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ASSESSING THE DRIVERS, BARRIERS AND ENVIRONMENTAL FACTORS IN THE ADOPTION OF SOLAR ENERGY: EMPIRICAL EVIDENCE FROM PAKISTAN

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ABSTRACT
The role of solar energy adoption as a viable solution to combat climate change, aligned with the objectives of the United Nations Sustainable Development Goals (SDGs). Many countries have extensively achieved goals of their renewable energy policies. For the same purpose, Pakistan has also imposed various renewable energy policies to convert their fossils fuel energy into renewable energy. However they always fail to achieve its targeted objectives. This study investigates that how socio-economic and environmental factors are responsible for the non-impressive share of renewable energy into the energy max. Based on the survey of 373 respondents from district Peshawar, logistic regression model was employed to investigate the impact of various factors on the solar adoption. In results it is concluded that socio-economic factors including: increase in property value, neighbor's participation and easily availability of solar system in the market has positive and statistically significant impacts solar adoption behavior. Although, high initial cost of solar system, unawareness of community regarding benefits of solar energy, fear of theft and non-availability of installment plans remain barriers in the ways of solar adoption. Moreover it has also been found that the culture of research and development for innovations in solar technology, and environmental sustainability due to solar system can be factors of motivation for the potential consumers to diffuse solar technology. As per results, it is recommended that government should start awareness campaign regarding benefits of solar energy. Moreover, solar related should be declared as tax free product to encourage local production at minimal costs.
Keywords Classification: Solar Energy; Socio-Economic Factors; Environmental Factors

INTRODUCTION
The need to adopt renewable sources of energy has become increasingly urgent in the cotemporary world. The world is facing a growing energy demand due to population growth, urbanization, and economic development (Ali et al., 2020). For enhanced macroeconomic variables like: high economic growth and employment level, reduction of income inequality and inflation rate and increased human welfare, a sufficient energy system is required (Saeed et al., 2020). Despite of the fact that access to the electricity rose to 90% of the world population, still about 660milllions people confronts electricity shortages in the world. Whereas the globe is still deprived of the affordable, sustainable and secured energy system (International Energy Agency, 2019). At the same time, the over-reliance on non-renewable energy sources like coal, oil, and gas has resulted in environmental degradation, including air and water pollution, and climate change. International organizations have realized the importance of reducing greenhouse gas emissions to combat climate change problem. Pakistan has an estimated potential of generating up to 2.9 million MW of solar energy, which is more than enough to meet its current electricity needs. Pakistan has taken several steps towards promotion of solar energy. It initiated Alternative Energy Development Board in 2003 to promote investment in renewable energy

projects. The launched of Renewable Energy Policy-2019 aiming to generate about 30% of the total electricity in energy mix through renewable energy. However, Pakistan has no considerable approach towards solar adoption which produces only 0.3% of electricity through solar PV technology. Pakistan remains motivated towards thermal electricity production; especially in the development of domestic coal, because of many factors, including local economic development, job creation, ensuring energy security and a reduction in the shortfall of energy production. Therefore, Pakistan remains in the list of mostly affected countries through global warming (Eckstein et al. 2019). However, economists do not recommend such projects until 2030, at least to achieve its goal (Indicative Generation Capacity Expansion Plan 2047) and to maintain low GHG emissions (World Bank, 2020). Keeping in view the drawbacks of fossil fuel energy, the world is in search of modules to produce electricity other than the conventional system: i.e., the following renewable energy system by adopting solar photovoltaic (Solar PV) power generation, biomass and wind power systems. The United Nations has a continuous focus on achieving Goal No. 7, i.e., *ensuring access to affordable, reliable, sustainable and modern energy for all*. About 60% of greenhouse gas emissions come from energy supply. 83% of energy usage is from fossil fuel energy system whereas the remaining 17% of energy consumption is from renewable energy. The Intergovernmental Panel on Climate Change (IPCC) cautions the member countries to ensure an 85% share of renewable energy in energy consumption by 2050 to avoid the worse impact of climate change resulting from non-renewable energy consumption (International Energy Agency, 2019). In this regards, solar energy being free of greenhouse gas emissions remained attractive option. The Conference of Parties (COP-26) has made practical steps for implementation of policies which include 32% energy generation through renewable energy by 2030, provision of financial incentives through International Finance Corporation, encouragement of research and development activities, promotion through education and awareness and through policy support & regulatory framework by the government for promotion of renewable energy. Among many sources of renewable energy, solar energy remained the most acknowledged source choice of the consumers in the world. According to Slocum et al. (2021), solar system contains the ability of proved energy security with minimal environmental problems and socio-economic benefits. Adoption of solar energy can also help to reduce import bills, providing energy security and job creations (Huang, 2010). Solar energy is abundant, readily available, and has the potential to provide an unlimited source of energy. Unlike fossil fuels, solar energy is clean and does not produce greenhouse gas emissions, making it an environmentally friendly energy source. As a result, there has been a growing interest in solar energy as a sustainable and clean source of power. However, the solar growth rate at the globe is recorded as 12% only with the 204.7GW solar electricity production in 2019 (Renewable Global Status Report, 2020). Germany produces 8.2% of their total electricity through solar energy; Italy produces 7.6%; Greece, 7.5; Belgium, 6.3%; China, 4.2%; France, 2.7% and Spain produces 2.6% of their total electricity through solar PV system (REN20, 2021).

Pakistan has a strategic location situated in the region of high irradiance where it receives almost $15.5X10^{14}$ KWh of solar irradiance annually. According to the World Bank (2020), Pakistan can produce electricity equivalent to its current electricity demand by exploiting about 0.071 percent of the country's terrestrial solar PV system. In order to promote renewable energy, the renewable energy policy of 2006 was implemented with the aim of producing 10% of energy supply through renewable energy technology by 2015 in Pakistan (Hussain, 2007). As per the government's newly implemented policy for alternative and renewable energy policy in 2019 and the Indicative Generation Capacity Expansion Plan (IGCEP-2047), Pakistan has a commitment to produce variable renewable energy (VRE) to 25% of its total electricity by 2025 and 30% by 2030; equivalent to over 24000MW. However, the share of renewable energy is still at a non-impressive rate, which is 0.3% of the total market energy demand in Pakistan (Hameed, 2019). Hence, the people of Pakistan do not have significant intention towards the adoptability of solar PV system either for household or for organizational purposes. Hence, analyzing responsible factors for such a non-impressive adoption rate is the key objective of this study. In the current literature, researchers have attempted to investigate various factors responsible for non-adoption of solar energy. Like Khalid and Junaidi (2014), Khattak et al. (2006) and Painuly

(2001) discussed the impact of various barriers and policy variables in adoption of solar energy. Similarly, Alam et al. (2020), Seetharaman et al. (2019), Qureshi et al. (2017) and Arnold & Yildiz (2015) have incorporated various socio-economic factors in solar adoptability model. Many researchers have claimed that environmental behavior and responsibility play important role in adoptability behavior of consumers towards solar PV system (Hemmati, 2017; Uddin & Khan, 2016; Muyingo, 2015; Schelly, 2014; Salazar et al., 2013, 2012; Battley et al., 2011 and Kang & James, 2007). Moreover, some studies have highlighted technical factors responsible for solar adoption behavior. Some of them include: Painuly (2001), Goosling et al. (2005), Hall & Bain (2008), Mirza et al. (2009), Sidiras & Koukios (2014) and Alam et al. (2020). However, to the best of our knowledge no study has been conducted to analysis the impact of barriers and drivers related to socio-economic factors and environmental factors in adoptability behavior of consumers towards solar PV system. Hence, this study makes an attempt to explore the impact of barriers and drivers of socio-economic factors and environmental factors on adoption behavior of consumers towards solar technology. For the purpose, this study is pioneered in conducting survey analysis while keeping the aforementioned factors in solar adoption model. In Particular it testifies the following hypotheses

H_{0a}: Socio-economic barriers have no impact on solar adoption behavior

H_{0b}: Socio-economic drivers have no impact on solar adoption behavior

H_{0c}: Environmental drivers have no impact on solar adoption behavior

2. Literature Review

2.1. Literature related to Socio-Economic Factors

This section of the literatures has discussed the views of researchers who have discovered that socio-economic factors as important determinants in influencing the decisions of consumers towards the adoption of solar PV system. In this regards, financial barriers such as initial capital cost, market imperfections, prices, demand and supply management, long payback periods, a lack of financing sources, and so on are the numbers of factors which have been advocated as economic-related factors in solar adoption behavior. In addition, it is also argued that the market dominancy of conventional source of energy makes them comparatively cheaper than renewable energy (Dulal et al., 2013). Besides economic factors, social factors have also been extensively discussed in the literature (Nasirov et al., 2015; Guo, 2014; Biemann and Bada, 2011; Jacobsson and Johnson, 2000). Consumers buy goods to establish social functions like status-seeking besides their non-social needs like food and shelter (Nelissen and Meigers, 2011). Nowadays, consumer's behavior is determined by the social clusters to which each individual belongs. As a result, buyers purchase things in order to build and sustain social bonds (Atulkar and Kesari2015). It has already been discovered that the social influence of peer group members has a role in the adoption of solar PV system (Palm, 2017). For example, when deciding to invest in a solar PV system, one is more likely to gather information from neighbors or peer group members who have already invested in solar system in order to make a more timely decision. Social setup & status and social network of the individual to which they belong can also determine consumers' intention towards sustainable and green energy (Atulkar and Kesari, 2018; Nelissen and Meijers, 2011, Faiers, 2006). Atulkar and Kesar (2018) argued that the installation of solar PV system helps the customers generate social status in society. Ozcan (2014) recognized that the positive image of society motivates its members and increases their confidence to motivate them towards green energy. Moreover, Schelly (2014) also advocated that a well-educated society influences its members towards the adoption of ecological-friendly products. Qurashi et al. (2017) investigated the factors influencing the adoption of solar PV technology in the residential sector in Lahore, Pakistan's capital city. Detail interviews were performed among respondents, both adopters and non-adopters of solar PV system, to rate the already notified factors of solar PV system adoptability using Roger's novel decision model. Aside from the fact that solar PV system has comparative benefits, the initial cost of a solar PV system has been identified as one of the most important impediments to the technology's widespread adoption. Similar results have also been confirmed from previous studies, including Jianjum and Chen (2014), Paravantis et al. (2014), Painuly (2001) and Nasirov et al. (2015). In the study of Alam et al. (2021), the potential factors that affect the intentions of local households towards the adoption of solar PV system in Malaysia were identified. From the sample study of 382 respondents, the result shows that there exists positive and significant effect of relative advantages on adoptability of solar PV system. Surprisingly, the study reveals that there exists a positive but insignificant relationship between the cost of the technology and solar PV technology diffusion. Marcello and Kenneth (2015) analyzed empirically the spatial patterns for solar panel adoptability for Connecticut. The results support that spatial neighbors can exist: in a particular block during six months, the adoption of solar PV system will increase by 0.44 system per-quarter within 0.5 miles of the system. Thus, a strong relationship exists between the adoptability of solar PV technology and the number of nearby installation locations for solar PV system. As for economic barriers, they have some indirect but significant impacts on the deployment of renewable energy. The economic barriers that they listed are: competition from fossil fuel energy, lack of financial institutions, high initial costs, and intangible costs of solar installation, which are the main economic barriers that create hurdles for consumers in adoption of solar PV system. Similar results have also been found in the studies of Raza et al. (2015), Dulal et al. (2013), Ansari et al. (2016) and Ohunakin et al. (2014). For the same purpose, Irfan et al. (2019) have incorporated some barriers in their decision model for solar adoption. To find the best possible alternative option for electrification for Pakistan, they collected solar radiation intensity data of various main cities in Pakistan. As a result, it is concluded that in terms of price, life span, maintenance and operation cost, a solar PV system has comparative advantage. Unawareness of market potential, high initial cost and the existence of risks are the main economic barriers to the adoption of solar PV system. In Ireland, Claudy et al. (2013) investigated the attitude-behavior gap for renewable energy. Using Behavioral Reasoning Theory, the result concluded that there exist countervailing influences of consumers' intentions in favor of or against the adoptability of solar PV system. In the stud of Raza et al. (2015) for Pakistan, it was reported that renewable energy output increased at a rising pace year by year during 2008-2014. In his study, he identified that lack of investment culture for renewables is one of the key factors behind non-adoption of solar PV system in Pakistan. Wijayatunga and Attalage (2005) contributed to the literature by analyzing the socio-economic and environmental benefits of adoption of solar PV system in rural Sri Lanka through survey analysis of 125 household solar users. The respondents are categorically divided into two groups: those who received direct grant of $100 from the government and those who have not so far. They expressed their satisfaction by arguing that their quality of life has been improved because of adoption of home based solar technology in respect of longer study hours by the children, watching TV for longer hours and reducing the risk of accidents of fatal kerosene lamp accidents. Jabeen et al. (2014) evaluated the solar technology utilization regarding social-economic prospects in Abbottabad, Pakistan. A survey is designed to sort out information regarding the objectives concerned from December 2012 to June 2013. It is observed that petrol generator and UPS remained costly source of alternative source of electricity. This indicates that there is high potential of solar technology utilization due to the least maintenance cost, zero petrol and electricity bills. Interestingly, 61.2% were willing to invest in solar technology utilization whereas 19% of the correspondents' focus was to invest subject to the availability of government subsidies on solar panel. Using a multivariate regression model and exploratory factor analysis, Ahmad et al. (2014) explored Malaysian perceptions of renewable energy consumption. Their study concluded that "usefulness," which they used as a stand-in for "relative advantage," indirectly affects how likely people are to get solar PV system. Moreover, there is a positive relationship between perceived behavioral control and the desire to use renewable energy. Zyadin et al. (2014) investigated the primary elements influencing renewable energy promotion from survey of 122 early-stage researchers and academics who completed their courses in UK and Cyprus. The results were compiled based on the respondents' geographical affiliation, with African academics citing a lack of mobilized public finance as a barrier to the adoption of renewable energy. The participants irrespective to their country of origin and profession, have highlighted some key barriers in adoption of renewable energy where lack of competition with fossil fuel energy system was one of them. To identify hurdles to solar PV dissemination, Karakaya and Sriwant towit (2015) used a state-of-the-art literature review survey based on the Web of Science database. They found that the adoption of solar PV system confronts several economic and managerial barriers. The much related economic barrier is usually linked with the increased initial cost of PV system. When potential customers compare the costs of PV system and traditional system, they usually choose the cheaper one (for similar results, see Zhang et al., 2011; Yuan et al., 2011; Sarzynski et al., 2012; Jacobsson and Lauber, 2006). In the studies of Pode (2013) and Ondraczek (2013), they conceptualized that the low level of purchasing power of individuals and economic affordability act as barriers to the adoption of solar PV system. Mainali and Silveria (2011) also termed the large gap between electrification costs and income levels of the people as the cause of hurdles in the way of adoption of PV system. Brudermann et al. (2013) regard the high investment needed for solar installation and uncertainty in funding provision as barriers to PV system adoption. Jayaraman et al. (2017) have exposed the perceptions of consumers towards solar PV system through a cross-sectional survey among Malaysian property owners. According to the data, respondents are interested in installing a PV panel system if they can get some money back in the form of power through a money back plan. Friends, family, and close coworkers as social factors influence the majority of respondents who want to acquire a PV panel system. Bawakyillenuo (2012) concentrated on the spread of PV system in Kenya and Zimbabwe with the goal of formulating policy suggestions for the Ghanaian instance. As a result of such research, the absence of multinational donor support for PV system appears to be a barrier to dissemination. Dorf (1984) conducted a survey study using a questionnaire and interview method among the 97 solar industries to investigate various factors which play a vital role in the diffusion of such technology. In the results, it is concluded that about 95% of the respondents identified that commercialization, which includes initial cost of capital and payback period, is an important determinant in the adoptability of solar PV system by the purchaser. In addition, the lack of a well-defined financial module has resulted weakened sales and marketing channels, lack of professional and trained staff, which causes consumers to think deeply before going into the solar system. Müller and Rode (2013) aimed to investigate factors responsible for the adoptability of solar PV system in the city of Wiesbaden, Germany. In particular, the authors' purpose was to determine if the adoptability behavior of each individual towards solar PV system is being affected by the already existing installation in the locality. To cover the purpose, a binary panel Logit model is employed with controllable social variables like variations in buying behavior and population density. The results reveal that the individual propensity to install the solar panel positively depends upon the previously installed solar energy system in close spatial proximity. Thus the more previously adopted solar PV system in spatial proximity, the higher the propensity for adoptability of solar PV system will be. Graziano and Gillingham (2014) have empirically examined the diffusion of residential solar system by incorporating the influence of spatial and socioeconomic factors on their adoptability in Connecticut, USA. The result concludes that the spatial neighbor effect is positive and statistically significant in the diffusion of solar PV system in the household sector. Again, it has been concluded that the smaller block groups are considered to evidence a relatively stronger neighboring effect in the diffusion of solar PV system than the larger block groups. Ansari et al. (2013) added to the literature by examining several impediments to solar energy's spread in India. Their research primarily tries to provide interpretative structural models for hurdles to solar energy application. Through interviews and conversations with academic and industrial professionals, barriers of high payback periods, lack of research and development, and high initial cost of solar PV system were found as economic and financial barriers out of thirteen barriers. Irfan et al. (2021) added literature to the structural framework of the theory of planned to gain a better understanding of the factors that motivate or inhibit consumers to adopt RE. About 353 households across five major cities in Pakistan have been collected in 2019. The findings indicate that impacting factors such as self-efficacy perception, perception of neighbors' participation, cost of renewable energy, and renewable energy awareness are all important in adoption of solar energy. In the study of Menon et al. (2020), various factors considered responsible for the adoption of solar PV system have been identified for the district of Thrissur, India. In a survey of 63 people, it was found that the level of environmental awareness, the benefits of the product, and the price and payback period were the most important factors in how people felt about solar PV system. Simpson (2015) quantified consumers' satisfaction from using solar energy in six geographic area of Western Australia to identify areas to improve policy for the adoption of domestic solar PV system. In the results, it is concluded that about 88% of the respondents have shown their interest in the installation of a solar PV system if they purchase a new home. The solar system meets the expectations of approximately 88% of solar energy users. Moreover, 76% of the respondents found a reduction in their bills with solar PV adoption; about 47% of the respondents believe that the available information are misleading and about 84% of the respondents advocated educational assistance is required to help people understand the real cost/benefits analysis of solar PV system.

2.2. Literature Related to Environmental Factors

Environmental concern refers to the level of awareness and commitment of individuals towards environmental problems. In the contemporary era, consumers are more likely to be aware of their ecological consumption behaviors that affect the environment (Rahbar and Wahid, 2011; Canova et al. 2020). Palm (2017) recommended that both technical and fundamental awareness make consumers' behavior curtain towards adoption of solar PV systems in Sweden. Due to the possession of such knowledge, consumers prefer to adopt green energy over fossil fuel energy to make an effort towards environmental sustainability (Tan, 2011). The primary knowledge of usages and benefits that households have can influence their decision to adopt PV technology (Salazar et al., 2013). The impact of environmental awareness on consumers' decisions towards green technologies has recently attracted the attention of researchers. Many studies exist in the available literatures which have concluded that environmental awareness by consumers can significantly affect the adoption and volatility of renewable energy (Dienes, 2015; Zhang et al., 2015; Liu et al., 2013; Komendantova and Yazdanpanah, 2017; Kowalska-Pyzalska, 2018). Residents who have environmental concerns cautiously observe their energy utilization pattern and possess positive behavior towards the adoption of renewable energy. This section of literature reviews provides various studies that have contributed to finding how environmental awareness, attitude, and responsibility of the individual relate to their behavior towards the adoption of a PV system. Eleftheriadis and Evgenia (2015) have found that the lack of environmental policy can be one of the main causes of non-diffusion of solar PV systems in Greece. In a Pakistan-based study, Qurashi et al. (2017) concluded that households expressed their perceptions that they have adopted solar PV systems because they have a sense of sustainability and environmentally friendly behavior. In the studies of Zhai and Williams (2011) and Menon et al. (2020), besides other variables, environmental consciousness in humans is believed to be an essential factor in the adoption of green technology. Unlike the existing studies, Menon et al. (2020) did not find environmental factors important in determining consumers' behavior towards adoption of solar PV systems. One possible reason they presented was the non-seriousness of government policy and people's attitude towards climate mitigation. Nyborg et al. (2006) also concluded that those who are more environmentally concerned are willing to pay more for green products (also see Balderjahn, 1988; Diamantopoulos et al., 2003; Fransson and Garling, 1999; Zimmer et al., 1994; Roberts and Bacon, 1997 for similar results).

Hessami and Yousefi (2013) prioritized factors that affect consumers' behavior towards the adoption of green purchasing behavior. It has been concluded that environmental concerns and government's role in environmental protection awareness are indispensable to uncover the public benefits of green products like solar PV systems etc. In the study of Dagher and Itani (2014), the hypotheses of perceived effectiveness of environmental behavior and their impact on green purchasing behavior of consumers have been analyzed for Lebanon. In results, by using the ANOVA test of regression analysis, it has been concluded that the perceived seriousness of perceived environmental responsibility, environmental problems and self-image in environmental protection are positively correlated with green purchasing behavior of consumers. The same results have also been concluded in the study by Lee (2006), who conducted a survey to find determinants of purchasing green products in the city of Hong Kong. In Balcombe et al. (2013), analyzed motivations and barriers to adoption of solar PV systems in the case of the United Kingdom. They reviewed a number of studies conducted to investigate factors which are responsible for the adoption of solar PV systems in the UK. Balcombe et al. (2013) concluded that along with the other motivations like reduced cost of electricity by PV micro-generation, environmental benefit remains an important motivation. It has been believed that micro-generation is an environmentally friendly technology and the goal of low-carbon emissions can be achieved through the use of solar PV systems (Caird and Roy, 2010; Leenheer et al., 2011). Bashiri and Alizadeh (2018) aimed to investigate factors that affect the adoption behavior of PV systems in the special consideration of Tehran's unique circumstances, air pollution, and other governmental support policies during 2015. The result suggests that the respondents who felt environmental degradation by fossil fuel energy are more interested in investment in solar PV systems. The same results have been concluded in the study of Wong and Cronin (2019) for Australia, Schelly (2013) for USA, Angowski et al. (2021) for Poland, Amoako and Wilson (2017) for China, Palm (2018) for Sweden.

3. Sampling Procedures and Techniques

The study employed questionnaire method for primary data collection as presented in appendices. It employed the method of simple random sampling for sample collections from population. For adequate number of sample, many researchers have defined their rule of thumbs to select adequate sample size for efficiently identifying the correct factor structure. Like, Gaur and Gaur (2009) considered 200-300 sample size as enough for identifying the correct factor structure and to address the research objective. Whereas Harri et al., (2010) recommended 100 or more sample size as valid sample Tabachnick et al. (2012) argued that the sample size should be at least 300 for reliable study results. Field (2005) recommended 300 and above sample size; Hinton (2004) suggested 200 number of sample size; Steven (1996) proposed sample size of 100-300 as adequate numbers of samples for factor analysis. The present study yields 373 numbers of respondents which are adequate number of samples sizes according to Kaiser-Meyer-Olkin (KMO). Because its test statistic is greater than the threshold value of 0.50 Bartletts test of Sphericity (Bartlett, 1954) has also confirmed the sampling adequacy as the calculated value of BTS test is statistically significant at P<5% (Tabachnick and Fidell, 2012). The outcomes of the KMO statistic and BTS methods for detecting the adequate numbers of samples are shown in below table 1:

Table No. 1 Tests for Sample Adequacy

Tests	Values
KMO measure of sampling	0.71
Bartlett's test	2148.5
D.f	120
Significance level	0.000

Following Painuly (2001), the questionnaire is boldly divided into two parts of items: demographic items and factors items. There were 05 items related to demographic whereas the remaining 12 items were related to socio-economic and environmental factors. Through demographic items, different questions related to gender, income, education level, adoption status of solar were asked. On the other side, the respondents were asked for different factors that could have a significant impact on the decision of consumer towards adoption of solar PV system. Factor related questions were developed in nature of five point Likert scale whereas demographic items were either Yes/No questions or with available choices. In order to test the internal scale consistency so called reliability, Cronbach's alpha coefficient (CAC) of reliability is employed (Moser and Kalton, 1989; Whitley, 2002; Robinson, 2009). Reliability of the model has also been confirmed by the Cronbach's Alpha (CAC) where its value is higher than the threshold value of 0.70.

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Table: 2. Variables and its descriptions

Codes of Variables	Descriptions	Expected Sign
High-Initial-Cost	The initial cost of solar system installation is very high	—
Marktng-Netwrk	Marketing network of solar energy does not work up to the mark	—
Community-Awarnes	The local community is unaware of the benefits of Solar PV system	—
Theft-Fear	I have fear of theft for solar panel.	—
Avail-Instalment	Solar systems are not available on installment base to support customers	—
Neighbor-Particption	Neighbors' participation in solar energy can influence my decision to adopt solar system	+
Prid-Felling	I feel pride because of installation of solar PV system	+
Market-Availbilty	The Solar system is easily available in the market	+
Recyclng-Damagpv	There is recycling process available for damaged solar panel	+
R&D-Gren-Energy	There is of research and development culture for green energy	+
Reduc-GHG	Utilization of solar energy reduces carbon emissions	+
Env_prot-Concrn	I adopt solar PV system because i am more concerned with environmental protection	+

4. Methodology

The binary logistic regression model, which assumes the logistic distribution function, was used in this investigation. Once the response variables are translated into Logit, this model employs the maximum likelihood method (**Carson**, 2008). It calculates the chances of consumers' adoptability of solar energy PV system. The Logit model takes place after the transformation of dependent variables into the natural log of odds [Logit]. Y_i symbolizes dichotomous dependent variable which assumes q for solar adopter and 0 for non-adopter of solar. A value of 0 is assigned which indicates that the respondent is non-user of solar energy, and a value of 1 indicates that individual is user of solar energy system. The model is given as below:

$$Y_i = \log(odd\ event) = \log\frac{prob\ (event)}{prob(non\ event)}$$

$$Y_i = \beta_1 + \beta_2\sum_{i=1}^{n} SOCIO - ECO_{Barriers-i} + \beta_3\sum_{i=1}^{n} SOCIO - ECO_{Drivers-i} + \beta_4\sum_{i=1}^{n} ENVIR_{Drivers-i} + ei$$

In the above equation, $\text{SOCIO-ECO}_{\text{Barriers}}$ is abbreviated form for socio-economic barriers; $\text{SOCIO-ECO}_{\text{Drivers}}$, and $\text{ENV}_{\text{Drivers}}$ for Environmental drivers. βis are the coefficient of explanatory variables where residual terms are shown by e_{i}..

5. RESULTS

The descriptive statistics which describes the nature of the data is explained in Table 3 as follows:

Table No. 2 The descriptive statistics for demographic item

Demographic Variables	Categories	Frequency	Percentage	Mean	S.E
Gender	Female	69	18.5	0.81	0.388
	Male	304	81.5		
Income Level (In Rs.)	20000-50000	55	14.7	2.49	0.974
	50001-65000	152	40.8		
	65001-80000	91	24.4		
	More than 80000	75	20.1		
Education level	6-10 year	16	4.3	3.40	0.572

	11-16 year	190	50.9		
	more than 16 year	167	44.8		
	Household	150	40.2		
Sector	Business Sector	108	29	1.90	0.838
	Government Sector	115	30.8		
Adoption Status	Solar Adopter	191	51.2	0.52	0.500
	Solar Non-adopter	182	48.79		

5.1. Testing Goodness of Model Fit for overall Model

The Pearson's chi-square statistic has been applied as shown in the below Table 4. According to the results of Pearson's test for model fitness, all the variables are statistically significant at 1% level of significance. It interprets that the model is good to fit indicating that the results of the regression model cannot be considered spurious (Kabir et al., 2013). Table 5 displays the outcomes of the binary logistic model.

Table No. 3 Testing Goodness of model fit for over all model

Items/Variables	Chi-Square	Items/Variables	Chi-Square
High_Initial_Cost	53.35 (0.00)	Prid_Felling	182.91 (0.00)
Community_Unawarnes	55.35 (0.00)	Market_Availbilty	174.82 (0.00)
Theft_Fear	85.22 (0.00)	Recyclng_Damaged_Pv	58.68 (0.00)
Non-Avail_Instalment	49.16 (0.00)	R&D_Gren_Energy	56.85 (0.00)
Proprty_Value	181.28 103.93	Reduc_GHG	50.04 (0.00)
Neighbor_Particption	110.28 (0.00)	Env_prot_Concrn	110.37 (0.00)

Notes: (a) Values in the parentheses show p-value of level of significance. (b) All the item variables are statistically significant at 1% level of significance.

Table No. 4 Socio-economic and environmental factors affecting solar adoptability

Factors	Variables	B-coefficient	S.E.	p-value	Exp(B)
	Constant	-18.113***	4.363	0.000	0.000
Socio-Economic Drivers	Proprty_Value	0.642**	0.308	0.037	1.901
	Neighbor_Particption	0.735**	0.295	0.013	2.086
	Prid_Felling	-0.293	0.311	0.346	0.746
	Market_Availbilty	0.671**	0.340	0.049	1.956
Socio-Economic Barriers	High_Initial_Cost	-0.627**	0.311	0.044	0.534
	Community_Unawarnes	-0.562**	0.287	0.050	0.570
	Theft_Fear	-0.759**	0.321	0.018	0.468
	Non-Non-Avail_Instalment	0.848***	0.299	0.005	2.336
Environmental Drivers	Recyclng_Damaged_Pv	0.698**	0.270	0.010	2.009
	R&D_Gren_Energy	0.537**	0.253	0.034	1.711
	Reduc_GHG	0.498**	0.243	0.040	1.646
	Env_prot_Concrn	0.668**	0.274	0.015	1.951

5.2. Socio-Economic Factors and Adoption of Solar PV System

Socio-economic variables are classified into two categories: socio-economic barriers and socio-economic drivers. These are discussed as follows:

Barriers:

The results of the logit model for socio-economic factors (including both barriers and drivers) that affect solar adoptability of individuals are presented in the Table 5.11. As for Socio-economic barriers, all items are statistically significant at 5% threshold value significance level. The socio-economic predictors namely: High_Initial_Cost, Community_Unawarnes and Theft_Fear shows negative impacts on the adoptability behavior of consumers towards solar energy as they own negative signed B-coefficient with odd ratios less than unity. The Odd ratio of High_Initial_Cost variable showing higher cost of installation and payback periods of solar PV system is 0.534. Hence, comparing its value with unity as it is less than one; interpreting that the consumers are 0.534 times less likely to adopt solar PV system if the initial cost of installation and payback periods rise by one level. The similar results are also found in the study of Karakaya and Sriwanttowit (2015) and Painuly (2001). Ansari et al. (2016) already explained that due to the lower efficiency of solar PV system along with the high initial cost of capital on solar PV system, the payback period remains higher which negatively affect the investors or consumers to adopt solar project. Similarly, the Odd ratio of the variable Community_Unawarnes is less than 1, e.g. 0.57 which shows that the consumers are 0.57 time at the lesser odd of being solar adopter if the individuals continuous to be unaware of the benefits associated with solar PV system. To tie this finding with the existing literature, it is worth to mention that Nasirov et al. (2015) and Paravantis et al., (2014) has also argued that insufficient information regarding the ecological and financial benefits of renewable energy is the main cause of solar system installation. (Rebani, Barham (2011); Ahmand et al. (2014); Zyadin et al. (2014) have also concluded with the similar results). In addition, the Odd value of Theft_Fear is 0.468 which also shows negative relationship between predictor Theft_Fear and adoptability behavior of consumers towards solar PV system. It means that as the fear of theft for solar PV system in the location rises, the individuals are 0.468 times at the lesser odd of solar adoption. The variable Non-Avail_Instalment has some positive value of "B" coefficient e.g. 0.848 with odd ratio of 2.336. This describes that individuals are 2.336 times more likely to adopt solar PV system if the Non-Avail_Instalment rise by one unit.

Drivers

Through factor analysis, the socio-economic variables namely: increase in property value (Proprty_Value), neighbor participation in solar energy (Neighbor_Particption), feeling of pride for being solar adopter (Prid_Felling) and easily availability of solar panel in the market (Market_Availbilty) are labeled as socio-economic drivers. To know their impacts on consumers' behavior towards adoptability of solar PV system, binary logistic model is employed. Among these drivers, it is found that only Prid_Felling are statistically insignificant as their P-values are higher than the 5% threshold significance level. Whereas the socio-economic drivers e.g. Proprty_Value and Neighbor_Particption and Market_Availbilty are statistically significant at 5% level of significant. Surprisingly, these variables have positive and almost similar value of "B" coefficients which are 0.642, 0.0.735 and 0.671 respectively. This implies that all of these socio-economic variables drive positively the adoption of solar PV system by their respective odd values.

Beside this, the respective Odd values for Proprty_Value, Neighbor_Particption and Market_Availbilty variable are 1.90, 2.086 and 1.956 where each of these values is greater than unity. This can interpret the same result that by one level increase in each of these drivers, the consumers are at the higher odd of being solar adopter. By confirming the result of the neighborhoods' role in solar adoption, the study of Kesari and Atulkar (2015) have also stated that besides economic variables, social clusters to which individuals belong, are also important to determine consumers behavior. In the research of Schelly (2014); Palm (2017) and Ozcan (2014) they have also found the similar results stating that the social influence of peer group members has a role in the adoption of solar PV system. Among all these socio-economic variables, Neighbor_Particption showing the impact of neighbors' participation in solar energy remains the most significant variables (due to highest magnitude) which positively influence consumers' behavior towards adoption of solar PV system.

5.3. Environmental Factors and Adoption of Solar PV System

The model of this study has incorporated some environmental variables namely recycling of damaged solar panel (Recyclng_Damaged_PV), research and development in green energy (R&D_Gren_Energy), reduction in greenhouse gas emissions (Reduc_GHG) and individuals' environmental concerns (Env_prot_Concrn). These variables are considered significant in determining decision of consumers towards adoption of solar PV system. According to the results of binary logit model, all of these predictors are statistically significance at 5% level of significance with positive "B" coefficients indicating positive relations with the predicted variable e.g. consumers' behavior towards adoptability of solar PV system. Recyclng_Damaged_PV shows availability of recycling process for solar panels wastes and RandD_Gren_Energy depicts research and development culture in the country. The respective Odd ratios of Recyclng_Damaged_PV and R&D_Gren_Energy are 2.009 and 1.711 which shows that the odd of being solar adopter are more likely to increase by the respective odd values if the variables of Recyclng_Damaged_PV and R&D_Gren_Energy increase by one unit. The results are consistent with the finding of Hansla et al. (2008); Danish et al. (2019) and Ali et al. (2019). Halabi et al. (2015) pointed out that to protect environment from global warming, continuous conventional energy plants should be replaced by the renewable energy through initiatives of upgraded module explored by research and development activities. Similarly, The Odd ratios of Reduc_GHG and Env_prot_Concrn are 1.646 and 1.951 respectively which shows that impacts of each of these variables on adoption behavior of solar PV system are positive. Hence, by one level increase in each variable e.g. Reduc_GHG and Env_prot_Concrn, the individuals are more likely to adopt solar PV system by the respective odd values of 1.646 and 1.951 (See Dienes, 2015; Zhang et al., 2015; Liu et al., 2013 for consistent results). Reduc_GHG represents the belief of respondents that solar energy can reduce carbon emission. And Env_prot_Concrn shows the concerns of individuals towards environmental protections. In summary, Recyclng_Damaged_PV has the highest Odd ratio e.g. 1.865. This indicates that ensuring the availability of recycling process for wastes of solar energy is the most sensitive variable which positively affects consumers' behavior towards adoption of solar PV system.

6. Conclusion and Policy Implications

This study attempted to investigate the impact of various socio-economic and environmental factors in determining consumers' behavior towards adoption of solar PV energy. This study conducted a survey of 373 respondents using logistic regression model. In results, it has been concluded that socioeconomic factors including: high initial costs and payback periods, fear of theft and community ignorance about the benefits of solar energy have been identified as barriers that have a negative impact on consumers' propensity to use solar energy. Whereas, availability of financial packages like payment on installment basis, easily availability of solar system in the market and neighbors' views regarding solar energy act as drivers to convince consumers towards adoptability of solar energy. The results have also supported the positive role of environmental factors on adoptability behavior consumers towards solar PV system. The consciousness of the individuals for environmental protection due to threat of climate change from carbon emissions is more important to motivate potential consumers towards green energy. Moreover it has also been found that the culture of research and development for innovations in solar technology can be a source of motivation for the potential consumers to diffuse solar technology. Among the environmental factors in the model, the variable of ensuring the availability of recycling process for wastes of solar energy is the most sensitive variable which positively affects consumers' behavior towards adoption of solar PV system. Based on the results, it is recommended for policy implementation that private sector must participate in financing production and adoption of solar energy to make it available at lower prices with some financial packages. Moreover, public must be educated about the economic and environmental importance of usages of renewable and sustainable energy.

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