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Clean Energy as an Alternative: Identification of Factors Determining the Willingness of Slum Dwellers

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Abstract

Increasing trends towards globalization and modern lifestyle are going to deplete energy resources rapidly. Increasing trends towards energy use directly harness the environment and ecosystem of the earth, depicting that energy will be one of the most important future problems of the world. Clean and sustainable energy alternatives are required to meet this demand to combat the antagonistic environmental problems. Renewable energy sources have the potential to fulfill the energy gaps without affecting the ecosystem and the greenhouse gases' emittance. The transformation of people causes the generation and creation of slum areas in the cities due to ever-increasing urbanization. Presently around one billion people are residing in slum areas. Most slum dwellers are found in less economically developed countries, which makes it 30% of the total population. The inhabitants of slum dwellers are more likely to be increased by two billion by 2030 and to three billion by 2050. Pakistan is facing a severe energy deficiency. The energy gap between energy supply and demand is widening with time. Limited fossil fuel resources allow the country to import nonrenewable energy resources to fill this gap. Gas connection problems and energy shortfalls compel urban households to use nonrenewable energy resources. The need of the hour is to diversify the energy resources like biogas, hydropower, solar, and wind to overcome the energy shortfall in the country. Fossil fuel usage for an energy source in households is the major cause of environmental degradation in urban households. Owed to bad smoke and insufficient ventilation, health-related problems like respiratory issues, stomach problems, and other contagious diseases are associated. The smoke that is caused by the combustion of biofuels impacts residents' health badly, especially respiratory problems. The primitive aim of this research is an assessment of energy sources being used and to dig out reasons for their impacts on the health conditions of residents of slum dwellers in Pakistan. Stratified random sampling is used for data collection and correlation analysis was performed to find out the result.

Index Terms: *Clean Energy, Dwellers, Health Conditions, Renewable Energy, Slum.*

I. INTRODUCTION

Facts revealed that the expansion in urban areas is a prime concern for less developed countries [1], and [2]. As in rural areas people are deprived of basic facilities of life like good health care facilities, accommodation, sanitized water, electricity, employment opportunities, education facilities etc. The availability of these accessibility encourages the rural population to move towards urban areas. As these amenities and services are way costly and out of reach for these migrated people. With their limited income resources, to settle themselves in urban life, these migrated people practice illegal ways to take possession of vacant places within or outskirts of cities or suburbs of cities. The transformation of people causes the generation and creation of slum areas in the cities [3].

According to research, around one billion people are residing in slum areas. Most slum dwellers are found in less economically developed countries, which makes it 30% of the total population. The inhabitants of slum dwellers are more likely to increase by two billion by 2030 and to three billion by 2050 [4]. According to the World Health Organization's estimation, 2.5 billion people use biofuels for cooking, which leads to chronic respiratory diseases [5], and leads to two million deaths of women and children per year [6]. A typical household in Peru, for cooking and heating, burns almost 3.6 tons of wood per year, having several ripple effects [7]. These lifestyles are chronic and cause dangerous long-term impacts [8]. It can add aerosols and carbon emissions to the environment [9]. Continuous wood gathering tends towards deforestation. A satellite map can be a valuable resource for calculating this devastating change [10]. United Nations (UN) has announced eight goals on a global scale to be met for improving the quality of life among common people and ensuring environmental sustainability [11]. The USA has been the world leader in renewable energy resources since the colonial era from the age of wood consumption to petroleum and dominated chemical products [12]. But with the advent of modern technological development

developing countries can leapfrog over devastating energy monopolies and can develop their own pathways to get momentous fiscal effects with little technological transformation. A climate expert Daniel Kammen commented in World Bank that there is a clear nexus between climate change, poverty, and energy use transformation [13]. The three significantly correlated with each other. Inefficient cooking with biomass robs a lot of precious social resources of women and kids, like time, quality of life, education time, social responsibilities, small businesses, playing, and health [14]. Solar cooking is an approach to breaking the energy nexus by reducing net heat loss factor consideration along with other factors and observing Newton's law of cooling and heating [15]. A combination of a heat storage container, a solar fuel-efficient cooking stove, and a solar cooker can be the combination of an efficient integrated cooking solution in sunny regions of the Globe [16], and [17]. Solar-based appliances for cooking and heating not only replace firewood needs but significantly finishes the need for fuels [18]. It will reduce fuel and energy consumption costs but also positively impacts the environment and health issues due to burning renewable fuels [19], and [20].

According to a United Nations report, overall cities comprise more than half of the population of the world [21]. Futurists have forecasted that this pattern will grow rapidly in the next coming decades, more particularly in Africa and Asia [22]. These regions of the world are having more slums and informal settlements due to an increase in urban growth and the frequent movement of people from villages to cities in seek of better income opportunities or city facilities [23]. Another report by the UN guesstimates that almost one billion of the total population of the world, which makes it one-sixth of the total population lives in slums. As predicted near 2030, almost five billion individuals will be residing in urban areas, whereas in the year 2007, the number was 3.2 billion, mostly people living life below the poverty line and lowest earners are compelled to live in slums [24]. Due to Poorer socio-economic situations, they have no other option than to live in slums [25]. People residing in such areas are more prone to catch transmissible diseases due to malnutrition and living conditions in slums, for instance unhygienic sanitation, the food they take, and bad health conditions [26]. Usually, the slum inhabitants in developing countries are mostly the ones who are leading a life in poverty. Their chances of getting a good income are exceptionally low. Of the few necessities of life sufficient supply of water is the most important of all [27]. But regrettably, most of the time, slum households do not have any system or infrastructure to have access to clean water. Sanitation planning is also very pitiable in slums [28], this causes an unhygienic condition of slums which makes favorable conditions for diseases to spread out [29]. As a result, we can say that slums are the result of bad management by the government, corruption, dysfunctional land markets, bad financial system, failed policies, and an unwilling political system Energy Profile [26].

The outrageous practice of cutting down the forest aggressively is a danger to environmental sustainability. Deforestation can occur due to human and natural factors. The leading cause of deforestation is human activity with an uncontrollable rate of cutting down activity. Countries that are suffering socioeconomically poor force their population to exploit natural resources for commercial gain [30], and [31]. About two and half billion population in the world relies heavily on biomass, which includes wood, dung, and shrubs. The consumption of biomass fuel is hazardous not only to the environment but also to individuals' health. Almost 3% of all diseases are results of smoke produced by wood further resulting in the premature death of around 1.6 million.

In South Asia, Pakistan with a north latitude of 24 & 36 and 61 & 76 east longitude covers an area of 796,096 km^2 of land [32]. The country depends heavily on fossil fuels [33], and [34]. According to research, approximately 60% of Pakistan's total foreign currency is being used to import fossil fuels. However, the country has limited restrictions and has its own fossil energy resources and has low energy consumption per capita of 501.6 kg of oil equivalent compared to the world average of 1790 kg of oil equivalent. Pakistan is therefore facing major challenges in the energy sector to meet growing demand at a rate of 11-13% per year [35].

II. LITERATURE REVIEW

The United Nations terms slums as regions of high population density, deprived of basic living conditions and spaces with high population density but with underprivileged infrastructure. The living conditions with underprivileged conditions, consequently, have undesirable impacts on both the physical and mental health of their inhabitants [29]. The slum is stated to be "a physically and socially depreciated residential area where satisfactory family life is impossible". Hence, it is important to upgrade the infrastructure of hygiene, sanitation, and the system of water supply [36].

Pakistan Social and Living Standard Measurement Survey 2008-2009 elaborates that 68% of the total rural domestic population and out of 53% of the total urban domestic population depend upon charcoal and wood as an energy source for cooking [37]. The role of energy in the daily life of a man is important and poverty is a condition for people who are deprived of basic needs of life, it is decided that there has a lot of association between energy and poverty. While poverty is a condition for people who are deprived of basic needs of life, it is concluded that there is a lot of association between energy and poverty [38].

From the aspects of basic facilities i.e., access to clean and drinking water, health facilities, and education, poor people are usually deprived of such services and thus have extremely limited or less access to sources of energy. Families with low income depend on traditional biomass. According to a survey, 30% of the population in Pakistan is using biomass fuel [39]. From the survey of 1998, 54% of the population consumes firewood, 18% dung, and 14% crops waste [40]. The usage of biomass fuel is injurious and damaging to health. So, in literature, there has been discussion to replace biomass fuel with some other source that is not hazardous to health and the surroundings [41]. Countries that are suffering socioeconomically force their population to exploit natural resources for commercial gain [30].

About two and half billion population in the world relies on biomass fuel, such as wood, dung, and shrubs [42]. The consumption of biomass fuel is hazardous to the environment and individuals' health. Almost 3% of all diseases are the results of smoke produced by wood further resulting in the premature death of around 1.6 million [30]. The number of slum dwellers has been increasing for centuries and it has reached 924 million, which is 36% of the total world's urban population. Global report on human settlement elaborates that after Sub-Saharan Africa, South Asia hosts the second largest slum in the world. About 37% of the population is residing in urban areas by this time and it is increasing with the rise of 3.97% per year (According to the survey of 2010-11); by the time of 2007, the total slum population is 47% of the total urban population.

Although Islamabad is a very well-planned city having over one million citizens, has got a number of migrants due to economic, social, and environmental planning in the last few decades. According to CDA, 0.1 million people are residing in the slums of Islamabad. In Lahore, 30% of the legitimate land is occupied by slum dwellers [43].

Socio-Economic Opportunities Index (SEOI) was designed to assess the level of deprivation. The results showed that 48% of people living in slums were deprived of the necessities of life. Most were uneducated and the literacy rate was as low as 55%. Out of which 56 were males and 46 were females. Those who were literate were not educated above matric. The employment rate was 77% overall. The employment rate among males was around 88% and 75% among females. But they were not doing proper full-time jobs. Their jobs were of very low income and an average of Rs 525 was their whole day expense also saving was nothing.

The socio-economic profile of individuals plays a major role in making a decision, for the selection of the energy source, their perception about that energy, health risks involved with that energy, and awareness related to health risks involved. Pakistan comes at 9 in the list of populous countries and its population is still increasing at the rate of 4.38% annually. One-third of its population is residing in urban areas [44]. A survey from a study of 1990-91 showed that of kids under the age of 5, 16% of them got acute respiratory infection within two weeks of the survey. Also, the cough is complemented by rapid breathing. Almost 40% of the population is settling in 'Katchi-Abadis', where they are living in less than 500 square meters of houses [45].

In urban areas, contamination through air and water is being faced by most of the earth's population [46]. There are many studies on the relationship between air pollution and different health issues related to stomach and respiration [47], and [48].

Making people aware of the risks involved with these exposures can make them change their behavior toward the consumption of energy usage [49-51]. Thus, it is very important to project new behaviors to change the perception and knowledge about the environmentally hazardous results of bad smoke [52].

A study was conducted in Peshawar, to assess how many people were using clean energy and how many of them were aware that what kind of energy is good for an individual's health and environmental friendliness. In this study, results showed many few people were willing to adopt anything that is expensive to their current cooking methods, but they are willing to adapt if it's easily available. But a study confirmed that an individual's qualification and monthly income depend on choosing whether they should use biomass stoves or not. Not only individual choices and convenience, socio-economic, political, economic, and institutional factors also matter to change people's minds [53]. Informal means of fuels have been used in South Asia to follow the energy ladder like dung, crop residue, gobar gas, firewood, kerosene, LPG, and electricity for cooking purposes. Evidence suggests that while it is possible to observe a such transition in urban and semi-urban areas, the change is very slow in rural areas [54].

III. MATERIALS AND METHODS

A. Proposed Research Model

The proposed research methodology shown in figure I below.

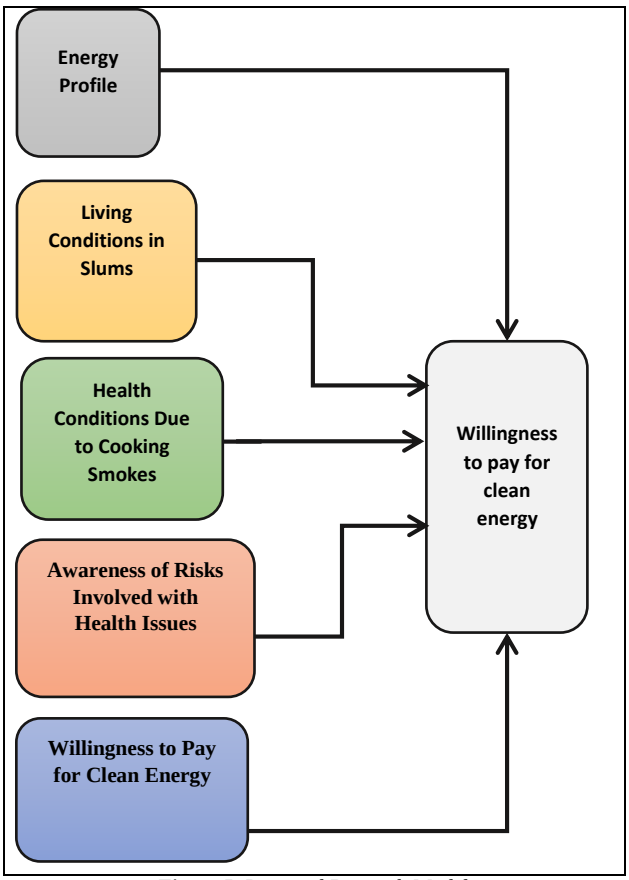

Figure I: Proposed Research Model

a) Problem Statement:

Rawalpindi is one of the oldest and largest cities in Pakistan. Urbanization patterns changed after independence and the announcement of the formation of its first planned city Islamabad, which was going to be the federal capital of the country. The selected slums are the oldest ones and were developed to fulfill the housing needs of a growing population. This research is part of the ongoing research, in which stratified random sampling was conducted to collect the housing sample of overall Rawalpindi city, out of which these slums are identified to collect the household energy profile information for the lower middle class of the area. Substandard living

conditions compel people to use alternative fuels for cooking resulting in critical health conditions due to cooking smokes. Studies involved in research come to the conclusion that uneducated people living in slums if properly get aware of the repercussions of cooking smoke due to non-renewable energy resources, not only involved with several health issues and diseases but also generate higher carbon emissions, are willing to pay for clean energy if properly financial incentives and tax rebates will be given to them.

b) Solvin's Formula:

When we do not have absolute information about the exact population, we use Solvin's formula for the sample size collection considering the in-hand information (Altares, 2003). See the below equation, i.e., eq. (1).

$$n = \frac{N}{(1+Ne2)} \quad (1)$$

Where;
N = Total Number of Household
e = Margin of Error
10%= 0.1(Confidence Level= 90%), and
5%= .05 Margin of Error with 95% Confidence Level.

Here;
For Rawalpindi,

n = N / (1+Ne2)
If;

We take Population,

n= 2098000/2098000*(.05)2
n=399.9
n=400 while using Solvin Formula for Population.

If;
We take the Number of Households for Sample Size calculation it will be,

n = N / (1+Ne2)
n= 889000/1+889000(0.05)2
n=99.8

But if;
We take Area into consideration for Sample Size with a 95 % Confidence Level and 5% Margin of Error it will be
Area= 259 (Survey can be done at every 5 km distance 259/5=51.8= 100).

A contextual study of these areas in terms of their topographical, demographic, and socio-economic features, sampling procedure, approaches used for data collection, data analysis, tools, and techniques to carry out this study. Statistical Package for the Social Sciences (SPSS) version 20.0, a statistical software platform was used to evaluate the questionnaires attained from the respondents while surveying study areas.

The city of Rawalpindi is located in Punjab Pakistan and the capital of Pakistan, Islamabad is adjacent to Rawalpindi as shown in figure II. The figure II was taken from 'The Urban Unit, Lahore'.

These two joint cities are recognized as the 'Twin Cities'. It is located at the coordinates of 33°36′N 73°02′E. The city is encircled by the Islamabad area on the north and east and with motorway and Taxila cities on the west. Its area consists of 250 square kilometers on the southwestern side of the national capital of Islamabad.

The city district of Rawalpindi covers seven independent tehsils i.e., Rawalpindi, Gujarkhan, Taxila, Muree, Kotli Sattian, Kahuta, and Kallar Syedan. There is a military headquarters of the Pakistan Armed Forces in Rawalpindi. The administration of Rawalpindi city is called Rawal Town Administration. The main Rawalpindi City is Rawal Town.

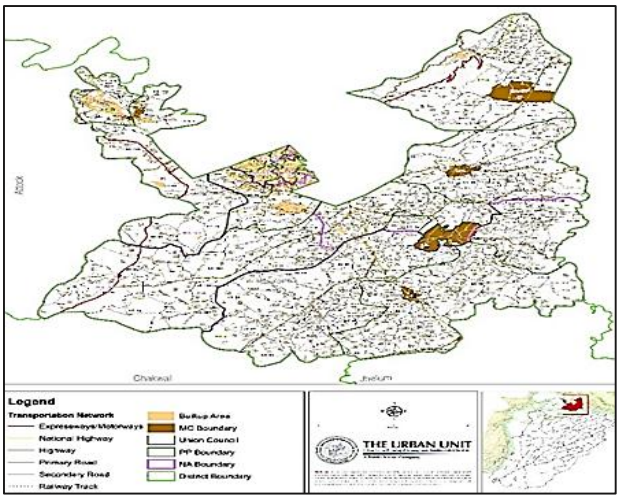

Figure II: Location of Rawalpindi

Rawal Town, Rawalpindi Cantonment Board, and the Rawalpindi Development Authority bear the jurisdictional responsibility of Rawalpindi. The city with the increased business opportunities was declared as the interim capital which witnessed a serious housing shortage in the city. Till then, the city grew tremendously but the infrastructure and services could not keep pace with the population growth.

Rawalpindi is the fourth-largest city in Pakistan by population and the third-largest metropolitan area in the country. The population inhibited approximately 2.1 million persons in 2017. The estimated population is 3.2 million persons by the end of 2020; 84% of the population is Punjabi, 9% is Pashtun, and 7% is from other ethnic groups [55].

B. Location of Slum Areas under Research

The study aims to analyze household energy usage and its impacts in the slum areas of Rawalpindi City as seen in figure III.

Figure III: Targeted Slum Areas of Rawalpindi

Four areas of the city were selected, including Gharibabad – near Chaklala Cantonment, figure IV, Do Manzali – near Rawalpindi Cantonment, figure V, Gawalmandi Supply and Gawalmindi – along Nullah, figure VI.

These above-mentioned figures i.e., figure III-Figure V, were taken from 'Google Earth Pro' (Dec 2019).

The majority of slum dwellers of Gharibabad have ownership rights and are settled legally. It is surrounded by Chaklala Cantt, Railway Scheme Chaklala, and Chaklala Scheme-III.

Figure IV: Location of Gharibabad Slum Area

Figure V: Location of Domanzli Slum Area

Domanzli is situated near the Rawalpindi Station Headquarters. Slum inhabitants of Domanzli have no property rights on the land on which they have resided. As this land is in the ownership of Government officials and the slum dwellers of Domanzli are working as housekeepers in the houses of these Government officials.

Figure VI: Location of Gawalmandi-Supply and Gawalmandi-Nullah Slum Area

Whereas, Gawalmandi is found near the Chaman Colony and Mohan Pura. For this research study, Gawalmandi is divided into two sections with the name of Gawalmandi-Nullah and Gawalmandi-Supply based on the names used by the residents of these slums. Households of Gawalmandi have illegal possession of the land they are living in. These slums' inhabitants are financially deprived and belongs to lower middle class. These areas were considered most conforming to the objectives of this research. A survey of these slum residents was conducted by distributing questionnaires among them. In order to find the factors determining the willingness of slum dwellers to shift to clean energy, the factorial method was applied under Principal Component Analysis (PCA) method. In PCA all energy usage variables concerning the user's behavior were incorporated, with which each component interpreting a percentage of variance, which previously has not been incorporated by any component. Social sciences allow 60% of the acceptable variance, which is going to be incorporated as approximately 70%. Factor identification is done while using the Kaiser criterion in which the Eigen value, should be more than 1. Sampling and question adequacy was measured by Kaiser-Meyer-Olkin (KMO) and Bartlett's test, which revealed a satisfactory value (KMO = 0.739 and $p < 0.001$ on Bartlett) as can be seen in table I. This test explains that the correlation matrix is an identity matrix, a significant correlation exists between questions and factor analysis, justifies the sample size.

Table I: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.739
Bartlett's Test of Sphericity	Approx. Chi-Square	8467.659
	df	595
	Sig.	.000

Out of the initial number of variables, ten components were identified by the Kaiser criterion, explaining a total of 71% of the observed variance; a percentage that is considered satisfactory for research in social sciences. Kaiser criteria identified ten components out of initial variable numbers, which explain 71% of the observed variance means results are satisfactory.

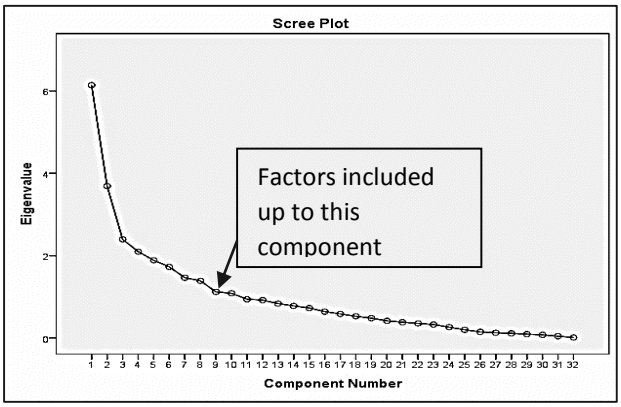

Figure VII: Factors Influencing the Willingness of Households

The scree plot above shows the component which contributes to determining the factors influencing the willingness of households (see figure VII). On examination of this plot, it was found that 9 components

having Eigen values of more than 1 explained the variation of 69%. The difference between Eigen values after the 9th component was minimum. Thus the 10th component was omitted (see table II).

The nine components were then analyzed based on the values in the rotated matrix and the analysis was repeated several times to include only those factors whose extraction value in the commonality table was more than 0.3 and those items which were selected which were showing correlation more than 30% with the nine components. These factors have a high correlation amongst themselves but are not correlated across the components.

In order to find out which factors contributed the most to these components, a detailed reliability analysis was applied, and those loading factors were excluded which lowered the value of Cronbach's alpha coefficient.

Cronbach's alpha coefficient's value of 0.7 was considered satisfactory and based on this criterion all nine components were tested. The factors contributing to the nine components along with their factor loading are shown in table III.

Table II: Comparison of Scree Plot and Eigen Values

Factor number	Scree Plot	Eigen values > 1
1	Accepted	6.139
2	Accepted	3.689
3	Accepted	2.397
4	Accepted	2.097
5	Accepted	1.887
6	Accepted	1.726
7	Accepted	1.464
8	Accepted	1.389
9	Accepted	1.121
10	Omitted as Scree Plot Curve gets Parallel to Axis after Factor No.9	1.085

Table III: Factor Matrix for Willingness to Pay for Clean Energy

Statement	Factor Loading								
	Factor - 1	Factor - 2	Factor - 3	Factor - 4	Factor - 5	Factor - 6	Factor - 7	Factor - 8	Factor - 9
Affordability of Households to Pay for Clean Energy	0.909								
Level of Affordability to Pay for Clean Energy	0.778								
Size of Household		0.927							
No. of Working Household Members		0.747							
Household Total Income		0.656							
Per Capita Income		-0.605							
Education Level of Household Head			0.633						
Literacy Status of Female Household Members			0.877						
The situation of Cooking Setup in a Household				0.742					
Ventilation Condition in the Cooking Area				0.913					
Level of Concern about the Health of a Person who Cooks the Meal regarding Cooking Practices					0.969				
Level of Concern about Children in Households regarding Cooking Practices					0.965				
Amount Spent on the Facility of Electricity during Summers						0.728			
Amount Spent on the Facility of Electricity during Winters						0.769			
Possession of Mobile Phone							0.829		
Possession of Television							0.728		
Prevalence of Asthma								0.649	
Prevalence of Breathing Problems in a Person who Cooks the Meal								0.722	
Prevalence of Breathing Problems in Children of Household								0.552	
Prevalence of Cough									0.698
Willingness to change to Clean Energy Appliance									0.656

IV. RESULTS AND DISCUSSION (FINDINGS OF FACTOR ANALYSIS)

In order to search out the factors influencing the willingness of households to pay for clean energy, factor analysis was performed. The analysis was run on 32 parameters which were reduced to 21 parameters and were clustered in the 9 factors shown in the table above i.e., table III. Some of the parameters contributing to the factors can be grouped and perceived as the factors lying under the same umbrella.

Further grouping of these factors enables us to conclude 8 factors mentioned below:

A. Factor-1: Household's Financial Strength for Paying Clean Energy

- Households' affordability for paying clean energy.
- Affordability level for paying for clean energy.
- Willingness to change to clean energy appliances.

B. Factor-2: Socioeconomic Profile of a Household

- Size of the household.
- Number of working household members.
- Household total income.
- Per capita income.

C. Factor-3: Literacy Level of a Household

- Education level of the household head.
- Literacy status of female household members.

D. Factor-4: Cooking Setup and Ventilation Condition in a Household

- The situation of cooking setup in a household.
- Ventilation condition in the cooking area.

E. Factor-5: Level of Concern Regarding Health of Household Members

- Level of concern about the health of a person who cooks the meal regarding cooking practices.
- Level of concern about children in households regarding cooking practices.

F. Factor-6: Cost Spent on Energy

- Amount spent on the facility of electricity during summers.
- Amount spent on the facility of electricity during winters.

G. Factor-7: Level of Familiarity with Information Technology Devices

- Possession of mobile phone.
- Possession of television.

H. Factor-8: Prevalence of Breathing Problems and Diseases Amongst Household Members

- Prevalence of asthma.
- Prevalence of cough.
- Prevalence of breathing problems in a person who cooks the meal.
- Prevalence of breathing problems in children of the household.

While willingness to pay for clean energy is a dependent variable, the above explanatory variables are the 8 factors influencing the willingness to adopt clean energy for cooking. The analysis of SPSS shows that these factors are statistically significant to influence willingness.

Amongst the above factors, the household's financial strength to pay for clean energy is the most influencing factor, followed by socioeconomic profile, literacy level, cooking setup and ventilation conditions, concern regarding health, cost spent on other energy sources, familiarity with Information Technology (IT) devices and prevalence of breathing problems and diseases in household members.

Some of these results are similar in a way to the study of Lagos State Nigeria. The most influencing factor from Yusuf's study was awareness of renewable energy sources [56]. In the above factor analysis, the variable of awareness was included initially among the 32 parameters. As per this research, the analysis found the level of concern regarding health due to cooking practices is more influencing than the level of awareness regarding cooking smoke. This suggests that households which are more concerned about their health regarding cooking practices are more willing to pay for clean energy.

The most influencing factor, i.e., the financial strength of households to pay for clean energy, suggests that slum dwellers need financial support from the government to provide these households with clean energy sources. As discussed in the section on willingness, households were willing to shift to clean energy sources only if it was to be provided at cheaper rates than the sources currently in use. Government should also encourage the use of clean energy through different policies such as by creating an environment for the easier production of clean energy equipment. This will help to build a sustainable renewable energy market for the easy purchase of clean energy products.

The factor of households' socioeconomic profile (Factor-2) which hugely relies on the per capita income suggests that households with higher per capita income will be more willing to use clean energy. Similarly, the literacy level of a household (Factor-3) suggests that willingness to pay for clean energy is influenced by the level of education. As discussed in the section on awareness regarding cooking smoke, it is evident that the level of awareness regarding cooking smoke is related to the education of household members.

Cooking setup and ventilation conditions in slums are poor which causes indoor air pollution and leads to many diseases. Factor-4 consists of the factors determining the situation of the cooking area in a household which also influences the willingness of households to pay for some other source.

The cost spent on other energy sources such as electricity also influences the willingness of households to pay for clean energy. More costs spent on other sources of energy will restrict households from paying for clean energy. Factor-7 suggests the more the households are familiar with communication devices, the more they will be aware of the effects of the energy sources they are using. This directly corresponds to their use of telecom devices with their awareness level regarding the impacts of cooking smoke.

Although last amongst the other factors, but with a huge impact on the willingness of households, Factor-9 suggests that the prevalence of breathing problems amongst the households also prompts them to shift to some other source which is cleaner. As evident from the results, breathing problems and diseases were more common amongst the households which used firewood for cooking purposes, and they were more willing to pay for clean energy. The government should conduct awareness programs to educate, and aware slum people of the diseases caused by cooking smoke.

V. CONCLUSIONS AND RECOMMENDATIONS

This study focused on cooking energies amongst low-income households specifically in the urban slums of Rawalpindi. The study explained the creation of slums and a number of factors influencing the choice of cooking energy. The results revealed that out of 400 households, almost half of them used firewood throughout the year and the other half were using natural gas during summers and firewood during winters, showing all the households were using firewood. While the cost spent on cooking purposes using firewood was a considerable proportion (33%) of the households' total income, resultantly limiting them to spending efficiently in order to raise their living conditions. It was revealed from the descriptive and correlation analysis that respiratory symptoms and diseases were significant amongst the households with a major prevalence of cough, chest pain, phlegm, and shortness of breath. This shows that households are not only financially challenged but also vulnerable to respiratory illnesses and do not have enough savings to protect themselves from various diseases. Given that the majority of the households were aware of the negative

impacts of cooking smoke, people were willing to adopt a source of energy that would be harmless to their health and would be eco-friendly. Households using firewood primarily for cooking purposes were willing to adopt the alternative source of energy to save costs spent on cooking energy whereas households using firewood partially in the absence of gas were willing to switch only if an uninterrupted source of energy is provided throughout the year for cooking purposes. While both types of households were willing to pay for clean energy if it is inexpensive and economical than the sources which are currently being used for cooking purposes.

The results also show that level of awareness regarding cooking smoke is associated with the education level of household members. While the prevalence of respiratory symptoms prompts households to shift to some clean source of energy. It was also revealed through this research that the level of concern about the health of household members regarding cooking practices among these households was significant.

It was found that most households were not familiar with the concept of clean energy and referred to clean energy as natural gas only. The majority of the households were found willing to use clean energy sources for cooking purposes and were willing to pay Rs. 1000/month on clean energy for cooking purposes. Major factors which influence the willingness of households to pay for clean energy are socioeconomic conditions of households, housing conditions, and awareness regarding the negative impacts of cooking smoke.

The initial speculation of budget, mismanagement of regularity authorities, lack of support from the government, and absence of governmental appropriate policies are major barriers to upgrading the development of clean energies other than natural gas in the country. A proper policy framework is required to create awareness amongst the overall public including the slum dwellers and to promote the usage of solar stoves overall. Utilizing solar energy on domestic as well as commercial levels will be beneficial for environmental and socio-economic factors in the long term.

Some of the recommendations are mentioned that need to be taken in order to promote the use of alternative sources of clean energy other than gas:

- Consumption of firewood should be discouraged through Government interventions as it leads to deforestation and poses great dangers to human health.
- Awareness campaigns should be planned to create awareness of health risks involved with the usage of cooking smoke and proper ways to reach out to them as it influences the households' willingness to shift to clean energy sources.
- Include the technologies of solar energy in national policies for cooking purposes.
- Investors and entrepreneurs should be promoted to invest in and encourage private sector participation in the improved cooking stoves.
- Entrepreneurs should be encouraged to step forward in the investment and incorporation of renewable energy sources in the housing sector and provide them incentives.
- Deployment of renewable sources of energy.
- The initiative should be taken to design solar cooking stoves locally to make them affordable for the urban slums.
- Awareness regarding the depletion of natural gas resources should also be spread in order to influence the willingness of households to use natural gas to shift to a clean source of energy.

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Authors Contributions

The contribution of the authors was as follows: Saima Gulzar's contribution to this study was the concept, technical implementation, and correspondence. Data collection, data compilation, validation and paper writing were performed by Rummana Sherwani. Abdul Waheed's contribution was supervision, and project administration.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The testing data is available in this paper.

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References

[1] Chirisa, I. (2008). Population growth and rapid urbanization in Africa: Implications for sustainability. *Journal of Sustainable Development in Africa, 10(*2), 361 -394.

[2] Chen, X. (2009). Shanghai Rising: *State Power and Local Transformations in a Global Megacity*. Minneapolis, Minnesota: University of Minnesota Press.

[3] Drakakis-Smith, D. (2000). Third World Cities (Second Edition ed.). London and New York: Routledge.

[4] Habitat, U. N. (2016). World Cities Report 2016: Urbanization and Development–Emerging Futures. *Publisher: UN-Habitat.*

[5] Agency, I. E. (2009). Regarding the earliest use of fire, Friendly Fire: The First Campfires Helped Hominids Survive the Night. Paris: Organisation for Economic Co-operation and Development.

[6] Bruce, N., Perez-Padilla, R., & Albalak, R. (2000). Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization, 78*(9), 1078-1092.

[7] Bodereau, P. N. (2011). Peruvian highlands, fume-free. *Science, 334*(6053), 157-157.

[8] Ramanathan, V. et al. (Nov. 27, 2001). Indian Ocean Experiment: An Integrated Analysis of the Climate Forcing and Effects of the Great Indo-Asian Haze. *Journal of Geophysics Research, 106*, no. D22(28), 371–98.

[9] American Association for the Advancement of Science. (2011). Aerosols Altered Asian Monsoons. *Science 333*, p. 1808.

[10] Arveson, P. (2012). Integrated Solar Cooking: An Underutilized Solution. *Perspectives on Science & Christian Faith, 64*(1).

[11] UN. (2011). United Nations Millennium Development Goals Report. UN.

[12] Gibbons, A. (February 5, 2010). Greening Haiti, Tree by Tree. *Science 327*, UN.

[13] Casillas, C. E., & Kammen, D. M. (2010). The energy-poverty-climate nexus. *Science, 330*(6008), 1181-1182.

[14] FAO. (2011). State of the World's Forests. United Nations Food and Agriculture Organization (FAO), Rome.

[15] WHO. (2011). *Health in the Green Economy: Co-benefits to Health of Climate Change Mitigation—Housing Sector*. Geneva, Switzerland: WHO Press.

[16] Loskota, B. and Wood, D. B. (October 2007). Solar Cooker Project Evaluation: Iridimi Refugee Camp, Chad. D. B. Wood, Chad.

[17] Cicchetti, D. A., & Metcalf, R. H. (1984). Pasteurization of naturally contaminated water with solar energy. *Applied and Environmental Microbiology*, *47*(2), 223-228.

[18] Kammen, D. M., & Lankford, W. F. (1990). Comparative study of box-type solar cookers in Nicaragua. *Solar & wind technology*, *7*(4), 463-471.

[19] American Society of Agricultural Engineers. (January 2003). Testing and Reporting Solar Cooker Performance. *ASAE*, *1*, 824-826.

[20] N. Adams. (2011). Household Cookstoves, Environment, Health, and Climate Change. Washington, DC: *The World Bank*.

[21] Habitat, U. N. (2016). Slum almanac 2015–2016: Tracking improvement in the lives of slum dwellers. *Participatory Slum Upgrading Programme.*

[22] United Nations. (2015). Sustainable Development Goals—United Nations. *United Nations Sustainable Development*, *2*. Retrieved from; https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[23] Ezeh, A., Oyebode, O., Satterthwaite, D., Chen, Y. F., Ndugwa, R., Sartori, J., ... & Lilford, R. J. (2017). The history, geography, and sociology of slums and the health problems of people who live in slums. *The lancet*, *389*(10068), 547-558.

[24] Javed, M. S., Raza, R., Hassan, I., Saeed, R., Shaheen, N., Iqbal, J., & Shaukat, S. F. (2016). The energy crisis in Pakistan: A possible solution via biomass-based waste. *Journal of Renewable and Sustainable Energy*, *8*(4), 043102.

[25] E. E. Lampard. (1965). Historical Aspects of Urbanization. (Chichester, Ed.) John Wiley and Sons

[26] Kamruzzaman, M., & Hakim, M. A. (2015). Child criminalization at slum areas in Dhaka city. American Journal of Psychology and Cognitive Science, 1(4), 107-111.

[27] Vlahov, D., Freudenberg, N., Proietti, F., Ompad, D., Quinn, A., Nandi, V., & Galea, S. (2007). Urban as a determinant of health. *Journal of urban health*, *84*(1), 16-26.

[28] Pandey, M. R., Boleij, J. S. M., Smith, K. R., & Wafula, E. M. (1989). Indoor air pollution in developing countries and acute respiratory infection in children. *The Lancet*, 427-429.

[29] Dziuban, E. J., Liang, J. L., Craun, G. F., Hill, V., Yu, P. A., Painter, J., ... & Beach, M. J. (2006). Surveillance for waterborne disease and outbreaks associated with recreational water—United States, 2003–2004. Morbidity and Mortality Weekly Report: *Surveillance Summaries*, *55*(12), 1-30.

[30] Odihi, J. (2003). Deforestation in afforestation priority zone in Sudano-Sahelian Nigeria. *Applied Geography*, *23*(4), 227-259.

[31] Vance, C., & Iovanna, R. (2006). Analyzing spatial hierarchies in remotely sensed data: insights from a multilevel model of tropical deforestation. *Land Use Policy*, *23*(3), 226-236.

[32] Bhutto, A. W., Bazmi, A. A., & Zahedi, G. (2011). Greener energy: Issues and challenges for Pakistan—Biomass energy prospective. *Renewable and Sustainable Energy Reviews*, *15*(6), 3207-3219.

[33] Douggar, M. G. (1995). Energy situation in Pakistan: options and issues. *Renewable energy*, *6*(2), 151-157.

[34] Valasai, G. D., Uqaili, M. A., Memon, H. R., Samoo, S. R., Mirjat, N. H., & Harijan, K. (2017). Overcoming electricity crisis in Pakistan: A review of sustainable electricity options. *Renewable and Sustainable Energy Reviews*, *72*, 734-745.

[35] Baloch, M. H., Abro, S. A., Sarwar Kaloi, G., Mirjat, N. H., Tahir, S., Nadeem, M. H., ... & Kumar, M. (2017). A research on electricity generation from wind corridors of Pakistan (two provinces): A technical proposal for remote zones. *Sustainability*, *9*(9), 1611.

[36] Van der Bruggen, B., Borghgraef, K., & Vinckier, C. (2010). Causes of water supply problems in urbanised regions in developing countries. *Water resources management*, *24*(9), 1885-1902.

[37] Alahdad, Z. (2012). *Pakistan's energy sector: from crisis to crisis: breaking the chain* (p. 50). Islamabad, Pakistan: Pakistan Institute of Development Economics.

[38] Ahmed, M. A., Ahmed, F., & Akhtar, M. W. (2006). Assessment of wind power potential for coastal areas of Pakistan. *Turkish Journal of Physics*, *30*(2), 127-135.

[39] World Health Organization . (2005). *Health in the green economy: Household energy sector*. World Health Organization.

[40] Fatima, R., Qadeer, E., Enarson, D. A., Creswell, J., Stevens, R., & Hinderaker, S. G. (2014). Success of active tuberculosis case detection among high-risk groups in urban slums in Pakistan. *The International journal of tuberculosis and lung disease*, *18*(9), 1099-1104.

[41] Fawz-ul-Haq, K. R., Jilani, R., & Haq, M. (2005). Large-scale hybrid solar-hydrogen electric power plants for Pakistan. In *International Hydrogen Energy Congress and Exhibition (IHEC).*

[42] Vance, C., & Iovanna, R. (2006). Analyzing spatial hierarchies in remotely sensed data: insights from a multilevel model of tropical deforestation. *Land Use Policy*, *23*(3), 226-236.

[43] Nawaz, S. (2018). Slums continue to mushroom across Islamabad. Retrieved from: www.pakistantoday.com.pk/2018/05/28/slums-continue-to-mushroom-across-islamabad/

[44] Grant, J. P. (1993). The State of the World's Children, 1993. Summary. (J. P. Grant, Ed.) Oxford.

[45] National Institute of Population Studies (Pakistan), Institute for Resource Development/Westinghouse (Columbia, & Md.). (1992). *Pakistan Demographic and Health Survey 1990/1991*. National Institute of Population Studies.

[46] Bickerstaff, K., & Walker, G. (2001). Public understandings of air pollution: the 'localisation'of environmental risk. *Global environmental change*, *11*(2), 133-145.

[47] Leem, J. H., Kaplan, B. M., Shim, Y. K., Pohl, H. R., Gotway, C. A., Bullard, S. M., ... & Tylenda, C. A. (2006). Exposures to air pollutants during pregnancy and preterm delivery. *Environmental health perspectives*, *114*(6), 905-910.

[48] Valasai, G. D., Uqaili, M. A., Memon, H. R., Samoo, S. R., Mirjat, N. H., & Harijan, K. (2016). Assessment of renewable energy for electricity generation: Using Pakistan TIMES energy model. *Sindh University Research Journal-SURJ (Science Series)*, *48*(4).

[49] Berry, P., Clarke, K., Pajot, M., Hutton, D., & Verret, M. (2009). The role of risk perception and health communication in adapting to the health impacts of climate change in Canada. *Natural Resources Canada.*

[50] Elliott, S. J., Cole, D. C., Krueger, P., Voorberg, N., & Wakefield, S. (1999). The power of perception: health risk attributed to air pollution in an urban industrial neighbourhood. *Risk analysis*, *19(*4), 621-634.

[51] Hillier, D. (2016). *Communicating health risks to the public: A global perspective*. Routledge.

[52] Sjöberg, L., Moen, B. E., & Rundmo, T. (2004). Explaining risk perception. An evaluation of the psychometric paradigm in risk perception research. *Rotunde publikasjoner Rotunde*, *84*, 55-76.

[53] Jan, I. (2012). What makes people adopt improved cookstoves? Empirical evidence from rural northwest Pakistan. *Renewable and sustainable energy reviews*, *16*(5), 3200-3205.

[54] Viswanathan, B., & Kumar, K. K. (2005). Cooking fuel use patterns in India: 1983–2000. *Energy Policy*, *33*(8), 1021-1036.

[55] Pakistan, G. O. (n.d.). Population and housing census of Pakistan, population census organization statistics division. 2. Census bull.Retrieved from: https://www.pbs.gov.pk/content/population-census

[56] Adepoju, A. O., & Akinwale, Y. O. (2019). Factors influencing willingness to adopt renewable energy technologies among micro and small enterprises in Lagos State Nigeria. *International Journal of Sustainable Energy Planning and Management*, *19*, 69-82.