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Netting Multidimensionality of Energy for Indoor Space Heating Across Rural Households of Rawalpindi division: A Multi-Tier Frame Work Approach

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Abstract
Energy make a emergence a good, sufficient and just life. The worldwide endorsement of "energy access for all" has come from Sustainable Development Goal 7. Fifty-six percent of people in Pakistan still rely on conventional biomass fuels. Current study aimed to evaluate the space heating access of rural household in districts of Rawalpindi division. For this intend, a framework has been operationalized put up by Energy Sector Management Assistance Program (ESMAP) World Bank for the very first time. This framework involves a comprehensive comparison of dimensional storage to determine various aspects of energy access i.e. electricity, cooking solutions, and space heating.. Primary data of 730 rural households of the Rawalpindi division using Multi stage random sampling techniques was collected through a wellself-structured questionnaire from districts namely, Rawalpindi, Attock, Jhelum and Chakwal. There are varying reflections of energy access of heating among districts of Rawalpindi division. Results of the analysis referred that Heating access rate was predominantly spoiled by collection time of fuel and lack of capacity to get their localities warm at desirable level in district Jhelum by scoring 56,8 points Weekly more than 7 hours is being spent on collection of fuel across rural households in all Districts. 40 % of the time, households are not able to get themselves warm in face of cold conditions. The study recommends that in order to place sixty percent households of lower tiers to finish in arena of higher energy access rate and with mission to escaping energy poverty, rigorous efforts would be required, through implementation of area specific interventions rather more generalized endorsements.

Keywords: Energy Access, Indoor Space Heating, Energy Poverty, Multitier Framework (MTF), Rural Household

1. Introduction
hroughout history, cold weather has been a silent yet formidable adversary, leading to countless deaths. Whether in wartime campaigns or everyday life, the historical record attests to the lethal impact of cold weather on manking. In Europe, dilemma has evolved in to fuel poverty, which is characterised as the inability to pay for sufficient heating to maintain a reasonable standard of living, impacted by housing conditions, energy prices, and socioeconomic variables, with its origins in the post-World War II period, when rapid industrialisation created an increase in the demand for energy. Economic inequality and growing energy prices have made it more difficult for a large percentage of households to maintain adequate heating over time Bouzarovski and Petrova (2015) and Boardman (2012). Although the term "fuel poverty" has different meanings in the developed world, it refers to not being able to pay enough heat for one's rural households. While it is associated with and contributes to "traditional" relative income poverty, its main causes are excessive energy costs and inadequately insulated rural households (Boardman, 2013). As a consequence, it's a matter of acute malnutrition, starvation, early death, and suffering. From the standpoint of human rights, nations must guarantee that their people have access to a level of products that meets their universal right to health and well-being. Adam Smith defined "necessities" in 1776 as "being trusted by the lower class as well as acquiring the trust of people." This is not only an aspect of national custom, but also an integral part of life. Winkler et al. (2011) argues "relative deprivation of resources" should be used instead of "absolute deprivation of resources."

Human instability is seen from a people-centered perspective, with resources and attention going toward fields such as health and education where people can reach their full potential. Capabilities, in the sense of a person's existence, relate to a person's ability to transform goods into useful tasks. According to Sen (1992) "a person's achievement; what he tries to do or be." For instance, food is a good that satisfies hunger and makes eating enjoyable, but to make this good "function" in daily life, a person needs to possess the necessary ability (i.e., good health). Therefore, goods are worthless unless they can be used to achieve something. Furthermore, the substantive liberty that an individual exercises to lead a morally upright life might be defined as skills.

Energy has a profound impact on people's lives and stimulates advancement in society and the economy. Some of the most basic requirements of humanity, including food, warmth, and light, are made possible with the help of energy. In addition, there is an abundance of data showing that enabling people access to reliable, efficient, affordable, and healthful energy sources can significantly impact growth, income, and health in addition to strengthening gender equality, education, and other infrastructure services (Audi & Ali, 2017; Padam et al., 2018; Ali et al., 2021).

In the present-day world, the most advanced energy sources required for human life are electricity and liquefied petroleum gas (LPG). New, affordable, and sustainable energy is made accessible to human progress through the UN's sustainable development priorities (Day et al., 2016; Audi et al., 2021; Ali et al., 2022). Hunger, lack of access to healthcare and education, and gender inequality constitute some of the challenges faced by communities without energy. (Zaman et al., 2019). Poverty reduction and growth efforts in rural and urban areas, access to electricity and new energy carriers will let them meet energy supply needs. the variability of providing energy services to the rural poor is different from that in cities, and about 75 percent of the poor in developing countries are actually rural population (Musango et al., 2020).

Achieving the MDGs, which include decreasing hunger, improving the status of women and children, and raising the standard of education—requires energy. Energy undoubtedly can promote economic progress, better living, community, and money growth. (Nussbaumer et al., 2013; Audi et al., 2020).

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Having access to new forms of renewable energy could remake human life in many different ways, including improving health and protecting the lives of women (Sadath & Acharya, 2017). Women have to gather firewood because there is not enough clean fuel for family heating; however, some of them enjoy fundamental rights, including safety, health, and education González-Eguino, 2015; Urpelainen, 2016; Audi & Ali, 2023).
Nations have the same issue of consumption alongside rising environmental expenses; therefore,regulation and management of their energy markets are necessary to monitor the extent of energy access globally. Between 1980 and 2023, Pakistan's population grew from 79.98 million to 232 million (Rehman, 2023). By simplifying household chores, household equipment for space heating significantly contributes to women's time liberation and increases their freedom to engage in income-generating activities. Time-consuming tasks are reduced for women, allowing them to focus on their economic aspirations and achieve financial emancipation. This change promotes economic growth and improves gender equality.Therefore, having access to time-saving equipment is essential for fostering a society that is both inclusive and economically vibrant (Grogan & Sadanand, 2013) (Khandker et al., 2009). Most 2.7 billion people who are estimated to rely on traditional biomass for cooking are impoverished individuals in developing nations, and most 1.4 billion people who lack access to grid power are also affected by energy poverty. The majority of individuals that rely on traditional biomass are found in South Asia and Africa (Mainali et al., 2018).
Households may save time, enhance their health, and reduce air pollution by using clean space heating. Shifting away from conventional heating and cooking methods has several multifaceted advantages. These include, but are not limited to, climate change, health, time savings, fuel efficiency, and decreased smoking (Barnes & Samad, 2018). Compared with open flames and conventional fireplaces, some solid fuel-based alternatives have entered the market in the last ten years that can increase combustion efficiency and lower pollutants. However, there are some factors that can lessen air pollution both indoors and outdoors, stop long-term deforestation and climate change, inspire women and girls, and push economic growth that have an impact on health and the environment such as fuel consumption, storage, or purchase (Abera et al., 2021).
The evolution of energy access for space heating has moved from basic provision to a holistic approach that recognizes the significance of affordability, accessibility, and sustainability. Assessing the status of indoor space heating is essential for evaluating its effects on people's health and well-being, energy poverty levels, energy source types, social inequality, climate change, and productivity. Sufficient energy access will reduce the time spent on firewood collection, especially for women and girls, and reduce the negative health effects of smoke solutions. Access to stable and high-quality energy will also improve productivity and economic growth, which may lead to employment and profitability.
Day et al. (2016) used the expertise method of Sen and Martha(1993), to demonstrate the relationship between energy use and well-being by visualizing energy deficit and consumption. Consequently, it is possible to determine different interference locations. Lack of energy is just one aspect of the big problem of inequality and insufficient welfare. However, this is important in itself, because energy is essential for long-term development and lifting people out of poverty. (Takada & Porcaro, 2005; Jannuzzi & Goldemberg, 2012; Pachauri, et al., 2012; Groh, 2014).
The Rawalpindi region is characterized by diverse topography, fluctuating weather conditions, and economic challenges, and addressing indoor household heating requires a multifaceted composition.In light of the above discussion, this study aimed to evaluate would be established as pioneer in accessing the variables affecting space heating in the Rawalpindi division's rural areas, as lacking notable consideration in the near past. Addressing research gaps by primarily using a multi-tier framework to assess the degree and intensity of energy availability and different attributes for space heating in rural households in the Rawalpindi division.

2. Research Methodology

Giving the family energy may enhance their pleasure by providing them with more choices to choose alternative activities and take care of essential necessities, comforts, and luxury. According to the competence context, human development is the process of making an individual more productive and valuable (Alkire, 2002,09).
In order to gather and analyze the multifaceted nature of energy deprivation in space heating and energy access at rural households in four districts of the Rawalpindi Division, the Multitier Framework (MTF) is implemented. An index for energy access for space heating has been accounted for, and the impact of energy access (capacity, affordability of indoor air quality, etc.) as measuring variables on rural households has been investigated.

2.1. Multi-Tier Frame Work

Energy Sector Management Assistance Programme (ESMAP), the World Bank developed a framework to assess the quantity and quality of energy supply and access. It is a comprehensive framework that includes all relevant information about household energy access. The MTF has primarily concentrated on offering rural households space heating, lighting, and clean cooking options. The framework can be used to monitor the evolution of its properties over time in many domains.
Metrics are employed by Bhatia and Angelou (2015a) to determine the value of each access attribute, together with criteria that dictate their distribution across tiers and a computational rule that unifies all the attributes into a single index. At MTF, the criteria used to determine if an access is unique have undergone multiple revisions. Each matrix employs a unique set of characteristics. The World Bank/ESMAP has bargained with the United Nations, developed access to energy, the World Bank, and the World Health Organization, as well as with development organizations and programmes (such as NDF, Lighting Africa, Practical Action, and the Global Clean Cook Coalition). A new technique for determining various degrees of energy usage has been created based on this criterion. Original proponents of the multilateral strategy included the Global Clean Cook stove Alliance (GACCS, 2012), Energy Outlook for the Poor (Practical Action, 2010), and the UN Secretary-General's Energy and Climate Change Advisory Group (Khan & Saleuddin, 1987). The evolving multi-tier system is summarized here, according to a mixture of characteristics that reflect the effectiveness of the energy supply, the degree of energy access is determined by the multi-tiered system of measurement.

2.2. Household Access to Energy

Households access to energy for remote households, particular access qualities were examined to take into account the household-level energy access condition. Household energy access was further divided into the following categories: (a) access to household electricity; (b) access to household cooking; and (c) access to household space heating.

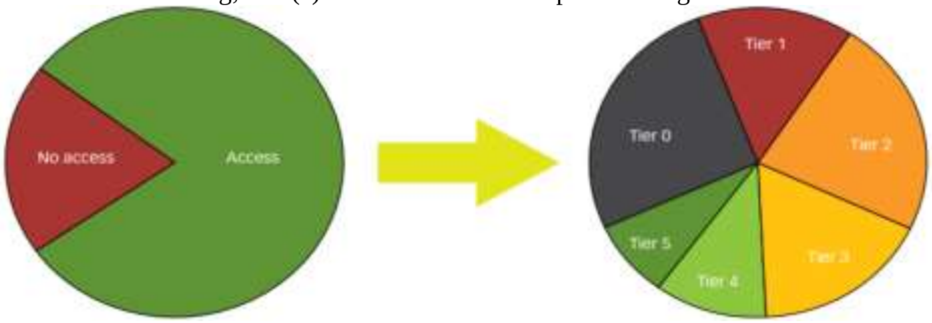

Figure 1: Binary versus multitier framework: Source: Bhatia and Angelou, 2015

Finally, it is now generally understood that in order to reliably obtain the range of needs to overcome energy shortages, measurement systems must provide energy related to household, environmental, and productive use (Bhatia et al., 2012). MTF adopts a different methos for this problem, and each set its own advantages and disadvantages. Further research on the choice of energy services and changes in energy demand may support the collection of standards based on basic equipment, and the amount of access to power facilities calculated through comprehensive surveys or secondary data.

MTF divides energy into three categories: electricity, cooking and heating systems, and a simple distinction between household, productive and community end-to-end energy service needs. Each individual demand is based on the recommended individual's calculation matrix layout level.

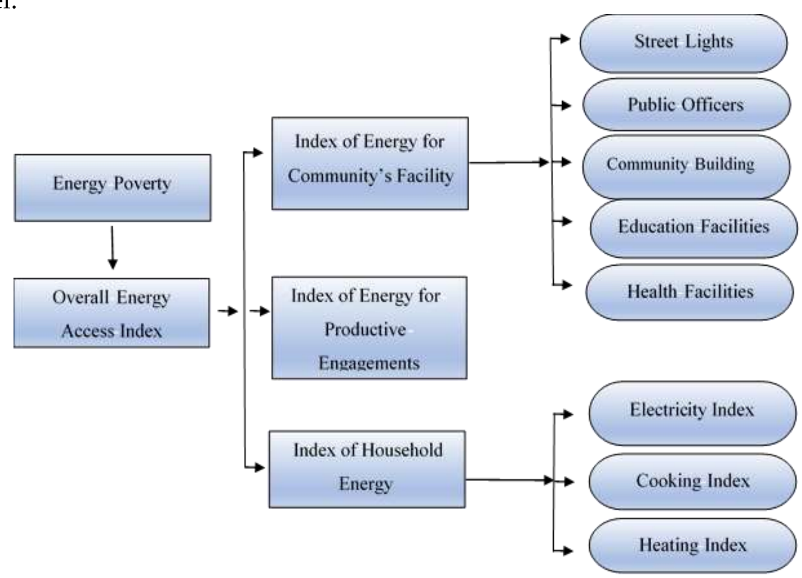

Figure 2 : Conceptual framework

2.3. Characteristics of Rawalpindi Division

The Rawalpindi division, which makes up approximately 25.8% of Pakistan's total land area, is rural households to the four main tributaries of the Indus River, Jhelum, Chenab, Ravi, and Sutlej, and includes fertile alluvial plains. Several mountainous regions, such as high altitude mountains and hill stations like Dunga Gali, Patrata, and Panj Pir in Murre district and Rawalpindi in the southwest, Margalla Hills in the northern part, and the salt range that divides the Rawalpindi division in the north from the rest of the province, are also included in the plains of the Rawalpindi division. The majority of people living in the Rawalpindi division speak Punjabi; however, some ethnic communities also speak other dialects in the area, such as Saraiki, Pothohari, and Majhi.

2.3.1. Climate

Regarding the climate of the area, much of it has peak weather conditions, which are accompanied by rainy and foggy winters. By mid-February, the temperature starts to increase. Springtime weather continues until mid-April, while the monsoon arrives in the Punjab region in July. May, June, July, and August are hot months, whereas October, November, and December are the coldest months of the year. The plateau's regional temperature, to put it briefly, varies from "-2 degrees in winter to 45 degrees in summer." However, over the past decade, 's climate patterns appear to have significantly changed, possibly partly because of inconsistent weather, soaring temperatures, and a lack of water storage facilities.

2.4. Demographics of Pothowar Plateau

2.4.1. Population

According to the administrative division, the Punjab province’s population is split into 42 districts and 11 divisions. As previously stated, different groups living in the province speak a variety of dialects based on distinct locations.Approximately one million individuals reside in the rural and urban regions of Rawalpindi division.

2.4.2. Education and Health

There are both government and public chartered high schools, colleges, and universities in the area. This is also a contributing factor to the province’s high rate of migration from around the nation, as many people relocate there in search of better career and educational possibilities. Comparing the health sector of the Rawalpindi division with other provinces in the nation, it was discovered to be in good standing. The province is home to modern hospitals and medical facilities that provide state-of-the-art care.

Table: 1: District Rawalpindi’s population and rural households

District	Attock	Chakwal	Jhelum	Rawalpindi
-Population	-1393550	-1212042	-868448	--2530117
-Rural Household	-228435	-217585	-145783	-418177

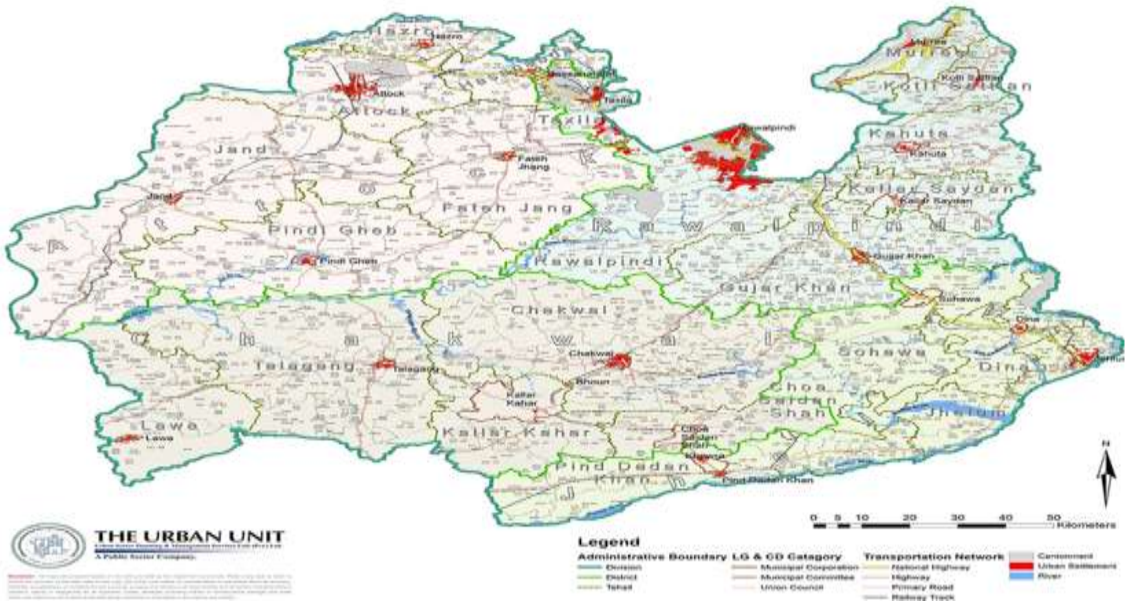

Figure 3: Map of Rawalpindi Division

Table 2: Multi teir Framework for Space heating (Source: Bhatia and Angelou, 2015)

Attributes		Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
1. Capacity			Personal space around individuals is heated	At least one room has heating		All rooms in the household have heating	
2. Duration					At least half the time when needed (>50% of the time)	Most hours when needed (>75% of the time)	Most all hours when needed (>95% of the time)
3. Quality					Comfortable temperature at least 50% of the time	Comfortable temperature at least 75% of the time	Comfortable temperature all the time
4.Convenience (fuel collection time in hrs/week)				<7	< 3	< 1.5	< 0.5
5. Affordability					Cost ≤ 2 times the grid tariff		Cost ≤ the grid tariff
6. Reliability (number of disruptions / day)					< 7	< 3	< 3(total duration <2 hours)
7. Indoor A Air Quality	PM		(To be specified by a competent agency such as WHO, based on	(To be specified by a competent agency such as WHO, based on	(To be specified by a competent agency such as WHO, based on health risks)	< 35 (WHO IT -1)	<10 (WHO guideline)
	CO					< 7 (who Guideline)	

2.5. Methodology of the Study

2.5.1. Rural Household Space Heating

The study has been centralized to space heatig whereas it has been specificaly evaluated for rural households of Rawalpindi division Eight criteria were used to gauge people's ability to access space heating, including capacity, duration, quality, convenience, affordability, dependability, indoor air quality, and safety. Space heating systems can be evolved in a number of ways, including direct solar heating, self-contained fuel heating, centralized fuel district heating, and electric heating. The amount of energy needed for room heating depends on a number of variables, such as the local temperature, the weather, the time of day, the size and orientation of the structure, its thermal insulation capabilities, and the carpeting on the floors. Instead, more hot liquids and better clothing (pullovers, blankets, etc.) will satisfy the calorie requirement. In order to access household heating (as needed), a separate multi-layer system is used, and a different energy access index is calculated for the space heating system.

2.6. Computation Of Index

Some specific functions were applied to the matrix. Scale or binary methods were used to estimate certain attributes. The decision regarding the choice of each attribute is governed by rules that must be adhered to to determine a signature. The attribute with the lowest total score under the final decision technique determines the final task. Levels were assigned to houses according to several factors. The overall results were compared locally and over time. Any region can be used to calculate the index.

The combination of household grade scores for each shape in a certain geographic area has raised to 100, according to household heating energy supplies that are currently available. The following is the formula for the overall energy access index;

$$\boldsymbol{Access\ Index} = \sum_{k=0}^{5} (P_k * V_k)$$

Where,

k = tier number

P = the proportion of rural households in kth tier,

V = value set with k

Describes hereby, the termV_k, has an intuitive interpretation that the value of V_k, take account of the degree of access enjoyed by households in Tier *k*. For example,

V_4 = 80 , i.e., people in Tier 4 are assessed to have full 80 percent access

V_3 = 60, i.e., people in Tier 3 are assessed to have partial 60 percent access

V_2 = 0, i.e., people in Tier 2 are assessed to have 40 percent access

2.7. Data Collection and Sampling Technique

The most populous and second-largest province in Pakistan by land area is Punjab. Its total area is 205,344 square kilometers, or 79,284 square miles, and its population is 212.2 million. Punjab comprises 42 districts, which are divided into four regions: southern, northern, central, and western.(GOP, 2017).

2.7.1. Sampling Technique

In north region, four districts of the Rawalpindi Division are considered, which include Rawalpindi, Chakwal, Jhelum, and Attock. In the Rawalpindi division, four tehsils were chosen at random, while in district Attock and Chakwal there are two tehsils, whereas district has one tehsil of Dina. A total sample of 730 rural households from four districts in the Rawalpindi division were surveyed to test the MTFs through using multi stage random sampling techniques .

2.7.2. Sources of Data

The proposed study is based on primary source of data. Questionnaire, was used as the major instrumentation for the collection of desired information. Surveying is quite important for getting the needed information. Direct face-to-face engagement is the most suited and typical mode of inquiry.

3. Results and Discussion

3.1. Multi-Tier Framework Outcome and Analysis

The World Bank's Energy Sector Management Assistance Programme (ESMAP, 2017; Bhatia & Angelou, 2015a) established a methodology to examine the characteristics and amounts of certain energy access attribute components. Concise structure that reflects in-depth knowledge of family access to space heating. The districts of Chakwal, Jhelum, Attock, and Rawalpindi were included in an empirical analysis of rural household energy access for space heating to determine how things are currently. The framework has assessed how certain attributes have changed over time for various geographic regions. In this research MTF has focused primarily on the provision of space heating.The research cameout by evaluating the accessibility of space heating in different districts, marking the initial step toward comprehensively measuring energy access and identifying energy poverty within rural households in the Rawalpindi division. This strategic approach aims to provide a district-wise analysis, contributing valuable insights into the specific challenges and requirements faced by rural communities, ultimately guiding effective interventions to enhance energy security and alleviate energy poverty in the regionAs a result, the framework presented qualitative and quantitative estimations of families' access to heating, considering criteria such as the availability, affordability, quality, legality, and dependability of space heating.

3.1.1. Access to Space Heating of District Attock

This research focused on elucidating the energy requirements for space heating, which are contingent on various factors such as time of day, weather, building characteristics, and location-specific heat resistance. Employing a tiered classification system (tiers 0 to

5), this study evaluates access to space heating based on crucial parameters such as indoor air quality, capacity, affordability, and safety.
in tier 0 face limited or no access to space heating energy. Subsequently through figure 4, only 10% of rural households attain at least tier 1 space heating, while 17 percent, 37 percent, and 25 percent access energy for space heating at tiers 2, 3, and 4, respectively. District Attock in Rawalpindi Division records a modest 8 percent of houses with complete energy access for space heating, as illustrated in the accompanying chart depicting the distribution of household access levels.

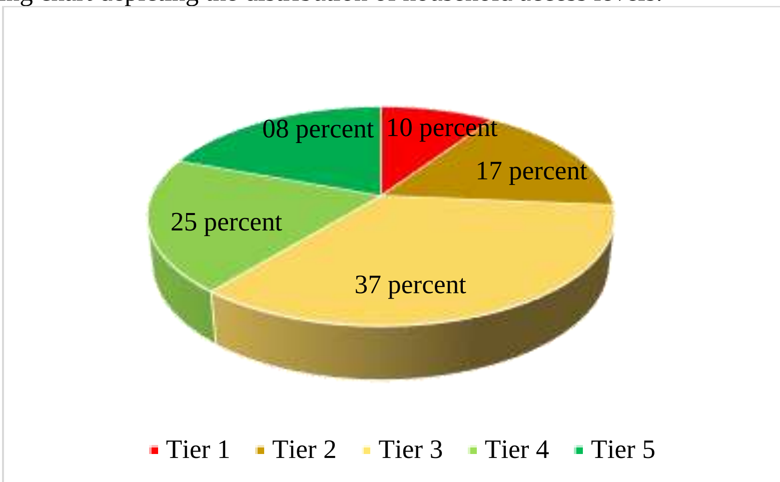

Figure 4: Space heating access tiers in district Attock

Three categories were identified for the energy access capacity for space heating, i.e., there is heating in every room, there is heating in at least one room, and there is no heating in any room. Therefore, only little or very little room for heating is present in 42 percent of tier 1 houses. families in District Attock have heating in every room; that is, ten percent of rural households have complete access to energy for space heating. in terms of as the duration of space heating is concerned, it has been established that it occurs 36%, 46%, and 18% of the time (50 percent of the time), at least 50% of the time (> 50% of the time), most of the time (> 75% of the time), and almost all of the time (> 95% of the time).
Referring to the degree of comfort attained in heated environments, the study emphasizes the importance of quality in space heating energy. Just 2% of households in Rawalpindi's District Attock reported feeling uncomfortable in the heated area, compared to 28% and 48% in Tiers 3 and 4. Interestingly, 22% of Tier 5 households reported feeling perfectly comfortable at 100%, revealing the wide range of comfort levels throughout various energy access tiers.
After the quality, capacity, and duration of energy access for space heating, reliability is another essential feature. The number of disruptions in energy availability for space heating per day and per week is used to calculate reliability in this context. The result indicates that 12 percent and 21 percent of the families in District Attock's tiers 2 and 3 and 24 percent and 43 percent of the households in tiers 4 and 5, respectively, faced disruptions every week for roughly 7 hours. In other words, the rural areas of District Attock demonstrated good overall energy reliability with respect to space heating. In the area of energy affordability for space heating, 73 percent of households in tiers 2 to 3 expressed satisfaction with energy affordability for heating, but only 27 percent of District Attock households felt the same way. The reason for this was a restricted budget, further 100% or complete safety was observed since no rural husehold in Tiers 0 to 5, has fatality or significant accident caused by space heating.

3.1.2. Access to space heating of district Jhelum

Access to space heating is also regarded as a crucial energy demand, particularly in Pakistan's rural areas. The outcomes of several factors pertaining to district Jhelum's energy access for space heating are recorded. According to tier 0, about 5% of households said they lacked the energy necessary for space heating. In figure 5, tiers 1, 2, 3, and 4 account 8 percent, 21 percent, 37 percent, and 22 percent of the Jhelum district's households, respectively. In Tier 5, it was found that 7 percent of rural families had complete access to energy for space heating. A crucial aspect of energy access for space heating is capacity, which refers to the area that needs to be heated. According to the results, just 26 percent of households in tier 1 have access to enough energy to heat their own personal rooms.
Moreover, 51 percent of households in tiers 2 and 3 and 7 percent of households in tiers 3 have access to heat energy that is sufficient to heat at least one room in their rural households. Just 16 percent of tier 5 households or households in the rural Jhelum district have full access to energy for space heating, or the thermal energy needed to heat every room in the house.
About the duration attribute, the findings showed that forty percent of Jhelum region rural households had energy constraints for space heating most of the time that it is needed. 47 percent of rural households in tiers 1 and 2 reported having the same amount of energy available for space heating as those in tier 0. However, among rural households in tiers 3, 4, and 5, 41 percent, 0 percent, and 20 percent said they had access to energy for space heating more than 50 percent, 75 percent, and 95 percent of the time when it was needed.
The degree of comfort in the heated room depends on by the energy quality used for space heating. Approximately 47% of households reported that at least 50% of the time they spent there was comfortable. Furthermore, for at least 75% of the time, 38% of Tier 4 households reported comfortable temperatures. It was discovered that just 13% of the comfortable, consistent temperatures.

Only 13% of rural Jhelum district rural households are exposed to the high-quality energy required for space heating.
Regarding the affordability of energy for space heating, more than two-thirds of families reported that the cost is twice as high as that of grid-supplied power. Of the residences, 27% still had the means to use energy for space heating. Furthermore, the availability of energy for space heating did not result in any occurrences of serious injuries or fatalities among Jhelum district rural households, suggesting that the district's safety rating remained at 100%.

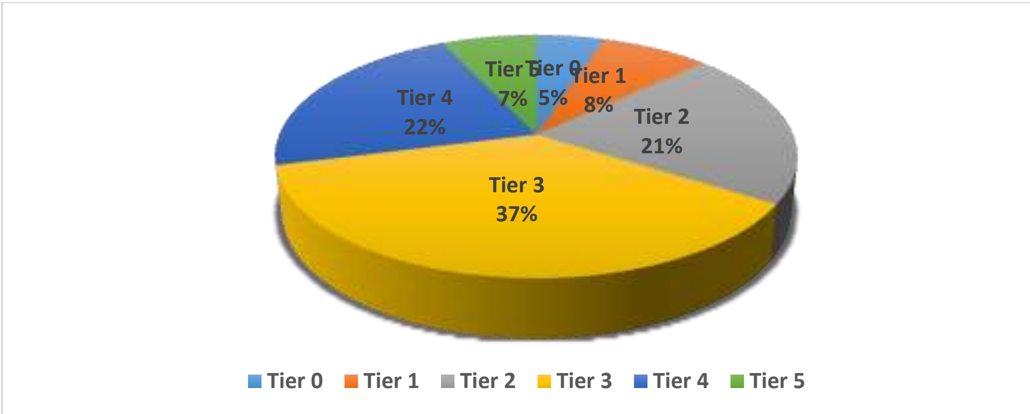

Figure 5: Space heating access tiers in district Jhelum

Access to energy for space heating was deemed inconvenient by nearly 18% of Tier 0 rural households. By comparison, the average amount of time that rural households in tiers 2, 3, and 4 reported spending collecting fuel for space heating was 7 hours, 3 hours, and 1.5 hours each week. No residence was completely practical in terms of sourcing fuel for thermal energy, as Tier 5 indicates. The quantity of daily disruptions in the supply of energy for space heating is referred to as reliability. Households exclusively in tier 2 rated Jhelum district energy access for space heating as an unreliable source. In contrast, tiers 3 and 4 of the Jhelum district saw disruptions that impacted 36 percent and 20 percent of residences, respectively, for longer than seven and three hours every day. Merely 14% of Tier 5 households reported no more than three daily interruptions in the energy supply for space heating, with each interruption lasting no more than two hours. When considering the abovementioned results, rural residents of the Jhelum district generally have negative opinions about reliability.

3.1.3. Access to space heating of district Rawalpindi

Following an investigation of rural households' access to energy for space heating in the districts of Attock and Jhelum, the study explored the characteristics of the rural areas in Rawalpindi district.
According to a study, tier 0 rural households in the Rawalpindi area have access to only 6% of the energy required for space heating. In tiers 1 through 4, the percentages of energy available to rural households are 10 percent, 20 percent, 27 percent, and 27 percent, respectively shown in figure 6. Of the Tier 5, only 10% reported having all or maximum energy available for space heating. The distribution of energy needed for space heating among rural households in tiers from 0 to 5.

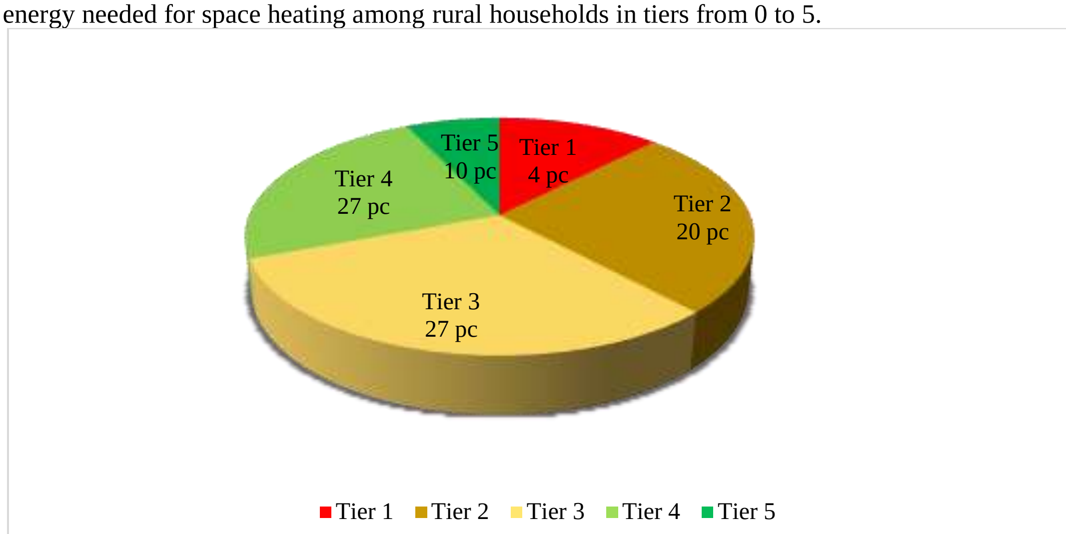

Figure 6: Space heating access of district Rawalpindi

Based on available data, a study indicates that 33% of rural households in Tier 1 have access to energy that is adequate for heating their personal space. Meanwhile only 37% and 14% of dwellings in Tiers 2 and 3 have access to enough energy to heat at least one room, respectively. Of the rural households in Tiers 4 and 5, sixteen percent still have access to enough energy to heat their entire rural households. Results for availability duration showed that 47% of tier 1 rural households could obtain energy when needed, but only for 50% of the time. 51% of rural households have access to the energy required for space heating when it's needed. Only 12% of houses in Tier 5 have continuous access to energy for space heating.

Half of the families said the temperature was comfortable when it came to the quality aspect. Comparatively, while the heat was on, 19% of tier 4 households and 28% of tier 3 households said that their rural households were always pleasant. The overall level of energy consumed for space heating in rural Rawalpindi region families was thus judged to be good.

In the Rawalpindi region, only 27% of rural families said they could afford the energy used for space heating, and 73% of households in tiers 2–3 said they were unhappy since their expenses were twice as high as when electricity was supplied from the gridForty percent of the families in Tier 2 report that their average weekly fuel collection time—also referred to as convenience—is longer than seven hours . Furthermore, 36 percent and 11 percent of families in Tiers 3 and 4 reported that their convenience exceeded three and one-half hours each week, respectively. Of the dwellings in Tiers 1 through 5, 3 percent, 2 percent, 60 percent, 13 percent, and 12 percent had poor indoor air quality. With an estimated 60% of them, households in Tier 3 were found to have the highest statistics for indoor air quality. While 31% of households experienced disruption for less than three hours per week, 17% experienced disruption for less than seven hours per week. However, there were no reported cases of injury or fatality among rural rural households in the Rawalpindi area.

3.1.4. Access to space heating of district Chakwal

Approximately 11%, 21%, 30%, and 27% of households in the Chakwal district are located in Tiers 1, 2, 3, and 4, respectively. It was discovered that 11% of rural families in Tier 5 have full access to energy for space heating. A vital aspect of capacity, or the area that requires heating, is that only 11% of tier 1 households had access to enough energy to heat their individual rooms, compared to 21% and 30% of tier 2 and 3 households, respectively, who could just heat one room and 27% and 11% of rural households, respectively, who could heat every room in the house. Regarding energy availability, 47% of tier 1 and tier 2 dwellings report the same condition. Nonetheless, when it comes to having access to energy for space heating, 30 percent, 27 percent, and 11 percent of rural households in Tiers 3, 4, and 5 reported doing so more than 50 percent, 75 percent, and 95 percent of the time.

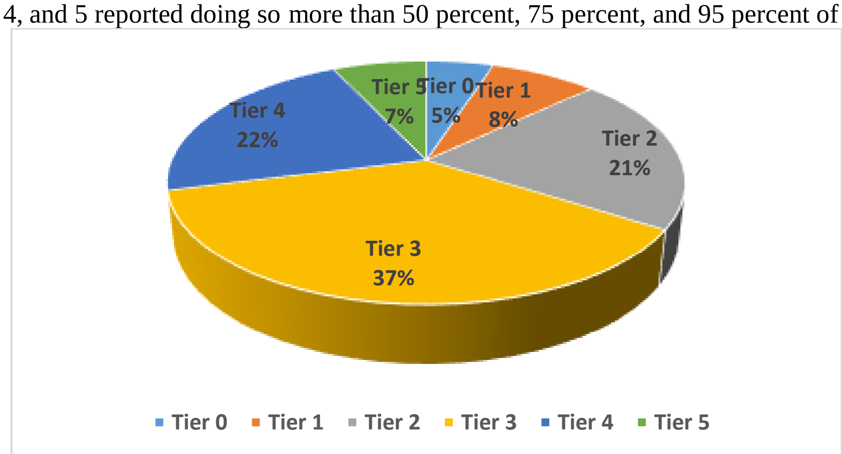

Figure 7: Space heating access tiers in district Chakwal

About 73% of households said they could not afford the energy because it was twice as expensive as energy from the grid . The remaining 27% of the rural households could pay for the energy required for space heating.. Moving on, no cases of significant injuries or fatalities were reported among ruralhouseholds, ensuring complete safety in the district. In tiers 2, 3, and 4, over 36%, 42%, and 14% of rural households said that they spent over 7, 3, and 1.5 hours a week, respectively, gathering fuel . No rural households was completely convenient for acquiring fuel for thermal energy. Dependability demonstrated the frequency of daily outages in the energy supply for space heating; in tiers 3 and 4, more than thirty percent of rural households reported outages that lasted more than seven and three hours, respectively. Merely 11% of families in Tier 5 experienced three or more disruptions in their energy availability for space heating within a 24-hour period.

3.2. Space Heating index

According to the data analyzed , Jhelum had the lowest access rate for space heating at 56.8 points, while the district of Chakwal had the highest access rate for space heating at 61.2 points shown in figure 8 (a), while in Rawalpindi, the access rate was 57.8, whereas in Attock, it was 59.

The analysis also examined the rates of households with access to heating by tier 3, with Attock having the greatest proportion 22.2, followed by tiers four 20, five 8, two 6.8, one 2. According to this, 59 points of Attock houses appear to have access to heating. In Jhelum, tier three had the greatest rate of heating access 22.2 , followed by tiers four 17.6, two 8.4, five 7, one 1.6 , and zero 0 in figure 8 (b) . According to the study conducted, district was able to end up having lowest among all districts of Rawalpindi division, and the largest contribution to district Jhelum was made by Tier 3 .

In the district of Rawalpindi, tier four has contributed 21.6 had the greatest part of index, followed by tier three 16.3, while tiers five 10 and two 8, There were just 2 units for Rawalpindi in tier one. Whict let district Rawalpindi to abosib access rate of 57.8 in the division.

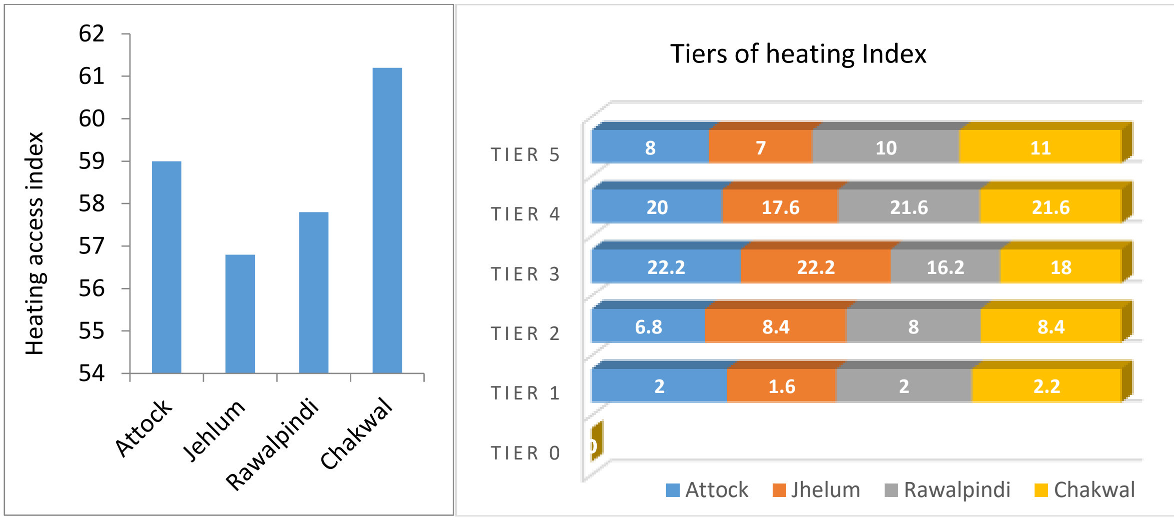

Figure 8(a&b): Space heating index

In Chakwal, tier four with 21.6 had the highest part for access index, which was followed by tiers three, 18 and four, 11. The results for tiers one and two were 2.2 and 8.4, respectively. This indicates that compared to rural households in other districts, Chakwal households have higher access to heating resources.

4. Conclusion

Pakistan's socioeconomic conditions are changing due to globalization, population expansion, and fast urbanization. It will be challenging to accomplish Sustainable Development Goal 7 and its targets, especially in terms of sustainable energy locally.

It is clear that there is a sizable gap in energy access for between districts based on the examination of access rates of space heating accross geographical locations of the Rawalpindi Division. Research concludes that rural households of district Jhelum has been traped in low accessibility of indoor space heating by scoring lowest index of 56.8 among the districts of Rawalpindi division. Households have to deal with more frequent disruptions and are typically kept away from comfortable temperatures, further index has been affected by convience and air quality of space heating attributes . Nevertheless, district Chakwal has provoked itself to be positioned at the top of the space heating index, i.e., 61.2, by ascertaining the reliability attribute and finding the cost of space heating within an affordable range. The affordability of indoor heating posed significant challenges for rural households in the district Attock. In Rawalpindi district, a seizable rural households of 37 percent, have curtailed them in higher tiers of 2 and 4.

Due to the interplay of different attributes across the researched area, a more geograpical embedded localized policy and targeted interventions in the long and short-term, would be appropriate. Implementing targeted subsidies for low-income families or financial incentives to equip rural households with clean, renewable energy sources and cost-effective heating solutions. Collaboration between NGOs and local authorities to undertake community-driven projects, promoting partnerships with private sector entities to develop and promote cost-effective heating solutions, launching public awareness campaigns. Conducting frequent monitoring and evaluation, to assess the impact of indoor heating policies over time using the Multi Tier Framework from the World Bank.

Certain critical facts of the energy access problem were overlooked, such as analysis of energy market, behavioral forces, geospatially analysis, technology transfer and gender issues.At the completion of the research, study provided baseline for the policy makers to develop the policies for energy access for spaceheating across Rural household's area of Pakistan.

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