

IMPACT OF ELECTRICITY AVAILABILITY ON RURAL WOMEN'S EMPOWERMENT IN HUNZA, GILGIT- BALTISTAN

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Received: October 18, 2024 Revised: November 18, 2024 Accepted: December 02, 2024 Published: December 09, 2024

ABSTRACT

Electricity is a substantial requirement for the development of a community in this modern era, and women as an essential part of society are also influenced by the availability of electricity because the availability of modern technology has led to several changes in their lives. Hence, there are no prior studies that have specifically, examined the impact of electricity availability on rural women empowerment in Hunza. Therefore, this cross-sectional study analyzed the impact of electricity availability on rural women empowerment in Hunza by developing a conceptual model using Partial Least Square equation modeling (PLS-SEM). Through the questionnaire survey data were collected from 354 women in Hunza. The hypotheses were validated by implementing structural equation modeling. The outcomes reveal a noteworthy favorable influence of electricity availability on rural women's empowerment. The study's findings contribute to a deeper understanding of the dynamics between electricity access and women's empowerment in rural contexts, particularly in regions like Hunza. Collectively, the findings underscore the significance of electricity availability in shaping economic, educational, decision-making, and time allocation opportunities for rural women, thus highlighting its crucial role in fostering their empowerment in communities like Hunza.

INTRODUCTION

Energy is an essential mode that connects all of the other sustainable development goals. It is investigated that access to sustainable, inexpensive, and consistent forms of energy plays a pivotal part in enhancing the quality of livelihood opportunities, such as education, achieving food security, refining nutrition, and endorsing sustainable agriculture. Additionally, the provision of green energy also eases the lives of women and prevents them from the issues they face because of the usage of traditional sources of energy. (Sadath and Acharya 2024)

Therefore, by acknowledging the necessities of the world's inhabitants and coping with emerging crises United Nations Organization proposed 17 sustainable development goals in 2015, among which goal seven is about the delivery of

sustainable and inexpensive energy to everyone by 2030.(Memimpin and Lead n.d.). Moreover, 733 million people live without access to electricity and 2.4 million people live without clean sources of energy for cooking. However, the worldwide electricity availability has been increased from 83% to 91% between 2010 to 2020. According to the current progress pace, the world is expected to reach only 92% of electrification by 2030. Additionally, according to the statistics for 2020, about 80% of the world's population who lack access to electricity were living in rural regions, limiting their prospects to better quality public amenities. Additionally, in Sub-Saharan Africa, 75% of the world's village inhabitants are deprived of access to electricity. (UNSD, WHO, IEA, IRENA 2021)

Additionally, the financial, social, and ecological health of the community depends on a reliable supply of power. The most important component of any economy is electricity, which is also crucial for sustainable growth. However, developing countries like Pakistan are suffering from energy crises. And around the world, about 188 million school-going students don't have access to electricity. In the context of Pakistan, around 70% of work activity is affected in the business sector due to inefficient energy which resulted in 300,000 job losses, and the leading causes of energy disruption in Pakistan are inefficient government policies, lack of investments, proper planning and errors made by the general public. (Hussain, Xuotong, and Maqbool 2023)

Furthermore, it is commonly accepted that better public infrastructure is essential for the development of the economy. It is commonly known that sustainable energy and decent roads are important for development (Salehi-Isfahani and Taghvatalab 2022). The unavailability of electricity is considered a prominent barrier to the expansion and well-being of rural communities mainly in third-world nations. Therefore, The World Bank and other development organizations have made access to modern and sustainable energy, especially electricity, one of their top priorities. (Khandker et al. 2012)

And in a study by (Grogan and Sadanand 2013) examined how the availability of electricity altered the life of the inhabitants of Nicaragua an impoverished nation in Central America. The study stated that those who have access to energy in rural regions spend more time working than those who don't have access to power, and access to electricity is also considered as a crucial cause which has even stopped some deforestation because using firewood to cook is mostly responsible for deforestation.

On the other hand, Electrification is the replacement of kerosene lamps with electric lighting fixtures like bulbs, fluorescent tubes, and compact fluorescent lamps (CFL) (Kanagawa and Nakata 2008). The process of generation and dissemination of electrical power for remote and rural areas is known as rural electrification. Electricity is considered an essential component for the well-being of women.

However, despite having sufficient sources of energy Pakistan is suffering from energy crises

which is severely impacting the lives of everyone. The major causes of this and ways to overcome this crisis are suggested by some of the studies which are mentioned here. In a relative review of China, India, and Pakistan's green energy sectors and sharing opportunities, (Ahmed et al. 2016) stated that the electric power system is based on the generation, distribution, and utilization of electric power through interconnected networks. There is a dire need to focus on renewable sources of energy for electricity production because electricity is an essential factor for the well-being of society. Pakistan has inefficient infrastructure, lacks financial capital, and insufficient awareness about green energy in rural regions. Hence green energy sources can be better utilized in the three countries and their sharing can be also effective for the maintenance of peace.

While emphasizing the importance of eco-friendly sources (Arshad 2023) stated that Pakistan has a plethora of eco-friendly energy sources that can be used instead of coal. Hence, Pakistan has 175 billion tons of coal reserves which is capable of producing 5000 MW of electricity for 40 years. Along with that sustainable energy forms like sun power, wind energy, biomass, and hydel power in Pakistan are capable of generating 40,000 MW of electricity. The sustainable forms of energy are cheaper than the conventional sources of energy. Through this, the energy crisis in Pakistan can be overcome.

(Ali et al. 2023) also stated that due to Pakistan's reliance on conventional sources of energy like fossil fuels the country is suffering from energy crises, and Small-hydropower projects and pump turbines are considered a sustainable way to accomplish the energy needs of people living mainly in rural regions. Because it can provide sufficient energy without causing environmental threats. Additionally, pumps as turbines are more feasible than conventional hydro turbines. However, lack of proper planning, insufficient budget, and improper knowledge hinder Pakistan from adopting these ways to meet the electricity demands of people.

According to the National Electric Power Regulatory Authority (NEPRA), report in 2016, 32,000 communities in Pakistan lack connectivity to the national grid system. Due to this local communities use a variety of sources of energy, Like kerosene oil, diesel, and firewood, for lighting

and cooking. This is because the majority of these communities are located in isolated areas, due to which it is expensive to expand the energy system. In the Himalayan region, between 80% and 85% of households have no access to electricity. Households having electricity access typically possess more assets and appliances and can work for longer hours than households without it and it has extended the load-shedding period, which prevents them from using numerous common equipment like refrigerators and television. (Ali et al. 2019)

Sustainable energy is also viewed as an essential tool to lessen the drudgery of women and boost the empowerment of women. Modern energy sources, such as electricity, have made it easier for women to work by increasing more spare time that they can spend working on additional income-generating activities during the day. The access to electronic gadgets like television and mobile phones due to the availability of electricity has an impact on gender relations by raising awareness of domestic abuse and other concerns about women's rights. Women have access to tools for networking and social support due to mobile phones. (Kim and Standal 2019)

According to (Pradhan Shrestha et al., 2023) the lack of access to adequate energy severely influences women by consuming their time and lessening their productivity. Hence, electricity is not only perceived as a leading factor in improving education and health facilities, but it also elevates female abilities in terms of enhancing their social interaction and networks, improving their decision-making autonomy, mobility, and accessibility of information. Along with that, electricity enhances the affinities of women with their spouses. Additionally, the women utilized their saved time in earning; for example, stitching clothes through motorized machines, and women also spent their time in farming and poultry, through which they earned plenty of money to accomplish their needs on their own, which also led to increased self-esteem and self-confidence in women. Electric appliances have made the lives of women more comfortable, and their spouses also use them to help them in the kitchen. And the benefits of electricity for women outweighed the benefits for men.

However, having plenty of energy sources, still, some parts of Pakistan still lack access to

electricity. These are mainly the "Off-grid" locations, which are places where the national power system is not present. As a result, Pakistan's first alternative and renewable energy policy was created in 2006. The strategy focused on sustainable solutions to deliver electricity to remote locations and places that are not wired to the grid. Where different sources constitute the total energy output including, hydrocarbons, natural gas, furnace oil, and coal. There are MHPPs (mini/micro hydropower plants) in Gilgit Baltistan (GB) with capacities ranging from 100 to 500 kW and a combined projected potential of 300 MW, the region's current energy-producing infrastructure cannot keep up with the area's escalating energy needs. (Proceedings 2018)

Additionally, in Gilgit-Baltistan, fuel wood is utilized in almost all houses for cooking and heating, whether it comes from on-farm sources or is purchased from local merchants. Thus, fuel wood meets by far the majority of the entire energy requirement. Kerosene, in particular, is an essential source of lighting; over half of all homes also use it as a second source of fuel for cooking. Due to the challenging access and expensive transportation constraints, liquefied petroleum gas (LPG) only has very little impact. The expanding usage of electric and electronic gadgets is another factor driving up the need for batteries. The seasonal gap between supply and demand for energy in Gilgit-Baltistan is a major issue for the country's hydropower plants: Due to the low water levels in the rivers throughout the winter, the supply is greatly decreased, while the demand is maintained or even rises as a result of the cold weather. It is not possible to make up for these power shortfalls with electricity from other plants due to the insular network configuration. If available, diesel generators are employed in these regions. (Risks and Spies 2011)

Therefore, the research aims to investigate the multifaceted impacts of electricity availability on rural women empowerment in Hunza, specifically; the study focuses on assessing the dimensions of education, decision-making, time allocation, and economic empowerment as indicators of women empowerment influenced by the availability of electric Moreover, various studies have focused on women's empowerment in the context of electricity availability, but little attention has been given to how women are influenced by the availability of

electricity, especially in rural regions of Pakistan mainly in the Hunza region. Therefore, this thesis tries to measure the causal relationship between the availability of electricity and women's empowerment along with that this study also wants to explore the mediating role of social capital in Hunza and attempts to examine the impact of electrification from the standpoint of the local women, using a 'gender lens, to critically explore and bring to focus how women's position and participation in society.

Literature review

The literature review section of the study presented a thorough review of the previously published data regarding rural electrification and its relation with women's empowerment, and in this section, the indicators of women's empowerment are also represented.

Rural electrification

Energy access is characterized as households having electricity and a clean, safe method of cooking. Additionally, for the calculation of home energy consumption, the International Energy Agency (IEA) has set a minimum yearly usage of 250 kWh in villages and 500 kWh in cities. By this definition, 1.2 billion people globally, especially those from rural regions, still lack access to electricity. In addition, most energy projects face a variety of difficulties, rural electrification failure can be brought on by a lack of legal framework coherence, a lack of expertise, a lack of transparency, and insufficient standards. And according to the researcher off-grid PV systems provide better fairness since they can give disadvantaged groups (such as women or indigenous people) access to electricity in places where

a grid connection would not be practical. Therefore, while planning energy solutions the consumers' socio-cultural reality should be kept in mind. (Feron 2016)

A considerable study by (Mahmud et al.,2013) states that the water resources of Pakistan can play a vital role in the energy sector for the production of electricity, however, despite that the country is the victim of an energy crisis and encountering a severe electric shortage. Most of the electricity in Pakistan comes from fossil fuels like gas and coal. Due to this the industrial sector and the citizens are

suffering from frequent load shedding. The key reasons behind this crisis are as follows; poor foreign aid, lack of proper planning and management, drastic population growth and most importantly looking over the water resources, due to this the power-producing capacity is much lower than the energy requirements. Additionally, Pakistan has more than 40,000 MW of hydel potential, however, 15% of that energy is utilized and the rest is exploited.

Moreover, the analysis of case studies from Nepal, Kenya, and Peru revealed that mini-grids based on biomass gasifiers or micro-hydro plants are mainly preferred because of their lower cost. But the middle-class families gain multiple advantages from solar electrification. However, Photo Voltic is not considered as efficient in enhancing financial and educational activities, and it primarily utilized is for radio, mobile phones, and TV. Additionally, donor-supported PV projects have had organizational, technical, and economic difficulties that have led to several projects failing within a short period. (Yadoo and Cruickshank 2012)

In another study, the modern energy services of Bolivia, Tanzania, and Vietnam were examined. And electricity was the modern form of energy which was focused in the three nations. Having access to reliable electricity in businesses has a crucial influence on reducing non-financial poverty through raising earnings from business operations. However, women often utilize less electricity-powered technology in businesses than men do. One reason major reason for this is the difference in gender representation across industries, as women are mainly represented in tailoring and home brewing, and they only use electricity for lighting. On the other hand, industries where men are highly represented are carpentry and metalworking, which mainly rely more on electric appliances. Along with this electricity has minimized the time spent on traveling and waiting times for clients of grain mills. However. Wealthy individuals benefit the most from access to energy. (Kooijman-van Dijk and Clancy 2010)

Rural Electrification and Women Empowerment:

Many studies have shown that access to affordable and clean energy for lighting significantly has substantial effects in a variety of fields and it also contributes to improving women's basic living

conditions. This section explores the most common findings from previous research regarding electrification and women's empowerment.

Women's empowerment is a way of authorizing women. It is a process through which the position of women can be enhanced by adopting multiple ways of empowerment like education, awareness, and training. Women's empowerment prepares and allows females to make decisions. And also enables the women to get the prospect to redefine gender roles, which also enables them to chase their anticipated goals. Some of the major indicators of women's empowerment include mobility, Economic freedom, decision-making autonomy, Political and legal mindfulness, and involvement in civic and political campaigning. (Mahbub 2021)

Additionally, empowerment denotes multiple social process that provides individuals control over their own lives and is considered a process that enhances the power that individuals can utilize in their own lives, communities, and societies. It is a combination of emotions associated with personal control, a proactive perspective towards life, and an establishing awareness of the socio-political environment. (Aldabbas et al. n.d.).

Furthermore, another study investigated that, during the Islamic revolution in Iran in 1979 a significant improvement in women's empowerment was noticed. A particular rise in female education and a decrease in the fertility rate were observed. Electrification accounts for about three-fourths of the decline in the gender gap in literacy in concerned villages from 1986-1996 when rural infrastructure was rapidly expanded. Hence, the study illustrated the importance of better infrastructure for women's empowerment by examining the quick growth of rural electricity in post-revolution Iran. Therefore, infrastructure development is an essential step towards economic growth, along with this it will also lower gender inequalities and promote women's empowerment. However, to achieve gender equality in every sphere like in employment, and involvement in Iran's civic and political life, women still have a long way to go. (Salehi-Isfahani and Taghvatalab 2022)

The study from Bahia, Brazil highlights how gender discrimination led to the inability access to clean energy and to what extent sustainability initiatives tackle these issues mainly in rural

regions. Through an electrification program, solar panels were installed in the communities. The households having low-capacity solar household systems led to more time poverty because the energy does not allow women to engage in productivity activities by consuming a large portion of their time in domestic activities. Additionally, women-focused social assistance initiatives have a crucial role in enhancing women's participation in income-generating activities. Due to access to energy changes were observed in cooking, distribution of household chores, care for family, lighting, and agricultural roles. And due to this women have more feasible access to information, education, health, and safety. (Leduchowicz-Municio et al. 2023)

As electricity has various impacts on different aspects of life, a study examining the relationship between electric supply and fertility scrutinized agricultural fertility in the United States, when the country's farms were electrified, technologically improved, and assimilated into society at large. New agricultural and home production technology was accessible with electrification, increasing farm values and incomes and reducing reliance on family labor. Due to this the desire for a large family and the monetary worth of children were subsequently diminished. Because the young children were mostly responsible for doing ordinary tasks like caring for the animals, supplying firewood, and pumping and bringing water. However, the electricity-based technology enhanced the farm outputs without depending on much labor. The relationship between electrification and fertility varied unpredictably by location in the US; in certain areas, the relationship was negative, while in others it was positive. (Cornwell and Robinson 1988)

Another study shed light on the household electronic gadgets in rural China, and how they consciously and unconsciously indulge the appliances in their daily lives, according to the author Chinese villagers are mainly inclined about the symbolic value of the product rather than its practical use, as mentioned in the study Television, washing machine, and water cooler which were present in the most of households but they are used in practical very little. Because for them such things symbolize that they are economically well off and fond of urban life. Additionally, most of the decisions regarding the purchase of electronic

appliances are made by men however it is also used by women and the whole family. Moreover, men handling electronic appliances is not only about predominating the equipment or expressing their masculinity rather it is also about taking care of their family. Although men and women might have their roles as purchasers and users, however, they use the product mutually, even though they might have various ways of using it. (Wu 2008)

Educational opportunities

Most of the reviewed data regarding electricity's impact on women's access to education showed a positive effect. Education plays an essential role in empowering women. Education enhances the self-esteem and self-confidence of a woman, and an educated woman is better aware of her rights and obligations, education is a way that enables individuals to enhance their horizons. And without education, gender empowerment is considered impossible. (Mandal 2013)

A noteworthy study (Kanti Bose, Uddin, and Mondal 2013) stated that an educated woman matters a lot for the well-being of society. In the case of rural Bangladesh were only responsible for household duties and had little time for education or reading because they had to focus on taking care of their families' needs during the day. They also went to bed earlier than usual because electricity is expensive and they lack other sort of energy. However, given that electricity is readily available, people have enough time after sunset to read, watch TV, and acquire computer literacy. As they are now aware of their abilities, rights, and capacity to pursue higher education. As a result, education rates are rising.

Additionally, a study from Peru revealed that youngsters are more likely to spend time studying at home when there is a higher possibility that their home is linked to the energy grid. The causation between the household's degree of education and its connection status is also reported to be better in households where the parents are educated. Additionally, children between the ages of 3 and 12 who study for an extra hour are less likely to have to repeat a grade. (Aguirre 2014)

Electricity made it possible for schools mainly private schools to use audio cassettes and computers for upper grades, and the availability of other facilities such as lighting and fans due to electricity in classrooms has made students feel

more comfortable. Additionally, the study hours of students have been extended due to which educational achievement has increased. Along with the benefits of electricity, it was also observed that students were not doing their homework mainly watching television. (Bastakoti 2006)

Economic opportunities:

Numerous studies have demonstrated that providing women with access to electricity and time-saving electric household equipment will enable them to engage in typical income-generating activities like starting a small business or working from home part-time. The findings of a study from a rural village in Myanmar ascertained that electricity supply, some of the women's essential gender necessities are accomplished by Lessing the pressure of household chores, and this helps in stimulating new income-yielding activities, however, according to the study, there was little evidence which is intensely related to empowerment of women by accomplishing her strategic needs like decision making autonomy, possession of resources and gender disparity. (*Promoting W Omen's Empowerment Through Access to Electricity*, 2020)

According to (Hendriks 2019), being financially integrated may have a transformative effect on women. When they actively take part in the economic system, women and girls may be able to better deal with risk, and support family expenses namely schooling. Fostering women's meaningful financial participation is a vital necessity for their financial empowerment and sustainable growth. To give women the prospects to overcome poverty for their well-being and development, it is crucial to increase their access to and usage of digital financial services. Women can benefit from digital financial services by having access to and control over their own money.

Moreover, the availability of electricity enables women to have higher exposure to digital media, for instance, television and radio. This better access to information may widen the horizon of women regarding income-generating avenues and social engagement. (Report, Irfan, and Science 2019)

After visiting a training facility in Hashim Mirbahar, a small town in Sindh, the researcher stated that the women of Hashim Mirbahar are significant family members who not only serve as household managers but also contribute

significantly to the family's income. In addition to using Facebook for promotion and sales, women used to create clothing. The researcher looked at how renewable energy affected household income, women's empowerment, home comforts, and health security in the community. Additionally, Hashim Mirbahar uses solar energy to produce all of its power. There are 4 clusters of solar panels there, and they each operate at a voltage rating of between 233-236 volts, depending on the quantity of sunshine and the time of day. (Report et al. 2019)

Time allocation:

(Emmanuel and Japhet 2022) Asserted that the time women spend on household chores is certainly minimal among those women who have electricity connections in their homes than those women who don't have access to electricity. These women can have more time they can allot to nurture their children, also access updates through phone and television along with that they are also able to have some time for rest. Additionally, they have the option of working outside the home, which frees up additional time for study time. Better communication and relaxation are made possible by the usage of phones and television, which benefits the entire household. Providing energy to families should take women into account since doing so would have a substantial impact on the economic growth of family members and the community. A more empowered society cannot exist without empowered women.

Moreover, research from Ghana investigates that a crucial reason behind women's time poverty in developing states is their intense involvement in household errands, for instance collecting water, and firewood and taking care of family members. Because people in developing nations are strongly bound by societal norms and values in which the public sphere is always associated with men and the private sphere is associated with women. Therefore, the nature of work opportunities also differs for both genders. However, the study states that there can be the possibility of making a shift in the gender roles especially those which are related to income generation, and for this purpose the provision of better infrastructure such as water and electricity is essential. And this will benefit those women who are already immersed in money-making ventures. Because more than 75 percent of women in rural Ghana seem as engaged in market

avenues, it is anticipated that further improvement in electricity access may enhance the time that they can easily allocate to revenue-generating activities (Costa et al. 2009).

According to another study, the average weight of firewood head loads by women is usually above 25 kilograms in Africa and women normally spend on fuel wood collection average of 360 to 720 hours per year. (*Promoting Women's Empowerment Through Access to Electricity*, 2020). Another study from Nicaragua, Central America states that due to the availability of electric light, the productive hours increased rapidly. For instance, it was found that women in Esteli, Nicaragua who rely on solar and off-grid electricity, confirmed that electricity has extended their day due to which they can allocate their extra time in income generating activities. (Grogan and Sadanand 2013)

Decision making:

According to (Samad & Zhang, 2019) decision-making is the potential of women to make decisions regarding their work, household responsibilities like meal choices, child rearing and their marriage, and other dimensions of their life and family's choices. Economically independent females are more likely those females have more influence over household resources. Due to their incomes, they are capable of buying electronic gadgets for households, such as a refrigerator, and television sets, and they are also able to buy land. Those sorts of women also have bank accounts, and sometimes women who own the household even pay the rent of the house on their own. Due to reliable electricity access women are also capable of having access to electronic media like the radio and TV, along with that the source of energy has also a major influence over the women empowerment index, for instance, for those households that are connected to the grid the Index is 0.5. And women living in off-grid households is 0.37. Because women in grid-connected households are capable of making decisions regarding their work, mobility, bank accounts, and engagement in women's associations.

An insightful study of Pakistan states that women's decision-making autonomy is enhanced due to electrification. Because improvement can be seen in those households which have electricity access, and according to the statistics of the study the decision-making autonomy of women is enhanced

in several aspects, such as decision-making ability is improved by 16.3 percent regarding the matters like buying groceries, 9.5 percentage on matters related to in terms of decision-related to buying of clothes and shoes, 2.6 percentage related to education, and 1.7 percentage in employment-related matters. Additionally, access to electronic media and involvement in income-generating avenues have enlightened women about gender equality and socio-economic opportunities in the market. (Paper 2018)

The results from rural regions of Homa Bay (Kenya), Chhattisgarh (India), and Mahadevsthan (Nepal), state that women mainly have less decision-making power about electricity and the choice of electric appliances, their lack of rights in this area was reflected in their subordinate position in the socio-material contexts. While compared to other groups of women, women in Mahadevsthan,

especially those who did not have a man in the home, were more likely to have access to electricity and be able to buy the items they desired. However, the widows in Homa Bay have access to power the least. (Sadath and Acharya 2017)

Conceptual model

The conceptual model in Figure 1 is formed in Smart-PLS is showing the association between the independent and dependent variables and the hypothesis, hence there are two variables in this study namely electricity availability and women empowerment, and there are four constructs of women empowerment and each construct of women empowerment have five indicators. Additionally, the conceptual model in this study can be advantageous for a better comprehension of the impact of the availability of electricity and women's empowerment.

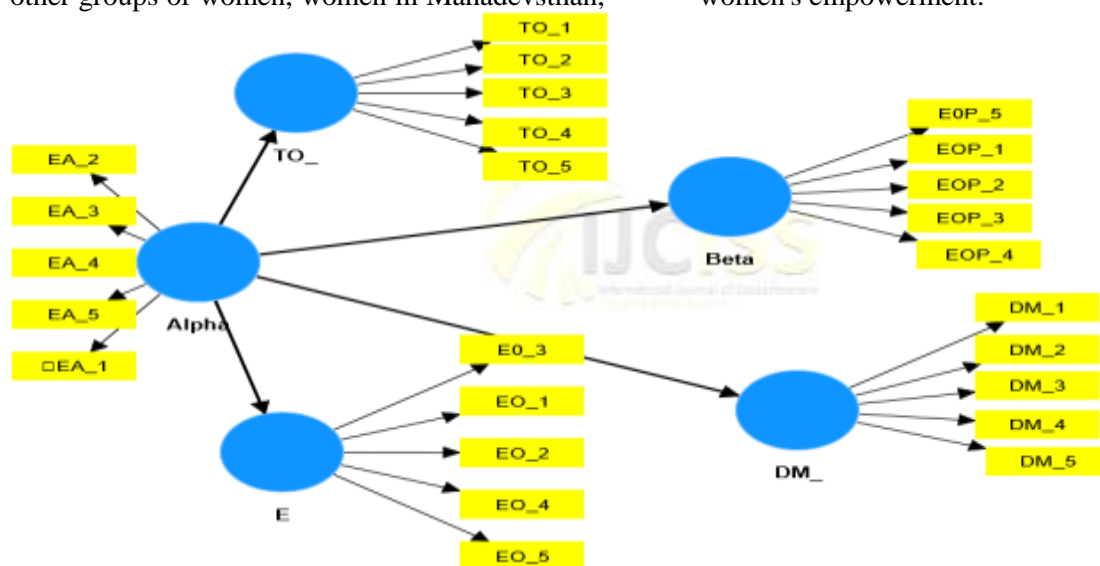


Figure. 1
Hypothesis

H1: The availability of electricity positively impacts women’s decision-making ability in Hunza.

H2: The availability of electricity positively impacts women’s access to education in Hunza.

H3: The availability of electricity positively impacts women’s economic participation in Hunza.

Research Methodology

This research employed a quantitative methodology, as quantitative research methodology is the most widely used methodology

by many researchers because the methodology is based on a deductive approach. This methodology mainly aims at exploring the interconnection between the predictor and outcome variable, along with quantitative research elucidating social and natural phenomena by assembling numerical data that are analyzed via mathematical and statistical methods. And the research is conducted objectively in an unbiased means. (Mahajan 2020)

Additionally, a thorough review of existing literature is conducted to understand the causal relation between the availability of electricity and women's empowerment, and the role of social capital as a mediation variable. Additionally, a survey questionnaire was designed to gather

insight from women regarding their perception of electricity availability. Purposive sampling was chosen to ensure the representation of specific respondents. Data was collected from selected geographic areas.

Study area

As Hunza is one of Gilgit Baltistan's 14 districts, it is situated in the north, Kashgar China in the north and east, districts of Nagar and Shigar in the south, Ghizer to the west, and the Wakhan District of Afghanistan's Badakhshan Province to the north-west all encircle the Hunza valley. Its geography, with its hilly sites, makes this region extremely expensive to expand the national grid, and the winter's lower river flows cause a reduction in the amount of electricity available. Due to its continued electrical isolation from the rest of the nation, this area experiences significant wintertime power shortages. It is the site of the illustrious Karakoram Mountain Pass and a key CPEC route. (Khan et al. 2021)

According to (Bhut et al., 2023) the Hunza water basin is crucial because it has potential importance in the generation of hydropower. The study focused study focused on thirteen river sites because the northern areas of Pakistan are rich in hydropower resources which can be essential assets for the provision of sustainable and clean energy access to people. However, due to a lack of investment, proper policies, and improper identification most places in Pakistan with hydropower are not explored. The study stated that the Hunza watershed can generate 392.6 GWh of electricity.

The number of approximate households in Hunza is 9,779, the population is 61,588, and number of males is 29,553 and females is 32,035. Hence, the measured source of electricity is hydropower along with diesel generators and solar photovoltaics are also used as sources of electricity.

Sample technique and sample size

According to the nature of the study, the study utilized Probability sampling. As the probability sampling technique guarantees generalisability of the study results of the target population, and the simple random sampling method every individual has an equal chance of being selected from the population.(Acharya, Prakash, and Nigam 2013). Therefore, through simple random sampling, a

total of 354 respondents were selected from Hunza, and the participants' ages ranged from 15 to above 50. The data was collected within two weeks from Hunza.

Data Collection Tools

According to the quantitative nature of the research, data were collected via structured questionnaires which were given to the respondents, respondents were requested to complete the questionnaire which was based on the Likert scale.

Data Analysis

For analyzing data Statistical Package for Social Sciences (SPSS) and Smart PLs were used. Descriptive statistics was applied for the evaluation of the demographic profile of survey participants. According to (Puteh, Hanafi, and Azman 2018) SPSS is a software developed by the IBM Corporation and is mainly utilized by researchers for data analysis purposes. SPSS undertakes both comparison and correlational statistical tests in the context of univariate, bivariate, and multivariate analysis for both the parametric and non-parametric statistical techniques. Additionally, in this study, Partial Least Squares Structural Equation Modelling (PLSSEM) was deployed to analyze the connection between electricity availability and women empowerment in Hunza, Pakistan. PLS-SEM is a multivariate statistical method that assesses measurement and structural models and assists in sorting out the associations between study constructs and their detected indicators and between the latent constructs overall (Leguina 2015). Within the impact of the electricity model, social capital is presented as a mediator variable to scrutinize its indirect role in the direct association between electricity availability and women's empowerment.

Additionally, path analysis is among a key application of SEM. In SEM the analysis of the linear associations amid the latent constructs and manifest variables can be performed. It is also capable of generating accessible parameters for the estimation of the associations among unobserved variables. Moreover, SEM assists in analyzing and testing numerous relationships at once in a single model with several relationships instead of analyzing each relationship separately. (Hussain et al. 2018)

Questionnaire design

A questionnaire-based survey was used to collect data from rural women. This structured questionnaire was prepared from previous studies; hence the questionnaire was devised to get the perceptions of women regarding the availability of electricity and its impact on women's empowerment in Hunza. A comprehensive questionnaire of a total of 33 questions, was developed to get input from participants, the questionnaire comprises two sections. The first part of the questionnaire contained demographic details about the target respondents, such as age, marital status, educational background, etc. The population characteristics which essential for understanding and contextualizing the findings. Section two consisted of the main questions; related to the indicators of women empowerment; decision-making, educational opportunities, economic opportunities, and time allocation, which

were thoughtfully selected based on existing literature related to the influence of electricity availability on the lives of rural women. The statements were Structured on a close-ended and organized based on a five-point Likert scale, in which the responses of the respondents were documented from (strongly agree = 1, agree = 2, Neutral = 3, disagree = 4, and strongly disagree = 5). It required every respondent to select a perceived importance rating of the variables based on personal experience. Respondents were asked to rate their agreement or disagreement with statements related to the impact of electricity on aspects such as education, health, decision-making, time allocation, and overall quality of life. This approach allowed for a holistic understanding of how electricity accessibility can contribute to or hinder sustainable socioeconomic development within the region.

Table 1:
Frequency table of demographic details:

Age of respondent		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 18	18	5.1	5.1	5.1
	18-28	219	61.9	61.9	66.9
	29-39	59	16.7	16.7	83.6
	40-50	39	11.0	11.0	94.6
	Above 50	19	5.4	5.4	100.0
	Total	354	100.0	100.0	

The table shows that there are five categories of participants' age. Out of the total sample, 18 respondents fell in the age range of less than 18, which makes 5.9% of the total respondents. The second most represented age group was 18-28, with 219 participants making up 61.9% of the

sample. The third age group from 29-39 is comprised of 59 respondents making up 16.7% of the sample, after that the 40-50 age group comprised 39 participants, representing 11% of the sample. Lastly, the above 50 age group had 19 participants, representing 5.4% of the sample.

Results of the study

Marital status:

Table-1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	194	54.8	54.8	54.8
	Married	155	43.8	43.8	98.6
	Divorced	3	.8	.8	99.4
	Widowed	2	.6	.6	100.0
	Total	354	100.0	100.0	

The respondents were categorized into four groups of marital status. Out of the total sample, 194 participants are single representing 54.8% of the total sample. 155 participants are married

representing % of the total sample, and the number of divorced participants was 3 which presents the .8% of the sample and 2 widowed participants make up the .6% of the total sample.

Table 2:

Educational background:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal education	12	3.4	3.4	3.4
	Primary school	25	7.1	7.1	10.5
	Secondary school	110	31.1	31.1	41.5
	Graduate	146	41.2	41.2	82.8
	Masters	58	16.4	16.4	99.2
	Above Masters	3	.8	.8	100.0
	Total	354	100.0	100.0	

The table and the pie chart illustrate the educational background of the respondents. There are six categories of educational background among which there were 12 respondents had informal education which represents 3.4% of the total sample, additionally, there were 110 respondents with secondary school education which comprised

31.1% of the sample. The most represented category of educational background is comprised of 146 graduate respondents which present 41.2% of the total sample. Respondents with a Master’s degree 58 represented 16.4% of the sample, last, three respondents had qualifications above master's which present .8% of the total sample.

Table 3:

Monthly household income:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 30,000	104	29.4	29.4	29.4
	30,000-60,000	123	34.7	34.7	64.1
	61,000-90,000	67	18.9	18.9	83.1
	91,000-120,000	22	6.2	6.2	89.3
	More than 120,000	38	10.7	10.7	100.0
	Total	354	100.0	100.0	

The table shows the income distribution of the respondents, where their income is categorized into five categories. 104 respondents or 29.4% of the respondents have a monthly household income of less than 30,000. Additionally, the majority of respondents, 34.2% (121 female) reported having a monthly household income of 30,000-60,000.

There were 66 respondents representing 18.6 of the total sample who had incomes ranging between 61,000 and 90,000. There were 22 respondents (6.2% of the total) having income ranging between 91,000-120,000. And the resp’ondents have an income of more than 120,000 37 who represent the 10.5% of the total sample

Table 5:

Number of household members:

Number of household members		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5	24	6.8	6.8	6.8
	5-8	240	67.8	67.8	74.6
	9-12	60	16.9	16.9	91.5
	13-16	20	5.6	5.6	97.2
	Above 16	10	2.8	2.8	100.0
Total		354	100.0	100.0	

The table shows the distribution of the number of household members of the respondents. Most households (67.8%) have 5-8 members, followed by 16.9% having 9-12 members. Less than 5% of

households have less than 5 members, and about 5% have 13-16 members. Only 2.8% of households have more than 16 members.

Table 6: Occupation:

Occupation		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	175	49.4	49.4	49.4
	Housewife	111	31.4	31.4	80.8
	Government employ	28	7.9	7.9	88.7
	Businesswoman	23	6.5	6.5	95.2
	Other	17	4.8	4.8	100.0
Total		354	100.0	100.0	

The table illustrates the distribution of occupations among the respondents. And 175 respondents were students (49.4%), followed by 111 housewives representing 31.4% of the total sample. And 28 respondents were Government employees which make up 7.9% of the sample, along with that there

were 23 (6.5%) were businesswomen, and others made up the remaining 19.2%, of government employees. Lastly, there was a minimum number of respondents who fall in the category of other which presents 4.8% of the total sample.

Table 7: Source of electricity:

Which source of electricity is available in your household?		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Hydropower	280	79.1	79.1	79.1
	Solar energy	30	8.5	8.5	87.6
	Generator	10	2.8	2.8	90.4
	Above all	21	5.9	5.9	96.3
	No access	13	3.7	3.7	100.0
Total		354	100.0	100.0	

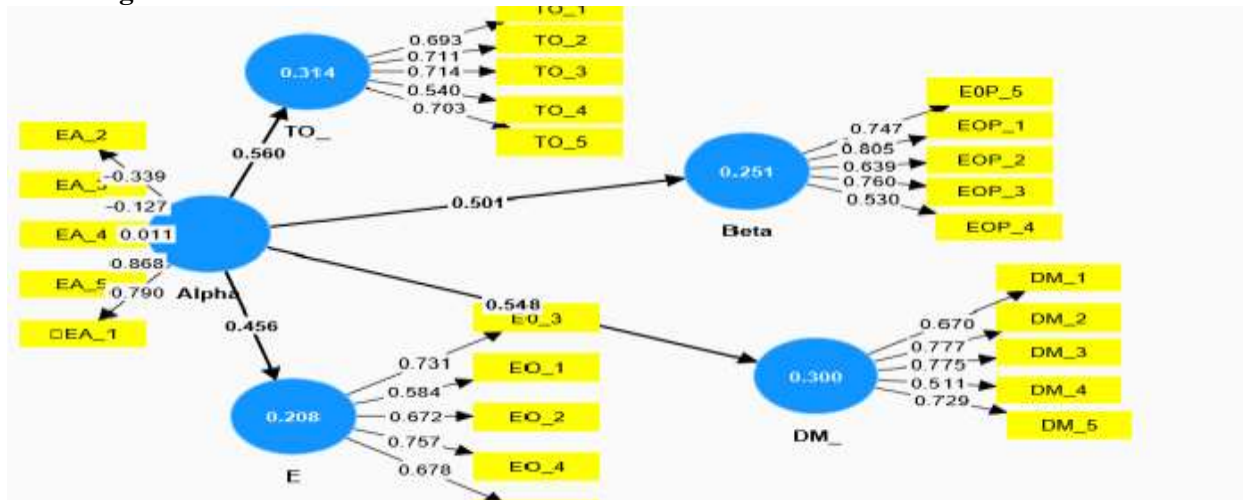
The above table illustrates the source of energy used in the households, where the most available source of electricity is hydropower which makes the 79.1% of the total sample, and in the 30

households of respondents, solar energy is available which is 8.5% of the sample. Additionally, the generator is the least available source of electricity in the 10 households making

2.8% of the sample, and 21 respondents have hydropower, solar energy, and a generator available in their household which is 5.9% of the

sample and there were 13 respondents (3.7% of the sample) who don't have access to any source of electricity.

4.2 PIs algorithm test



The PLS model shows the association between electricity availability (EA) and indicators of women's empowerment, which are economic opportunities (EO), educational opportunities (EOP), decision-making (DM), and time allocation (TO).

means that as electricity availability increases, economic opportunities, educational opportunities, decision-making, and time allocation for women all increase as well.

Electricity availability has a positive effect on all four indicators of women's empowerment. This

Overall, the PLS model suggests that electricity availability is an important factor in promoting women's empowerment.

R-square

	R-square	R-square adjusted
Beta	0.251	0.249
DM_	0.300	0.298
E	0.208	0.206
TO_	0.314	0.312

The R2 is a statistic of variance explained in the endogenous variables and, by implication, is a statistic of the model's predictive accuracy. Weak, moderate, and substantial model validity are determined based on the R2 values. Greater than 0.26 indicates a strong effect, 0.13 to 0.26 moderate, and 0.02 to 0.13 weak effect (43). For the model to have predictive accuracy, R2 must be > 0.10 (Field, 2000:370) If R2 < 0.10, then the conceptual model is regarded as not adequate for explaining the endogenous variables.

Decision-Making. These values suggest that as electricity availability increases, the level of women's empowerment in decision-making also tends to increase.

Outer Loadings results

1. Decision-Making (DM):

These outer loadings range from 0.511 to 0.777, indicating positive associations between electricity availability (EA) and the five indicators of

2. Educational Opportunities (EOP):

The outer loadings vary from 0.530 to 0.805, demonstrating positive relationships between EA and the five indicators of Educational Opportunities. Higher electricity availability is associated with increased opportunities for women's education.

3. Economic Opportunities (EO):

These outer loadings range from 0.584 to 0.757, indicating positive relationships between EA and the five indicators of Economic Opportunities.

Higher electricity availability is linked to enhanced economic opportunities for women.

4. Time Allocation (TO):

These outer loadings vary from 0.540 to 0.714, illustrating positive associations between EA and the five indicators of Time Allocation. This suggests that increased electricity availability is correlated with improved time allocation for women.

5. Error Terms (Alpha):

These loadings range from -0.339 to 0.868. While most indicators have positive loadings, indicating a positive relationship with EA, EA_2, and EA_3 have negative loadings. These error terms represent unexplained variance in the latent variable EA.

R-square Overview:

1. Beta (R-square = 0.251, R-square adjusted = 0.249):

The R-square value of 0.251 indicates that 25.1% of the variance in the Beta (EOP_5) indicator is explained by the model. The adjusted R-square considers the number of predictors in the model.

2. Decision-Making (DM) (R-square = 0.300, R-square adjusted = 0.298):

The R-square value of 0.300 suggests that 30% of the variance in the Decision-Making indicators is explained by the model, indicating a moderate fit. The adjusted R-square adjusts for the number of predictors.

3. E (R-square = 0.208, R-square adjusted = 0.206): The R-square value of 0.208 indicates that 20.8% of the variance in the Economic Opportunities indicators is explained by the model. The adjusted R-square accounts for the number of predictors.

4. TO (R-square = 0.314, R-square adjusted = 0.312):

The R-square value of 0.314 suggests that 31.4% of the variance in the Time Allocation indicators is explained by the model. The adjusted R-square considers the number of predictors in the model.

Hence the outer loadings and R-square values collectively reveal the strength and direction of the relationships between electricity availability and the chosen indicators of women's empowerment. The positive loadings and meaningful R-square values underscore the significance of electricity availability in influencing economic, educational, and decision-making opportunities, as well as time allocation for women.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Alpha	0.298	0.568	0.293	0.302
Beta	0.747	0.784	0.827	0.494
DM_	0.734	0.756	0.824	0.489
E	0.735	ms0.743	0.816	0.472
TO_	0.699	0.707	0.806	0.456

odel fit summary

	Standard model	Estimated model
SRMR	0.102	0.158
d_U LS	3.407	8.107
d_G	0.667	0.940
Chi-square	1357.095	1692.838
NFI	0.582	0.478

The model fit summary shows the comparison between the saturated and estimated models. The values of SRMR represent the mean standardized difference between the observed and predicted correlations. A low SRMR value indicates a good

model fit. Residuals are not zero, although model SRMR (0.158) is higher than saturated model SRMR (0.102). This index is described as differences between the observed and fitted covariance matrices. A greater d_U LS indicates a

worse fit; in this case, the estimated model ($d_{ULS}=8.107$) has a worse fit than the saturated model ($d_{ULS}=3.407$). The index evaluates the difference between the variance-covariance matrix observed and predicted. Smaller values of d_G are preferable, and the derived model demonstrates a higher d_G : 0.940 than the saturated model (0.667). The model chi-square compares the fit of the fitted model to one that properly fits the data. A higher chi-square value indicates a worse fit, here the chi-square value of the estimated model is 1692.838 and the saturated model is 1357.095. The NFI evaluates how much better the estimated model represents the data than a null model. We want a high NFI; however, the estimated model has a lower NFI (0.478) compared to the saturated model (0.582). The discrepancies between the actual data and the estimated model are also shown in the summary of model fit: (SRMR, d_{ULS} , d_G , Chi-square) are larger than that of the saturated model, and model NFI is smaller than that of the saturated model. The fit may become acceptable by further optimizing or modifying the model.

Results of hypothesis testing

Table-- reveals the analysis of the structural model. The results reveal that the H1 outcome depicting the availability of electricity positively impacts women’s decision-making ability in Hunza was statically significant at the 5% level ($\beta = 0.3156$; $t = 7.1312$; $p = 0.000$). Thus, the results supported Hypothesis 1,

Hypothesis 2 stated, “The availability of electricity positively impacts women’s access to education in Hunza was statically significant at the 5% level ($\beta = 0.4231$; $t = 6.0361$; $p = 0.000$). Thus, the results supported Hypothesis 2,

Hypothesis 3 stated the availability of electricity positively impacts women’s economic participation in Hunza was statically significant at the 5% level ($\beta = 0.665$; $t = 0.4521$; $p = 0.000$). Thus, the results supported Hypothesis 3,

Hypothesis 4 states the availability of electricity positively impacts women’s time allocation in Hunza.was statically significant at the 5% level ($\beta = 0.315$; $t = 4.9321$; $p = 0.000$). Thus, the results supported Hypothesis 4,

Hypothesis path	Standard beta	t- values	value	Decisions
EA >WD	0.3156	7.1312	0.000	Supported
EA>ET	0.4231	6.0361	0.000	Supported
EA>EP	0.665	0.6651	0.000	Supported
EA>TA	4.9321	4.9321	0.000	Supported

Conclusion:

Providing affordable, reliable, and clean energy is one of the essential goals among the sustainable development goals, as electricity availability is an essential element for the sustainable development of a community or nation. However, despite having abundant sources of renewable energy such as sun power, wind energy, biomass, and hydel power, Pakistan is suffering from energy crises due to poor planning and insufficiency of funds. Moreover, thousands of rural communities in Pakistan lack connectivity to the national grid system, because it is quite hard and expensive to expand the grid system in such regions. Therefore, Hunza as a remote region of Pakistan with mountainous geographic terrain also lacks access to the national grid system, hence the primary reliance of the inhabitants of the Hunza are off-grid systems, such as micro-hydro power plants and solar energy.

Therefore, this cross-sectional study examined the impact of electricity availability on rural women's empowerment in Hunza. The study aims to address the gaps in the prior studies because there is a lack of research on how women are affected by the availability of electricity in Hunza. Hence, the study results proposed that there is a positive association between electricity availability and women empowerment and that as electricity availability increases, economic opportunities, educational opportunities, decision-making, and time allocation for women. Hence, this study will be beneficial for decision-makers, researchers, and policymakers.

As, women's empowerment is of paramount importance because it not only contributes to gender equality but also improves the growth and well-being of society, and there is an intricate relationship between electricity availability and women's empowerment. It is believed that for the

achievement of sustainable goal 5 (gender equality) the proper availability of goal 7 is important which is based on the provision of inexpensive and clean forms of energy because women mainly suffer from time poverty, as they spend most of their time in household chores and for the accomplishment of those chores such as cooking women in rural areas mainly rely on traditional sources of energy like wood, coal and kerosene due to which they suffer from different diseases. Along with that women also spend most of their time on activities like fetching water, grinding grains, and collecting wood.

Furthermore, electricity availability is also considered to play an essential role in lessening the drudgery of women and boosting their empowerment of women, as electricity has overcome the burden of women and helps them to save and allocate their time to productive activities like expanding their study hours, they are also able to earn money through different income generating avenues and ultimately their economic freedom assist them to make decisions for their selves and families and the usage of the modern form of the electronic gadget also helps women to have access to information. Access to electronic gadgets helps women to ease their physical burden and also helps women to participate more fully in both domestic and external activities, ultimately contributing to their overall well-being and socio-economic advancement.

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