

# The Rural Consumer Adoption of Sustainable Energy: A PLS-SEM-ANN Approach of Conceptual Model Development and Cross Country Validation of Pakistan and Malaysia

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## Research Article

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# Abstract

Sustainable and alternative energy sources of biofuel and solar power panel have been revolutionizing the lives and economy of many countries. However, these changes mainly occur in the urban areas and the rural population section has long been ignored by policy makers and government in the provision of energy. It is only recently that solar and biofuel are finally making in road to provide cheap and clean energy sources to rural population. As a result, literature on consumer behavior of rural population towards sustainable energy sources are still very scarce. The present research aims to fulfil this gap by developing a conceptual model to investigate the adoption of solar power and biofuel energy resources in the cross-cultural setting of Malaysia and Pakistan. The data was collected from the rural areas of Pakistan and Malaysia. The two-stage data analysis method of partial least square structural equation modeling (PLS-SEM) and artificial neural network (ANN) have been applied to satisfy both linear and non-linear regression assumption respectively. The results show that consumer in rural areas of Pakistan are willing and possess intention to adopt both biofuel and solar power for commercial and domestic use. Additionally, the results confirm that Branding, Economic and Altruistic factors are important in yielding intention to use towards biofuel and solar power panel in Pakistan which are validated by the results obtained in Malaysia. Other factors such as climate change awareness, retailer services quality and ease of use are also important. The results offer wide ranging theoretical and managerial implications.

## 1. Introduction

Sustainable energy solutions such as solar and biofuel energy, have the potential to overturn disasters caused by the impact of environmental pollution (Michaelides, 2012; Schlager & Weisblatt, 2006; Kruger, 2006). The production and consumption of solar and biofuel energy do not emit anything similar to greenhouse gases (Tuomisto et al., 2012). Furthermore, such energy solutions are also viable; as in the case of biofuel, it helps governments to reduce commercial, household and agricultural waste by recycling into energy (Demirbas, 2008), thus, creating twin benefits of waste reduction and energy production (Osman et al., 2019). Due to the many benefits solar and biofuel energy, governments, corporation and communities have been speeding up the process of adoption of such sustainable energy solution (Stančin et al., 2020). Governments around the world have been observed giving tax breaks, investing installation and technologies and propagating the wider adoptability of both solar and biofuel energy solutions. (Mollica & Balestieri, 2020). Corporations by looking at its future impact upon their own profitability have also speed up production and distribution of these energy solutions to both retail and industrial consumers (Kath et al., 2020). Communities have seen dream coming true of having access to uninterrupted, cheap and clean supply of energy (Mousavi et al., 2021; El-Houari et al., 2020). Despite the increasing rate of adoption, the hope of complete transition towards clean energy solutions, the likes of solar and biofuel, is still elusive (Naumann & Rudolph, 2020) and thus more research and innovation are needed to fill this gap to help the world to achieve complete transition.

Generally, the sustainable energy portfolio includes solar, biofuel, wind and geothermal sources (Chandler, 2009). The government and corporations are involved in both production and distribution of energy from

these sources (Tzankova, 2020). However, it has been observed that, communities have also been adding into production-consumption of clean energy mainly from two sources of solar and biofuel (Hoffman & High-Pippert, 2005; Walker et al., 2020; Rae & Bradley, 2012). The production-consumption model of solar and biofuel are the only sources of energy utilized by the rural communities in the emerging and newly industrialized countries (Vergragt et al., 2014). The production-use of sustainable energy among the rural community is ranging from domestic household to commercial and economic use (König et al., 2020). It is widely believed that such transition especially among the rural communities will help to alleviate social-economic backwardness, as most developmental budget in emerging and newly industrialized countries is being spent on the urban centers (Giampietro et al., 2013; Ouedraogo, 2017; Zaman & Abd-el Moemen, 2017). Despite the wide ranging positive impacts of sustainable energy production and consumption, such phenomenon remains unclear as in regard to the factors that are propelling the adoption of sustainable energy among the rural communities. In addition, it is also unclear whether the basic motivation behind production-consumption is in powering the household or in utilizing for opening and running small scale business which can be of important sources of income.

The research on sustainable energy from the behavioral perspective is gaining pace (Saleem et al., 2021; Kowalska-Pyzalska, 2018a; Kowalska-Pyzalska, 2018b). However, most of the researches focused upon the household and commercial users residing in the urban centers (Kowalska-Pyzalska, 2019; Şenol, H., & Zenk, 2020; Villamor et al., 2020). But it has been observed that in some rural communities the pace of adoption of production-consumption of sustainable energy is greater than in urban centers (Han & Wu, 2018) especially in areas where the access of electricity is not available to the communities (Malik, 2020) and in rural places where consumers experience frequent electricity supply breakdown (Sapkota et al., 2014). Despite the huge potential, there is scarcity of literature which can help to understand consumer behavior of rural communities behind the adoption, production and consumption of sustainable energy (Han & Wu, 2018; Clausen & Rudolph, 2020; Gorb et al., 2020; Barbier, 2020). Therefore, current research is attempting to understand the consumer behavior of rural communities in both emerging and newly industrialized market cross culturally (Ullah et al., 2021; Lau et al., 2020) by interplaying the relationship among the factors which lead to adoption of either solar energy or biofuel energy in both household and commercial activities (Asante et al., 2020; Sarker et al., 2020).

The current research proposes several factors which have not been studied both cross culturally and in the context of rural communities which provide basic motivation to adopt, consume and produce the sustainable energy (Iskin et al., 2020; Bourcet, 2020). Most of such kind of factors are associated with solar and biofuel energy (Kaur & Rehman, 2020; Alipour et al., 2020; Leibensperger et al., 2021) as wind power and geothermal energy sources are expensive to adopt and install. The current research also attempts to understand the difference in effect between each factor on solar or biofuel adoption over household or commercial use (Alizadeh, 2020). Concurrently, the current research tries to understand the mediating role of biofuel or solar energy adoption in between the range of motivational factors and use of energy for household or commercial purpose (Jabeen et al., 2020; Makki & Mosly, 2020). The current research building from works of published literature, has constructed a proposed range of motivational factors for the adoption of sustainable energy and leading to its production and use for both commercial

and household use (Gong et al., 2020). These factors include Branding Factors (Manouchehrabadi et al., 2020) Retailers Services factors (Ali et al., 2020) Altruistic factors (Ali et al., 2020) Weather and life styles factors (Komendantova, N., & Neumueller, 2020) Product and Services Awareness Factors (Rahman et al., 2020; Simon, 2020) Economic Factors (Whittle, et al., 2020) Ease of use factor (Masukujjaman et al., 2021).

The objective of the current research is to bridge the gap in the current literature by providing empirical evidence on the consumer behavior towards the adoption, production and consumption of sustainable solar and biofuel energy from rural communities of emerging and newly industrialized economies of Pakistan and Malaysia. The empirical evidence from rural communities in emerging economies such as Pakistan, is highly limited despite of the wide range adoption (Jan, 2021). Additionally, the current research also attempts to contribute to the literature towards the understanding of the phenomenon through cross cultural lenses (Sekaran, 1983). Thus, the current research has collected and compared the data from rural communities of Malaysia which is a newly industrialized country with a relatively high rate of adoption-consumption of clean energy and Pakistan, a country with a growing population and an emerging economy. The rest of this paper is followed by literature review, methodology, data analysis, conclusion and recommendations.

## 2. Literature Review

### 2.1. Economic Value

Economic factor has greatly illustrated as the consumption experience by (Holbrook, 2006) as an economic value. Literally, economic factors derived when consumers seek to achieve their consumption related objective through pricing benefit or quality excellence (Holbrook, 2006). The consumers have always been observed to achieve their objective from pricing benefits (Mendoza-Abarca & Mellema, 2016), superior quality (Pappas, 2017), low perceived risk (Wang et al., 2019) and product relate feature (Schuitema & De Groot, 2015) et cetera. Therefore, it can be said that economic factors or values that consumers seek from solar energy or biofuel can become important determining factors in developing intention (Yu & Fang, 2009; Al-Debei & Al-Lozi, 2014). The literature argues that consumer economic values have the potential to be satisfied from both forms of alternative energy products and services, i.e. solar power and biofuel, from a variety of perspectives. Both solar and biofuel energy are alternative energy solution which offers big savings in terms of money which otherwise has to be paid to the energy services provider (Mohamed & Lee, 2006), savings in generator fuel expenses (Yasmin & Grundmann, 2019), lower side effect in terms of hazards and health (Brown et al., 2020), consistent supply (Oh et al., 2010), consistent quality (Botelho et al., 2016) and environmental friendliness (Lee & Holden, 1999). Thus, it can be argued that consumer economic values are potential factors that need to be empirically tested in the cross rural areas setting. So the current research has hypothesized that;

**H1** *Economic Factors of consumer have significant impact on the intention to adopt solar and biofuel energy solution.*

## 2.2. Altruistic factor

The altruistic factor of consumer can be described as an individual “concern for how my own consumption behavior affects others where this experience is viewed as a self-justifying end-in-itself as when engaging in ethically desirable practices in which “virtue is its own reward” (Holbrook, 2006). Altruism can have a role in accelerating adoption of alternative energy products and services that should be tested. This is based on the notion that consumers may think that their decision to adopt and consume alternative energy is morally responsible behavior (Lee & Holden, 1999). Consumers have developed the idea that alternative energy consumption is not only viable economically but it is also viable morally (Hahnel et al., 2014) as alternative energy solution has promised to protect our environment from degradation (Arpan et al., 2014), will offer continuous and uninterrupted supply of energy (Oh et al., 2010) which will have profound positive impact upon household, especially for females and children (Jia et al., 2017). Besides that, consumers often experience a kind of intrinsic value in using and adopting alternative energy solution upon being motivated by other users and consumers (Ding et al., 2014) which will further motivate their decision in light of society’s view (Menges et al., 2005). Further, consumer’s altruism also plays a part in a form of indirect attitude (Hartmann & Apaolaza-Ibáñez, 2012) which stems from the fact that consumers in order to satisfy the inner self, can start a propagation of benefits and positive aspect to other members of society (Panda et al., 2020; Sweeney et al., 2014). Therefore, based upon such assertions, the current research has hypothesized that;

*H2 Altruistic Factors of consumer have significant impact on the intention to adopt solar and biofuel energy solution.*

## 2.3. Product and Services Awareness Factors

The product and services awareness refer to the extent to which a consumer of rural area knows about biofuel and solar power energy products and services (Bailey, 2005). The knowledge of product includes basic features of products (Ambali & Bakar, 2014), functions (Kane et al., 2003), usability and usages (Lakshmi et al., 2020), main brands or manufacturer (Marselina, 2019) and prices (Irfan et al., 2019) while services aspect of product includes retailers’ promotion techniques of installing, repairing and provision of any extra information that can enhance basic utility of product (Pokharel, 2003; Mishra et al., 2019). Product and services awareness is crucial in developing intention and adopting the alternative energy products such as biofuel and solar power (Akroush et al., 2019). Governments, environmental activists and corporations around the world are spending considerable amount of resources especially in rural areas, to create awareness of solar and biofuel products (Malik et al., 2020) through experimental methods of providing demonstration of the products and distributing for free (Yadav et al., 2019). The literature further argues that the, road to final adoption and consumption of the solar and biofuel runs from the awareness of such products (Rahmi et al., 2019). Due to higher level of education and more advanced mass media, urban consumers tend to be more aware than rural consumers of the alternative energies. Therefore, current data on the role of products and services knowledge in developing intention

of rural consumers to adopt either of the alternative energy solution of solar power or biofuel, is limited. So, the current research hypothesized that;

*H3 Products and Services awareness factors have significant impact on the intention to adopt solar and biofuel energy solution*

## **2.4. Climate Change Awareness**

The weather and lifestyle factors refer to the extent of weather condition in the area in which rural peoples are currently undertaking their livelihood and extent to which weather conditions induce necessary changes in the style of conducting such livelihood (Al-Ghussain, 2019). The rising temperature or global warming due to greenhouse gases effect has negative impact upon people's livelihood (Salleh, 2016) and such impact seems to be more profound in the rural areas as compared to the urban areas (Devereux, 2001; Singh, 2020). The commercial mobility from village to market, working schedule in farms and fields and health of farmers and rural people are some of the effects well noted in the literature (Cline, 1992). Further, it is increasingly raised and argued that of the effects of global warming in rural areas due to the lack of supply of electricity through traditional grid is also responsible for aggravating the situation (Schoen, 2017). Thus, researchers and policy makers have long ago been calling for innovations and solutions that can provide the rural communities with energy supply from electricity and gases which will bypass traditional grid bases supply (Zheng et al., 2010). The reason is to make rural communities more self-dependent in energy production and consumption for the support of their overall livelihood (Rosenthal et al., 2018). The solar and biofuel energy solution finally fits into such scenario where it helps rural communities to produce and consume energy themselves without any interruption of energy breakdown (Rahman et al., 2017) and use such energy solution in daily lives (Yaghoubi et al., 2019). Thus, current research hypothesized that;

*H4 Weather and lifestyle factors have significant impact on the intention to adopt solar and biofuel energy solution.*

## **2.5. Ease of Use Factors**

The ease of use can be defined as feature of product, services and system to provide its user easiness in performing function of product, services and system safely, effectively, and efficiently hedonically (Karahanna & Straub, 1999). The level of difficulty further increases with low amount of general awareness and literacy rate (Cao & Niu, 2019) as in the case of rural users. The user manuals and guides accompanied with product are always helpful but such manual and guides becomes ineffective in the case of rural consumers (Gök et al., 2019) due to low literacy rate. The literature has identified that, both electronic and electric products and services have problem of being considered not easy to use (Kardooni et al., 2016) and it is the reason that, many of innovative and effect products are difficult to be adopted by consumer widely due to their lack of ease of use (Al-Rahmi et al., 2019). However, considering solar and biofuel as electric and energy products, it has been observed both in the literature and practiced that, solar power panel and biofuel are not intricate in terms of its installation and functions (Bandara & Amarasena, 2018; Nehrir et al., 2011). The health hazards as literature indicate is always central concern

of consumers as for electric and electronic product are concerned (Chandel & Agarwal, 2017) and consumers tend to pay huge amount of money to vendors for helping them to install and guide them on its proper functioning (Acharya & Marhold, 2019). But, it has been noticed that, such factors are virtually invisible in the solar power and biofuel. The consumers easily install, maintain and repair energy producing products without paying extra amount of money to vendors (Extance, 2019) and there are not any health hazards been found while installing and using solar and biofuel products and services. Thus, based upon such assertion, current research hypothesized that;

**H5** *Ease of use factors have significant impact on the intention to adopt solar and biofuel energy solution.*

## **2.6. Retailor Services Factors**

The retailing or retailer's services factors are referred as the extent to which a retailer is providing sales and marketing services to consumers of both solar power panel and biofuel (Lee & Chow, 2020). The services by retailors include information on solar panel and biofuel products and brands, information on associated biofuel and captive products and services, easy access to vendor for installation and repairing, shipping of products from retailors location to site of installation which can be home or commercial place and any other additional information which can add value to consumer perception (Kolay, 2015). The literature suggests that, retailor play a crucial role in enhancing consumer perception of value of products and brand (Das, 2014). In the case of brand extension of line and launching a completely new product, company's manager depends upon retailor to generate the demand for the products (Völckner & Sattler, 2006). This is also a case with innovative and radical new product. The one of important reason of such an effective role of retailor in consumer demand generation and satisfaction is that, it is retailor who is a bridge in between company and consumer and retailor have direct contact with consumer (Vlachos et al., 2010). Corresponding to such assertion in the literature, role of retailor in the alternative energy solution of solar and biofuel is also important and similar (Luthra et al., 2015; Jelti et al., 2021). The importance of role increases further in the rural areas where retailor is only source of information and promotion. Thus, based upon such evidence, current research has hypothesized that;

**H6** *Retailer's services factors have significant impact on the intention to adopt solar and biofuel energy solution.*

## **2.7. Branding Factors**

The branding factors refer to an attempt by equipment manufacturer and distributor of solar power and biofuel to brand it and its products and services offered to the consumers (Larsen, 2017). The branding process or effort includes developing necessary elements of brand such as Name, logo, color, theme, graphics, sound or jingle, packaging and tagline (Moriarty & Franzen, 2008). The literature on the branding is one highly developed (Christodoulides & De Chernatony, 2010). The empirical evidences have shown that, branding is critical factors in issues such as consumer purchase intention (Martín-Consuegra et al., 2018), consumer adoption (Alashban et al., 2002), consumer loyalty (Van der Westhuizen, 2018) and firm's financial success (Crass et al., 2019). The literature further enlightens us that, branding is

closely associated with consumer psychology (Vogel & Watchravesringkan, 2017). The consumer psychological issues such as high perceived quality of products and services (Sanyal & Datta, 2011), high perceived utility (Winzar et al., 2018), higher perceived value (Kim et al., 2019) and lower perceived risk are well mitigated through development of strong brand (Kirchoff et al., 2019). The branding activities have also been observed actively in the sustainable and alternative energy solutions (Larsen, 2017). The term green brands have is occurring in the literature frequently and empirical evidences suggest us that, branding activities in product related with environmental sustainability such as solar and biofuel has significant and positive impact upon consumer perception and behavior (Zubair Tariq, 2014). The evidences on relationship between branding and intention is well recorded in other green products except solar and biofuel and most of these evidence are based upon urban samples. Thus, it is needed to calculate effect of branding factors on intention and adoption in rural phenomena. So, current research hypothesized that;

*H7 Branding factors have significant impact on the intention to adopt solar and biofuel energy solution.*

## **2.8. Intention of Solar power panel**

The intention of consumer is referred here as a prospect of consumer who will purchase or he/she is willing to purchase a solar power panel in near future (Ramayah, 2010). The past researches have been indicating that, intention is always closely related to the final purchases and adoption of product and services (Besharat et al., 2014). The intention is powerful construct in the literature of both consumer and human behavior. As it is referred in theory of planned behavior (TPB), people always develop an intention of adopting or discharging the certain and specific behavior (Ajzen, 1999). Therefore, it is argued here that, for final adoption and usage of solar power panel whether for the purpose electrifying home or commercial business, intention towards solar power panel is mediating factor (Kumar et al., 2020). Previous researchers have employed range of factors that can be instrumental in yielding the intention towards the solar power panel (Parkins et al., 2018) and many have been attracted towards TPB which argues that, attitude, subjective norms and perceived behavioral control are responsible for developing intention generally (Liu et al., 2020). Those factors enshrined (Liu et al., 2020). Although factors enshrined in TPB are important and empirical evidence are available in support of it within context of solar power panel (Yadav & Pathak, 2016). Current research argues that, due to nature of solar power products itself and understanding and comparing the adoption of solar power in context domestic and commercial purpose, range of other factors can also influence which include Branding Factors (Gong et al., 2020) Retailors Services factors (Manouchehrabadi et al., 2020) Altruistic factors (Ali et al., 2020) Weather and life styles factors (Komendantova & Neumueller, 2020) Product and Services Awareness Factors (Rahman et al., 2020) Economic Factors (Simon, 2020) Ease of use factor (White et al., 2020; Masukujjaman et al., 2021) upon intention of consumer towards solar power panel and finally to the domestic and commercial adoption. Thus, current research hypothesizes that;

*H8 Intention to adopt and install have positive effect towards adoption of solar power for home.*

*H9 Intention to adopt and install have positive effect towards adoption of solar power for commercial use.*

*H10 There is a mediating effect in between factors and adoption of solar power for home.*

*H11 There is a mediating effect in between factors and adoption of solar power for commercial use.*

## **2.9. Intention of Biofuel energy**

The intention of consumer is referred here as a prospect of consumer who will purchase or he/she is willing to purchase a solar power panel in near future (Ramayah et al., 2010). The past researches have been indicating that, intention is always closely related to the final purchases and adoption of product and services (Besharat et al., 2014). The literature has indicated variety factors employed to yield the intention towards the biofuel or biogas products and services (Yaghoubi et al., 2019) and with obvious role of factors to yield the intention as provided in the TPB (Chin et al., 2019). Although factors enshrined in TPB and by other researchers are important and empirical evidence are available in support of it within context of biofuel or biogas are strong (Yaghoubi et al., 2019; Chin et al., 2019; Bakhtiyari et al., 2017). Current research proposes to operationalize range of factors that needed be tested such as (Gong et al., 2020) Retailors Services factors (Manouchehrabadi et al., 2020) Altruistic factors (Ali et al., 2020) Weather and life styles factors (Komendantova & Neumueller, 2020) Product and Services Awareness Factors (Rahman et al., 2020) Economic Factors (Simon, 2020) Ease of use factor (White et al., 2020; Masukujjaman et al., 2021) with intention of consumer towards biogas and biofuel which can help us to understand biogas' and biofuel's adoption towards both domestic and commercial use. Thus, current research hypothesizes that;

*H11 Intention to adopt and install have positive effect towards adoption of biogas' and biofuels for domestic use.*

*H12 Intention to adopt and install have positive effect towards adoption of biogas' and biofuels for commercial use.*

*H13 There is a mediating effect in between factors and adoption of biogas' and biofuels for home.*

*H14 There is a mediating effect in between factors and adoption of biogas' and biofuels for commercial use.*

## **2.10. Theoretical review of adoption**

The concept of adoption whether household or commercial adoption which is addressed in next is derived from product adoption (Roger, 1976). The concept of new product adoption refers to a process where consumer of new and older product started to get aware of product, understand its value and finally starting to use it for both commercial and domestic purpose where applicable (Roger, 1976; Kalish, 1985). The innovation diffusion theory (Roger, 2010) which has been undergoing certain changes and modification has been key in explaining the product adoption by consumers (MacVaugh, J., & Schiavone,

2010). The empirical researches and evidence on the product adoption under the lens of innovation diffusion theory are wide ranging which have been instrumental in understanding product adoption (Zanello et al., 2016). The empirical evidences on relationship in between intention and adoption of the new or old product is also wide-ranging where researchers have been employing range of factors in the intention yield (Islam, 2014). Thus, it can be argued based upon published literature that, theoretical relationship exists in between intention and adoption.

### **2.10.1. Household adoption of biofuel and solar**

The product adoption of alternative energy solutions such as solar power panel and biofuel have remained issue for policy makers and researcher's community (Solangi et al., 2011). As researchers and policy maker have been arguing to fight poverty and other socio-economic issues with instrument of energy inclusiveness (Yadav et al., 2019), alternative energy solutions such as solar power panel and biofuel is playing an effective role (Giampietro et al., 2013; Ouedraogo et al., 2017; Zaman et al., 2017). The solar and biofuel products can be adopted for domestic or in home uses for variety of different purposes such as electrifying their homes clean source of cheap sources of cooking and different others uses (Alkin et al., 2018). The home based adoption of solar power panel and biofuel is also increasing day by day due to the perceived usefulness and value of solution (De Felice et al., 2019). The dynamic of solar power panel and biofuel adoption in rural areas are bit different to that of urban areas. The researches published in literature are mostly focused upon the urban residential consumers. The rural and cross cultural aspect of residential or domestic solar power panel and biofuel adoption is clearly missing. Further, as both solar power panel and biofuel are different in nature, functioning and price, evidences are needed to understand which product among solar power panel and biofuel is at priority of final adoption in the rural areas.

### **2.10.2. Commercial adoption of biofuel and solar:**

The alternative energy products such as solar power panel and biofuel have potential to help societies to achieve socio-economic objective through energy inclusiveness and supply for commercial purpose (König et al., 2020). It is argued that, people specially at rural areas can become generate income and employment for themselves with low cost and clean energy solutions (Sun et al., 2021). The variety of business opportunities have been tapped by people in rural areas by using the solar power panel and biofuel solution (Gandini et al., 2017). This include completely removing electricity charges for small scale retailer shops where electricity tariffs are higher as compare to domestic tariffs (Khan et al., 2016). The use of solar power panel and biofuel for small scale production facility like carpenter, shoes maker, barbers, tailor and many others (Boakye et al., 2020). Further, solar power panel and biofuel is also contributing in the home based venture run by women specially. However, rural and cross cultural aspect of commercial solar power panel and biofuel adoption is clearly missing. Further, as both solar power panel and biofuel are different in nature, functioning and price, evidences are needed to understand which product among solar power panel and biofuel is at priority of final adoption in the rural areas. The current research is step in further to develop understanding of adoption.

## **3. Methods And Materials**

### **3.1. Research design and approach:**

The purpose of current research is to establish a causal relationship in between critical factors related to biofuel and solar power panel and intention to adopt that can lead to final adoption of solar power and biofuel for either domestic use or commercial use. The factors which are affecting the intention that can yield adoption are derived from previous literature and theories such as innovation diffusion (Rogers-Everett, 1995) and theory of planned behavior (Ajzen, 1991). Therefore, by looking at aims and objective of research current research has proposed quantitative research design (Gregar, 1994). The definition and operationalization of variables (factors, intention and adoption) have been done from past literature. The current research has employed a survey questionnaire as tool of data collection which is mostly used by previous research is studying adoption of alternative energy (Rehman Khan & Yu, 2021). The unit of analysis for current research is cross cultural rural consumers of Pakistan and Malaysia. The decision of cross cultural analysis of data is rooted in the literature gap. The current research proposes a two stage method of data analysis using structural equation modeling (SEM) and Artificial neural network (ANN) (SEM-ANN) (Hayat et al., 2020). The SEM is famous tool of data analysis by energy researcher of consumer behavior but its results capture mainly the linear characteristic of the consumer behavior and in practice it is not always the case. Thus, ANN is proposed which is non-linear data analysis tool to be used to complement the results of SEM (Curry et al., 2002).

### **3.2. Rationale of cross cultural sample**

The cross cultural analysis of Pakistan and Malaysia is based upon the literature gap. The countries selected for current cross cultural analysis is based upon the distinction of emerging markets in case of Pakistan and newly industrialized country in case of Malaysia. The literature suggests that, both emerging and newly industrialized economies are developing a policy mainly aimed at the rural development (Zainoddin et al., 2017; Israr et al., 2017). The major objective of their policies is uplifting rural populace from socio-economic backwardness and achieving sustainable economic growth. Thus, comparison between emerging and newly industrialized economies is more logical than comparing between developed and newly industrialized or developed and emerging economies.

### **3.3. Population and sampling**

The population of current study includes the rural population of Pakistan and Malaysia which is 67.5% and 24% respectively (Government of Pakistan, 2019; World Bank, 2019). The current research selected one state and province and division within that state and province of Malaysia and Pakistan which is home to majority of rural population where government and rural communities are taking part in adoption of alternative energy consumption for both domestic and commercial use. The Table 1 illustrate the selection of state, province and division within. The current research has employed purposive non-probability sampling technique to collect the data. The reason of employing purposive non-probability

sampling is scope and objective of research and researcher’s judgment (Sharma, 2017). The total sample drawn from cross cultural population is approximately 400 (Saunders et al., 2009).

Table 1  
Population Characteristics

Population Characteristics		
	Malaysia	Pakistan
<b>Sate or province</b>	Sabah	Sindh
<b>Division</b>	Sandakan Division	Larkana Division
<b>District</b>	Tongod	Larkana Division
<b>Localities</b>	Tongod town and some adjacent villages	Dokri, Badh, Ratodero, Naudero

### 3.4. Data collection and instrumentation

The current research has employed the survey questionnaire as instrument of data collection. The questionnaire is developed at five-point liker scale ranging from Strongly Disagree to Strongly Agree (Nemoto & Beglar, 2014). The measure on each variable is developed from previous studies. The Tables 2 illustrate number of items used to measure each of variables in the conceptual framework and sources from where items are adopted. Corresponding to strategy of purposive sampling, questionnaire is distributed among the participants who have knowledge of solar power and biofuel and participants can understand the English language with support from the researchers in case of difficulty. The verbal demonstration of questionnaire in local language had also been given to the participants.

Table 2  
Data Collection Instrument

S.No	Variable	No of items	Sources
1.	Economic Factors	8	Sweeney & Soutar, 2001
2.	Easy to use factors	4	Segars & Grover, 1993
3.	Product awareness	5	Yoo & Donthu, 2001
4.	Climate change awareness	6	Halady & Rao, 2010
5.	Altruism factors	5	Steg et al., 2014
6.	Retailor Services Quality	5	Yuen & Chan, 2010
7.	Branding Factors	4	Chen, 2010
8.	Solar and Bio Power Intention	5 Each	Faiers et al., 2007; Kapoor & Dwivedi, 2020
9.	Household and Domestic adoption	6 Each	Li et al., 2015; Shabbir, 2010

### 3.5. Data Analysis

The current research has employed two stage method of data analysis combining Structural equation modeling (SEM) and artificial neural network (ANN). The SEM is a famous tool of data analysis (Hair et al., 2011) by energy researcher of consumer behavior. However, it is more suitable and often used to analyze the linear behavior of the consumer, and in practice consumer behavior always appear to be nonlinear. To overcome this difficulty, we employ ANN for an additional analysis. Thus, ANN is proposed which is a non-linear data analysis tool to complement the results of SEM (Leong et al., 2020). The current research proposed to employ variance-based SEM which is also called as partial least square SEM (PLS-SEM). The PLS-SEM will be used for calculating measurement model for purpose of establishing the validity and reliability of instrument and data itself and structural model for the purpose of testing hypothesis of current study (Hair et al., 2011). Secondly, current research proposes to employ forward back propagation type of ANN which is based upon sigmoid function (Leong et al., 2020). The neural network will be consisting of three layers, input, hidden and output layers. The input layer is consisting of independent variable and output layer is dependent variable while, hidden layer perform function of transformation of non-linearity in between input and output layers (Kubat, 2017). The software packages employed for conducting data analysis is the SmartPLS 3.4 for PLS-SEM and IBM-SPSS 21.0 for ANN and demographic analysis.

### 4. Data Analysis

The current research has employed the two-stage data analysis method (Leong et al., 2020) where hypothesis is tested with help of Partial least square structural equation modeling (PLS-SEM) techniques

and results obtained from PLS-SEM are further complemented with help of artificial neural network (ANN). The results are presented in following sections.

## 4.1. Partial Least Square-Structural Equation Modeling (PLS-SEM):

### 4.1.1. Construct validity and Reliability

The reliability of data collection instrument refers to internal consistency of items with their respective construct and validity of data collection instrument refers to assuming that, items of each construct are only measuring their relative phenomena rather than other (Price et al., 2015). The construct reliability in present research have been tested through tests of Cronbach's alpha (CA) and composite reliability (CR) and construct validity is tested through tests average variance extracted (AVE) (Cheah et al., 2018). According to literature of PLS-SEM, construct validity can be assumed when each constructs report value of 0.50 on AVE (Hair et al., 2018). The results presented in Table 3 shows that, data collection instrument used in collecting the data from both Malaysia and Pakistan has achieved both construct validity and reliability.

Table 3  
Construct Validity and Reliability

Variables	Pakistan			Malaysia		
	CA	CR	AVE	CA	AVE	AVE
Altruism	0.863	0.908	0.711	0.798	0.859	0.577
Branding factor	0.775	0.835	0.559	0.776	0.817	0.531
Climate Change Awareness	0.845	0.773	0.555	0.920	0.949	0.861
Commercial Adoption	0.766	0.863	0.618	0.770	0.854	0.542
Easy to Use	0.880	0.926	0.807	0.784	0.868	0.632
Economic	0.791	0.861	0.612	0.798	0.866	0.622
House Hold Adoption	0.882	0.909	0.667	0.885	0.904	0.612
Product and Services Awareness	0.951	0.962	0.836	0.953	0.964	0.841
Retailor Services Quality	0.899	0.926	0.714	0.905	0.929	0.725
Solar Intention.	0.881	0.914	0.681	0.890	0.919	0.696
Biofuel Intention.	0.881	0.914	0.681	0.890	0.919	0.696

### 4.1.2. Discriminant Validity: Pakistan and Malaysia:

The test of discriminant validity is one of important test to assume the validity in the instrument of data collection and it is applied to assure that each construct is different from other and each construct is separate and measuring their own phenomena. The SmartPLS 3.0 has helped us to calculate discriminant validity through criterion of Fornell Lorcker. The Fornell Lorcker test is now a day widely accepted test of assessing discriminant validity (Henseler et al., 2015). To assume discriminant validity, Fornell Lorcker value of each construct must be higher on their own as compare to other constructs (Hair et al., 2018). The discriminant validity tests are presented in both appendices A (Pakistan) and B (Malaysia). The result shows that, each constructs have achieved discriminant validity and measuring separate phenomena.

### 4.1.3. Explanation of variance

The variance in the present research model is explained through  $R^2$  which is also referred as co-efficient of determination. The  $R^2$  is proportions of variance in the dependent variable explained or contribute by each of independent variable (Glantz et al., 1990). The  $R^2$  is determined before testing a hypothesis and statistical literature concludes that for a dependent variable, it is necessary that, all of independent variable must contribute variance of above 0.20 or 20% (Cohen, 1992). The results shown in Table 4 clearly indicate that, each of dependent variable in the model has higher value  $R^2$  than accepted which is 0.20. Thus, it is concluded that, present research has explained appropriate and acceptable level of variance for hypothesis testing.

Table 4  
Explanation of Variance

	Malaysia		Pakistan	
	R2	R2 Adjusted	R2	R2 Adjusted
<b>Commercial Adoption</b>	0.275	0.271	0.242	0.238
<b>Household Adoption</b>	0.304	0.301	0.288	0.284
<b>Solar Intention</b>	0.590	0.575	0.538	0.522
<b>Biofuel Intention</b>	0.581	0.566	0.532	0.516

### 4.1.4. Model Fitness

The model fitness of research model refers to how well set of predictor fits on the observation (Stephens, 2017). The SmartPLS 3.0 offers to measure the goodness of fit of research model through various indices and one of most widely used model fit indices being followed for PLS-SEM is called as Standardized Root Mean Square Residual (SRMR). According to literature of PLS-SEM, value of SRMR less than 0.10 or of 0.08 is considered as model achieving goodness of fit (Hair et al., 2019). The results shown in the Table 5 confirms that, models of present research have achieved the goodness of fit as value of SRMR is less than 0.10 or of 0.08.

Table 5  
Model Fitness

	<b>Saturated Model</b>	<b>Estimated Model</b>
Pakistan	0.084	0.113
Malaysia	0.094	0.117

### 4.1.5. Structural Model:

The present research has employed bootstrapping based upon 5,000 sub-samples procedure to test the hypothesis (Hair et al., 2019). The present research is cross product and cross cultural where set of independent variable are hypothesized as factors of yield intention towards two green energy cross products i.e. Biofuel and Solar power energy in cross country rural area market of Malaysia and Pakistan. Therefore, to have better visualization of results, present research model is breakdown into four models. The structural models for each product namely biofuel and solar power energy are developed separately for each country namely Malaysia and Pakistan. The Table 4 summarized results of structural models of biofuel intention towards household and commercial uses for both Pakistan and Malaysia. The Table 6 summarized results of structural models of solar power energy intention towards household and commercial uses for both Pakistan and Malaysia.

### 4.1.6. Structural Model- Biofuel Intention:

The Table 4 shows the cross cultural results of biofuel intention towards household and commercial adoption. The results show that, for both Pakistan and Malaysia, there is positive effect of biofuel intention towards the both household and commercial adoption. But, as for as factors of biofuel intention are concerned, for Malaysia, two factors; easy to use and Product awareness are insignificant with biofuel intention. While for Pakistan four factors; climate change, easy to use, product awareness and retailers services are insignificant with biofuel intention.

Table 6  
Structural Model Analysis

Hypothesis	Pakistan		Malaysia	
	Beta	P Values	Beta	P Values
Altruism -> Bio Fuel Intention	0.288	0.005	0.220	0.044
Branding -> Bio Fuel Intention	0.571	0.000	0.520	0.000
Climate Change -> Bio Fuel Intention	0.194	0.037	-0.028	0.605
Ease to Use -> Bio Fuel Intention	0.075	0.494	0.081	0.467
Economic -> Bio Fuel Intention	0.169	0.005	0.168	0.005
Bio Fuel Intention -> Commercial	0.508	0.000	0.489	0.000
Bio Fuel Intention -> Household	0.552	0.000	0.519	0.000
Product Awareness -> Bio Fuel Intention	-0.034	0.742	0.049	0.637
Retailor Services -> Bio Fuel Intention	0.202	0.029	0.168	0.091

#### 4.1.7. Structural Model- Solar power energy Intention:

The Table 7 shows structural model results of solar power intention for both Pakistan and Malaysia. The results show that for Malaysia, only one hypothesis developed in between product awareness and solar intention is rejected. While for Pakistan four hypotheses; impact of climate change, easy to use, product awareness and retailor services quality on solar power intention is rejected.

Table 7  
Structural Model Analysis

Hypothesis	Pakistan		Malaysia	
	Beta	P Values	Beta	P Values
Altruism -> Solar	0.262	0.014	0.205	0.046
Branding factor -> Solar	0.558	0.000	0.512	0.000
Climate Change -> Solar	0.192	0.000	-0.091	0.449
Easy to Use -> Solar	0.228	0.027	0.077	0.500
Economic -> Solar	0.168	0.006	0.169	0.005
Product Awareness -> Solar	-0.143	0.139	0.033	0.759
Retailor Services Quality -> Solar	0.189	0.040	0.150	0.141
Solar -> Commercial	0.524	0.000	0.492	0.000
Solar -> Household	0.552	0.000	0.536	0.000

## 4.2. Artificial neural Network (ANN) Analysis:

The artificial neural network (ANN) analysis is incorporated into current study to predict importance of each of independent variable into dependent variable (Teo et al., 2015). The ANN incorporate non-linear relationship in between both exogenous and endogenous variable and it is robust in predicting the relationship with both non-normal data and outliers (Taneja & Arora, 2019). The current research is cross cultural and product analysis of household and commercial adoption. The current research has applied four ANN models in each country. The first two ANN is based upon factors and intention to towards biofuel and solar intention and third and fourth is towards commercial and household adoption of each country. The feed forward backward propagation (FFBP) with sigmoid function is used train and test ANN algorithm with tenfold cross validation approach to avoid oversimplification bias in ANN model (Leong et al., 2020).

### 4.2.1. ANN Model Validity:

The current research has operated tenfold ANN analysis to avoid oversimplification of ANN model and obtain ANN model fitness (Leong et al., 2020). The Root Mean Square Error (RMSE) indices are calculated for both training and testing data of ANN model. The RMSE is calculated ten times as ANN is operated tenfold and average of RMSE is calculated at the end. The Table 8 shows average RMSE value for different model on the data of Malaysia and Table 9 average RMSE value for different model on the data of Pakistan. The literature on RMSE statistics concludes that, RMSE value within range of 0 and non-negative shows the perfect fit of model especially ANN (Heravi et al., 2004). The results of RMSE of both testing and training of each of model from Malaysia and Pakistan as shown in Table 8 and 9 shows that,

RMSE value of all of models are both within 0 and non-negative. Therefore, it is concluded here that, models of ANN used for current study are fit statistically. The ten times RMSE calculation different ANN models are attached in appendix C to J. The Table 8 and 9 only depicts average of RMSE of each model.

Table 8  
ANN Model Validity-Malaysia

Malaysia	RMSE (Training)	RMSE (Testing)
<b>Inputs:</b> Altruism, Branding, Climate, Easy to Use, Economic, Product awareness, Retailor Services <b>Output:</b> Solar Intention	0.010242571	0.022470046
<b>Inputs:</b> Altruism, Branding, Climate, Easy to Use, Economic, Product awareness, Retailor Services <b>Output:</b> Biofuel Intention	0.130889571	0.109271
<b>Input:</b> Solar and Bio Fuel Intention <b>Output:</b> Commercial Adoption	0.163166757	0.168794
<b>Input:</b> Solar and Bio Fuel Intention <b>Output:</b> Household Adoption	0.130570961	0.119395

Table 9  
ANN Model Validity-Pakistan

Pakistan	RMSE (Training)	RMSE (Testing)
<b>Inputs:</b> Altruism, Branding, Climate, Easy to Use, Economic, Product awareness, Retailor Services <b>Output:</b> Solar Intention	0.122668737	0.112757641
<b>Inputs:</b> Altruism, Branding, Climate, Easy to Use, Economic, Product awareness, Retailor Services <b>Output:</b> Biofuel Intention	0.136947	0.117559
<b>Input:</b> Solar and Bio Fuel Intention <b>Output:</b> Commercial Adoption	0.181633	0.161928
<b>Input:</b> Solar and Bio Fuel Intention <b>Output:</b> Household Adoption	0.144105	0.133102

### 4.3. Sensitivity analysis:

The sensitivity analysis is conducted to measure relative importance of each of input neuron or factors used in the ANN model on output neuron or factor. The results result of sensitivity analysis is calculated as average of tenfold application of ANN model. The results are presented in the Table 8 and 9.

#### 4.3.1. Sensitivity Analysis-Intention:

The sensitivity analysis cross cultural and cross product purchasing intentions results are shown in Table 10. The results show that, Branding factor is most important factor in the purchasing intention of both biofuel and solar in both Pakistan and Malaysia. The factors which comes after branding as for as relative importance are concerned Economic and Altruism in every model. However, factor relative importance of factors such as climate awareness, easiness in use, product awareness and retailer's services awareness changes in different models.

Table 10  
Sensitivity Analysis-Intention

	Malaysia		Pakistan	
	Solar	Biofuel	Solar	Biofuel
Altruism	44.29%	43.00%	44.92%	41.99%
Branding	97.60%	97.60%	99.81%	98.00%
Climate	32.24%	34.53%	27.58%	31.71%
Easy to Use	35.76%	30.83%	17.49%	18.16%
Economic	62.41%	59.20%	54.72%	47.39%
Product awareness	17.84%	17.58%	28.74%	23.91%
Retailor Services	18.45%	19.26%	31.69%	22.35%

### 4.3.2. Sensitivity Analysis-Adoption

The result of sensitivity analysis of commercial and household adoption of biofuel and solar power energy is presented in the Table 11. The results show that, Solar power energy has more relative importance on commercial adoption (95.82%) as compare to household adoption (85.19%) in Malaysia. While, biofuel has more relative importance on household adoption (98.21%) in comparison with commercial adoption (76.76%). Further, results of Pakistan show that, solar power has more relative importance (95.5%) as compare to commercial 84.62%). While, biofuel has more relative importance on commercial (90%) as compare to household (81%).

Table 11  
Sensitivity Analysis-Adoption

	Malaysia		Pakistan	
	Commercial	Household	Commercial	Household
Solar Intention	95.82%	85.19%	84.62%	95.95%
Biofuel Intention	76.76%	98.21%	89.65%	81.08%

## 5. Discussion

The present research attempted to study cross cultural consumer behavior of rural population in Pakistan and Malaysia towards the two of the most innovative energy products of present age i.e. solar and biofuel energy. The outcome of this study is interesting from both managerial and theoretical perspective. The results of the present study conclude that both biofuel and solar power panel products have become increasingly important sources of energy for household and commercial activity purpose in rural areas of Malaysia and Pakistan. The following paragraphs present the discussion in detail.

## 5.1. Biofuel Intention

The results of partial least square structural equation modeling (PLS-SEM) from Malaysia have concluded that two of factors, namely, ease of use ( $P=0.494$ ) and product awareness ( $P=0.742$ ) do not have any significant relationship with the intention to consume energy from biofuel sources. However, all other factors such as branding ( $\beta = 0.571$   $P=0.000$ ), altruism ( $\beta = 0.288$   $P=0.005$ ), climate change awareness ( $\beta = 0.194$   $P=0.037$ ), economical factors ( $\beta = 0.169$   $P=0.005$ ) and retailer services factor ( $\beta = 0.202$   $P=0.029$ ) have significant relationship with biofuel intention. A further result of ANN corresponds with results of PLS-SEM. The ANN results show that of accepted hypothesis, Branding, Economic, Altruism, Climate change and retailer services factors are important in determining the intention towards biofuel energy sources. The results conclude that, biofuel energy providers need to focus much upon the branding of their products with pricing and lower economic cost at heart of such branding campaign. The results of PLS-SEM-ANN also call for the promotion of consumer altruism through various means to increase and yield purchasing intention towards biofuel. The study has confirmed the notion that climate change awareness is a real factor in purchasing intention of goods which promises environmental sustainability. Lastly, services of retailer of biofuel can also play a vital role in increasing the intention towards the biofuel. Therefore, energy supply promotion to the consumers should include the aspect of retailers as well.

The results with the data collected from Pakistan are different from Malaysia. The PLS-SEM results show that climate change ( $P=0.605$ ), ease of use ( $P=0.467$ ), product awareness ( $P=0.637$ ) and retailer services quality ( $P=0.091$ ) do not have significant impact upon the biofuel intention. But Branding ( $\beta = 0.520$ ,  $P=0.000$ ), Altruism ( $\beta = 0.220$ ,  $P=0.044$ ) and Economic factors ( $\beta = 0.168$ ,  $P=0.005$ ) have significant impact upon the biofuel intention. The results of ANN also in line with PLS-SEM where branding is the most important factor followed by economic and altruistic factor. Current literature is highly limited on reasons to support such inconsistency of results with theory. In view of the difference in development status and social culture between Pakistan and Malaysia, such inconsistencies could be attributed to various factors such as education, income and others. Thus, more research is needed to explain these phenomena.

## 5.2. Solar power intention:

The PLS-SEM result on data from Malaysia concludes that only product awareness ( $P=0.139$ ) has insignificant impact upon the solar power purchasing intention. The other factors of Branding ( $P=0.000$ ,  $\beta = 0.558$ ), Economic ( $P=0.006$ ,  $\beta = 0.168$ ), Altruism ( $P=0.014$ ,  $\beta = 0.262$ ), Climate Change awareness ( $P=0.000$ ,  $\beta = 0.192$ ), Ease of use ( $P=0.027$ ,  $\beta = 0.228$ ) and retailer services quality ( $P=0.040$ ,  $\beta = 0.189$ ) all have significant relationship with the solar power purchasing intention. The ANN results also correspond with those of PLS-SEM. Therefore, it is concluded that focusing on branding, economic, altruism, ease of use, climate change awareness and retailer services respectively will yield purchasing intention among the rural communities in Malaysia.

The results from Pakistan on solar power purchasing intention follows the same pattern of biofuel intention. The PLS-SEM results show that climate change ( $P=0.449$ ), ease of use ( $P=0.500$ ), product awareness ( $P=0.759$ ) and retailer services quality ( $P=141$ ) do not have significant impact on solar power purchasing intention. On the other hand, Branding ( $\beta = 0.512, P=0.000$ ), Altruism ( $\beta = 0.205, P=0.046$ ) and Economic factors ( $\beta = 0.169, P=0.005$ ) have significant impact on the purchase intention for this product. The results of ANN are also in line with PLS-SEM where branding is the most important followed by economic and altruistic factor. More research is required to understand the inconsistent aspect of the Pakistan consumer behavior towards solar power purchasing intention.

### **5.3. Household and Commercial Adoption:**

The results of PLS-SEM from Malaysia have demonstrated that solar power has positive impact towards household ( $P=0.000, \beta = 0.552$ ) and commercial adoption ( $P=0.000, \beta = 0.524$ ), with similar results pattern for biofuel towards household ( $P=0.000, \beta = 0.552$ ) and commercial adoption ( $P=0.000, \beta = 0.508$ ). The results of PLS-SEM of data collected from Pakistan also show similar results in which both solar and biofuel intentions have positive and significant impact towards household and commercial adoption. Therefore, it is concluded here that consumer purchasing intention towards biofuel and solar power panel can be translated into actual adoption of biofuel and solar power energies for commercial and household use purpose by the rural communities in Pakistan and Malaysia.

The results of ANN reveal the cross cultural differences with reference to commercial and household adoption of biofuel and solar power panel. The results show that commercial adoption of solar panel is higher among Malaysian rural consumers than households in Pakistan. Further, biofuel has higher acceptance for household use among Malaysian rural consumers while it has higher acceptance for commercial use among Pakistani rural consumers. Thus, it is concluded that both solar power and biofuel energy are important mix of sustainable and alternative energy resources which the people in the rural areas of Pakistan and Malaysia are keen to utilize for both commercial and household purpose.

## **6. Conclusion**

The present research has studied the cross cultural behavior of rural consumer towards sustainable energy products, specifically on biofuel and solar power panels. The current research studied the behavior of rural consumers towards biofuel and solar power panels. Previous studies have been focusing on consumer behavior towards sustainable energy products and solutions by employing famous theories such as theory of planned behavior, technology acceptance model and others. But, there is a lack of literature which asserts the consumption of sustainable energy is different from other kinds of goods and services. Sustainable and alternative energy sources are based upon model of producing and consuming electricity without any intermediaries especially government. Thus, a gap in literature exists which calls for studying such consumer behavior from a very different perspective. So, the current research guided by the results of published literature, developed and tested a number of factors which can help to enhance the intention towards sustainable and alternative energy sources of biofuel and solar power panel. Further, it has been seen from scientific and other sources of literature that alternative and sustainable

energy sources have good potential for both domestic and commercial purpose. However, no scientific study has been conducted from this perspective. Thus, the current research has also incorporated and compared the prospective domestic and household adoption. Lastly, sustainable and alternative energy sources are already driving an energy revolution in the rural areas. However, the rural population in many countries, including Pakistan, has long been overlooked by the authorities on energy supply. Thus, an alternative and sustainable energy source offers an important solution to energy access for both commercial and domestic purpose. Various reports have pointed out that sustainable and alternative energy sources are reviving rural economy. Therefore, the current research offers valuable insight on this perspective.

The current research has employed PLS-SEM-ANN to satisfy both linear and non-linear relationship assumption. The results of data analysis have confirmed that both solar power and biofuel, two products studied in the present research, have significant and positive impact on both commercial and household adoptions. The results show that, biofuel is more favored for commercial use in the rural areas of Malaysia while solar power panel is more preferred in Pakistan for commercial purpose. For domestic consumption, on the other hand, biofuel is preferred by the rural population in Pakistan, while in Malaysia the choice is solar power. The results of PLS-SEM-ANN have shown that factors such as branding, economic and altruism, are powerful factors that can drive intention towards both biofuel and solar power which further leads to household and commercial adoption. The other factors such as climate change awareness, ease of use, retailers' service quality, are also helpful in yielding the intention in Malaysia only. The findings of this research offer a variety of practical and theoretical implications.

## **6.1. Managerial Implication:**

The present research offers three practical implications. First, the current research has confirmed from empirical evidences that consumption of solar power and biofuel is growing in rural areas of both Pakistan and Malaysia. Therefore, energy investments in this aspect need to design the marketing framework that will incorporate the needs and wants of rural consumers. Secondly, the present research offers an important insight regarding both biofuel and solar power panel sources. The research results confirm that the rural consumers are willing to adopt both biofuel and solar power for commercial and domestic use. Thus, brands that offer solar or biofuel solution should design their promotion campaign to focus on both segments of consumers. Finally, the present research suggests that providers of biofuel and solar energy solution should also take into consideration the elements of economic factors in their promotion to the rural sectors. The results of the present research corroborate the findings of earlier studies that economic factors are instrumental in yielding the intention of consumers.

## **6.2. Theoretical Implications:**

The present research offers four implications for theory of innovation diffusing and planned behavior. First, while most researchers have been relying upon linear method of regression, the current study has employed PLS-SEM-ANN method of data analysis to satisfy both linear and non-linear regression assumptions. Second, the current research has analyzed cross culturally Malaysian and Pakistani cross

product biofuel and solar power data and cross segment domestic and household data. The results offer an interesting insight regarding adoption of sustainable alternative energy where it is confirmed that both the theory of planned behavior and innovation diffusion is popular in such analysis. Third, the present research is conducted in the context of rural areas. Currently literature on sustainable and alternative energy in rural area context is highly limited. Thus, the current research contributes to the theory by providing empirical evidences. Lastly, the current research confirms that, Branding, Economic and Altruism are important factors in yielding intention towards both solar power and biofuel energy in Malaysia and Pakistan.

## Declarations

**Author Contributions:** “Conceptualization, J.A. and Y.C.Y.; methodology, JA.; software, JA.; validation, JA. and Y.C.Y.; formal analysis, JA.; investigation, J.A and Y.C.Y.; resources, J.A and Y.C.Y.; data curation, J.A.; writing—original draft preparation, J.A and O.K.H.; writing—review and editing, J.A, A.Y.H.N and O.K.H.; visualization, Y.C.Y and O.K.H.; supervision, Y.C.Y and J.A.; project administration, J.A and Y.C.Y.; funding acquisition, Y.C.Y and A.Y.H.N. All authors have read and agreed to the published version of the manuscript.

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**Consent to Participate:** Not applicable

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## Figures

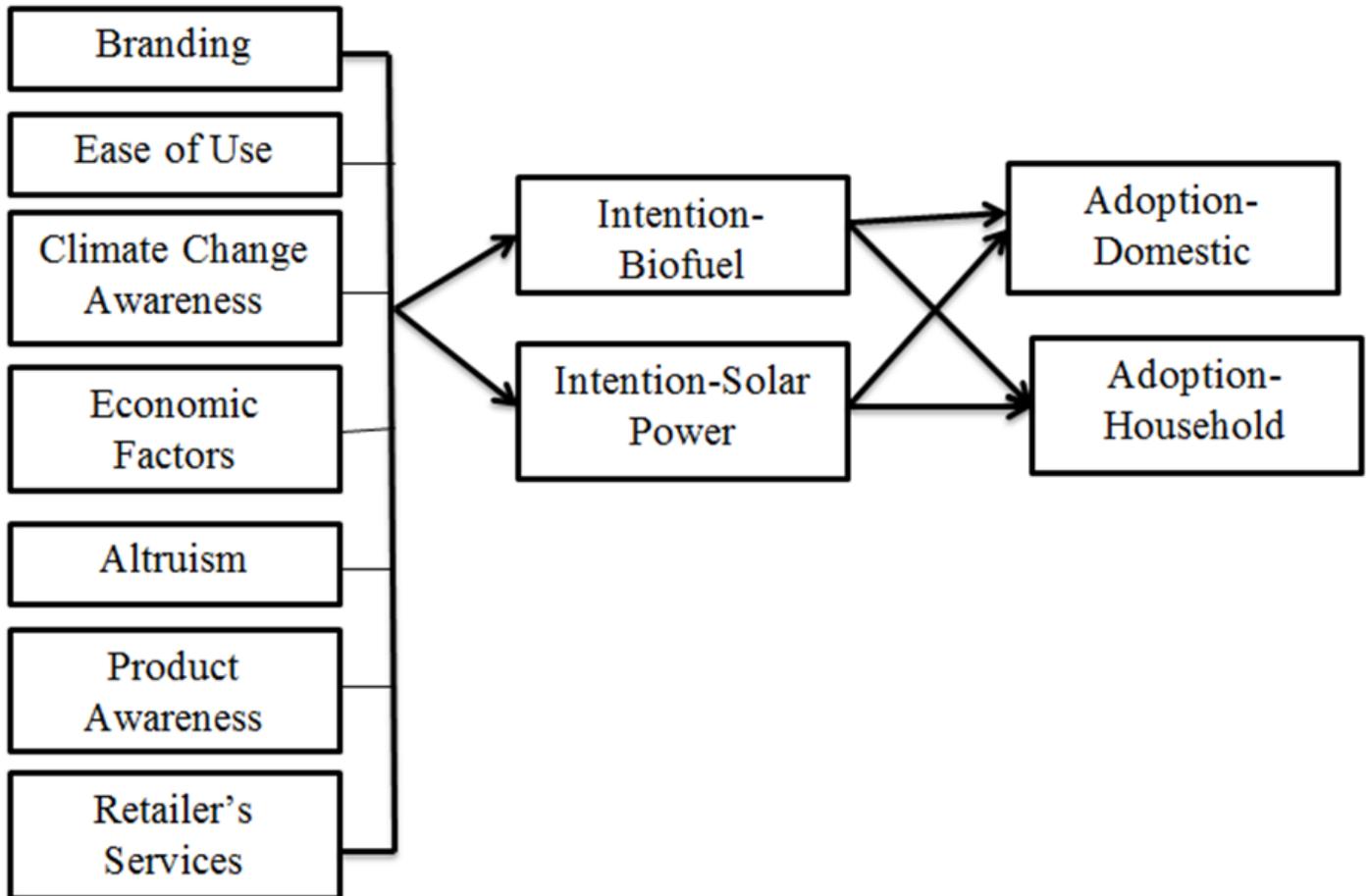


Figure 1

Conceptual Model of Study

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