	Level of significance	0.00
F-statistics	13.25	Number of observation	257

*=Level of Significance at 1 percent, **at 5 percent.

The findings from Table 4 confirm the results obtained through linear regression analysis, revealing specific associations between various factors and the utilization of green energy. The analysis indicates that age, education level of the respondent, and house ownership exhibit a negative correlation with green energy adoption. Notably, the education level of the respondent is highly significant at the one percent confidence level. On the other hand, the gender of the respondents, land ownership, family size, and the status of being a migrant worker show a positive relationship with green energy adoption. However, it's important to highlight that only gender and land ownership exhibit significant associations at the one percent significance level.

In more detail, the negative association between age and green energy use suggests that older individuals are less inclined to adopt renewable energy sources, whereas younger individuals show a preference for green energy alternatives. Similarly, the negative relationship with education underscores that people with lower educational levels are less likely to embrace green energy solutions.

Conversely, the positive and highly significant relationship associated with gender indicates that males are more inclined to adopt renewable green energy sources. Moreover, an increase in family size corresponds to an increased likelihood of green energy utilization, while migrant workers are more likely to adopt green energy when their family income rises. Interestingly, house ownership is negatively related to green energy adoption, implying that owning a house does not necessarily lead to the use of renewable green energy sources. Conversely, land ownership is positively and highly significantly linked to green energy adoption, suggesting that landowners, often considered more affluent, are more likely to embrace renewable energy options to enhance sustainability and improve their quality of life.

The Caliber of Renewable Energy

Table 5

Independent Variable	Dependent Variable: Green Energy Use	
	Coefficient	Level of Significance
elect_use	-0.0455932	
gas_exp	0.0001798	*
gas_conction	-0.3293164	*
Genrtr	-0.3816815	*
elect_blckouthh	0.0019633	*
_cons	0.8121779	

Notes

R-squared	0.6037	Level of significance	0.00
F-statistics	76.46	Number of observation	257

*=Level of Significance at 1 percent, **at 5 percent.

The findings from Table 5 affirm the results obtained through linear regression analysis. It indicates that there is a negative correlation between gas connections, electricity use, and generators and the usage of green energy. Furthermore, Gas connection and generator exhibit a significant negative relationship at a one percent confidence level. Conversely, Gas expenses and the occurrence of electricity blackout hours per week show a positive relationship and are also significantly associated with green energy use at a one percent confidence level.

The negative relationship between Gas connection, electricity use, and generators with green energy usage is particularly pronounced and highly significant. This is likely due to the fact that individuals tend to rely on one conventional energy source at a time on a micro-level, and if that energy source becomes unavailable, they opt for green energy sources. Additionally, the positive correlation between electricity blackout hours per week and green energy use is highly significant, suggesting that as blackout hours increase, people are more inclined to turn to renewable green energy sources. Gas expenses also exhibit a positive relationship, as increasing gas expenses over time tend to coincide with higher utilization of renewable green energy sources.

Traditional Utilization of Renewable Energy Sources

Table 6

Dependent Variable	Independent Variable: Green Energy Use	
	Coefficient	Level of Significance
sp_no	0.0001011	
Solargood_cost	0.4904248	*
Infosrce_neighbour	0.0100775	
Green_energy_solar	0.4936657	*
Infosrce_internet	0.0033117	
Solar_qty	0.0030398	
Battery	0.0296657	**
_cons	-0.207066	

Notes

R-squared	0.9810	Level of significance	0.05
F-statistics	1841.28	Number of observation	257

*=Level of Significance at 1 percent, **at 5 percent.

The findings from Table number 6 provide further support for the conclusions drawn from the linear regression analysis, which highlights the role of solar power in advancing green energy adoption. Specifically, it underscores that solar panels, their quantity, the utilization of batteries for energy storage, and certain factors like cost-effectiveness and sources of information play crucial roles in promoting green energy adoption.

Solar panels emerge as a cost-effective and influential catalyst for green energy adoption. Their affordability, both in terms of installation and operational expenses, bears significant statistical importance, evident at the one percent level. Furthermore, an increase in the number of solar panels and their quality is positively associated with a higher adoption of renewable green energy. When solar panel quantity increases, there is a corresponding rise in the use of environmentally friendly energy sources.

Conclusion and Recommendation Policy

Based on the findings of this study's data analysis, it can be concluded that the age of respondents exerts a significant influence on their adoption of solar panels and other renewable green energy sources. The study reveals that older individuals are less inclined toward using renewable solar energy compared to

their younger counterparts. Additionally, the data analysis indicates that highly educated respondents show a lower preference for renewable energy sources compared to those with middle or lower levels of education. Consequently, there is a need for government policies aimed at promoting the adoption of renewable energy sources, particularly targeting older and more educated individuals.

Furthermore, the study's results also highlight that homeowners are less likely to embrace renewable energy sources. To encourage greater adoption of renewable energy at the household level, it is advisable for the government to consider providing subsidies for renewable energy usage in residential settings.

The study's analysis highlights a significant disparity in the utilization of renewable energy sources within the study area, primarily due to the limited availability of conventional energy sources such as gas and electricity. This disparity presents a substantial opportunity to encourage and implement the use of renewable energy sources. Consequently, it is imperative for the government to develop a comprehensive program aimed at promoting the adoption of renewable energy sources in the southern districts of KP. To achieve this, the government should prioritize improving technological efficiency and raising awareness about renewable energy sources in the study area, thereby educating the public about their advantages, including their eco-friendliness and cost-effectiveness, at the grassroots level.

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