The acceptance of solar water pump technology among rural farmers of northern Pakistan: A structural equation model

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The acceptance of solar water pump technology among rural farmers of northern Pakistan: A structural equation model

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Abstract: The situation of electricity is deteriorating in Pakistan and load shedding prevails in all parts of the country which not only affect the general life but also leads to lower agricultural productivity in rural areas. The purpose of this study is to explore the factors that influence the acceptance of solar water pump (SWP) technology. For this purpose, a SWP technology acceptance model was proposed based on technology acceptance model (TAM) and unified theory of acceptance and use of technology. Six variables were used to assess the model which includes; perceived usefulness, perceived ease of use, facilitating conditions (FC), cost tolerance (CT), awareness and attitude towards SWP usage. Data were collected from 450 rural farmers employing structured questionnaire through face to face interviews. The questions were orally translated to farmers due to lack of education. The method of structural equation modeling was used to test and confirm the hypothesized model. Results indicated that out of eight hypotheses, seven were supported while one was not supported. Moreover, the results show that better predictors of SWP technology usage were gender, age, education awareness, CT, FC, ease of use and usefulness. The study is valuable as it applied TAM to study the factors influencing the acceptance of SWP technology for the first time in the context of Pakistan.

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*Corresponding author: Abdullah, College of Economics & Management, Huazhong Agricultural University, No. 1, Shizishan Road, Hongshan District, Wuhan 430070, Hubei, P.R. China
E-mail: abdeco@webmail.hzau.edu.cn

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Additional information is available at the end of the article

ABOUT THE AUTHORS
Currently, Abdullah is doing Master in Agricultural Economics & Management at Huazhong Agricultural University Wuhan China. This research focused on the acceptance of solar water pump technology among rural smallholder farmers of northern Pakistan for irrigation purpose. The country is suffering from severe problem of load shedding and the use of solar water pump is the need of the day. The basic objective is to test the technology acceptance model in the context of Pakistan. He has attended many seminars and workshops on themes related to Economics, political concepts, peace & development, human rights, management skills and education. He has diverse research interest including Agricultural Economics, Development Economics, Micro-Economics, Energy Economics and Behavioral Economics. He has also published several papers and a few are submitted to journals.

PUBLIC INTEREST STATEMENT
Currently, the supply falls short of demand that results in “load-shedding” which prevails all over the country. Solar water pump (SWP) is a better alternative to traditional water pump owing to the high prices of diesel and vulnerable situation of electricity in Pakistan. Keeping in view the relatively low income, education and traditional use of technology by the farmers in northern Pakistan, the aim of this study is to identify and investigate factors that affect the acceptance of SWP technology. For this purpose, a SWP Technology Acceptance Model was developed based on Technology Acceptance Model. In addition, three other factors; “Facilitating Conditions”, “Awareness” and “Cost Tolerance” were incorporated in the final model. To the best of our knowledge, this is the first study to examine the influence of PU and PEOU on attitude towards SWP usage in the Pakistani context.
1. Introduction

Solar power is a viable and natural choice for pumping water. It is economically attractive and can provide reliable service for decades. Photovoltaic water pumping (PVWP) has several beneficial characteristics including simplicity, reliability and cost effectiveness. The match between seasonal water needs and seasonal solar resource is a good one. “A typical system configuration includes a PV array, pump, controller, inverter (for AC), and over current protection” (Foster & Cota, 2014). Previously PVWP was used for small pumping loads, but the scenario has changed over the last few years and now PVWP has become very competitive, supporting high loads. For example in Africa, PVWP is used for two purposes i.e. for irrigation and community water supply. In Kenya about 50% of PVWP are being sold for irrigation and 50% for community water supply. In Ghana, nearly 40% of PVWP are sold for irrigation and 60% for community water supply. Despite limited data, the available evidence suggested that in West Africa, solar water pump (SWP) has played a significant role in her irrigation sector by providing additional income to smallholder farmers during the dry season (Abric et al., 2011; Giordano, De Fraiture, Weight, & van der Bliek, 2012).

The economic viability and reliability of SWP made it the number one choice for irrigation in the rural hinterland. Solar water pumping is used on large ranches in western US, Mexico, Australia and Canada (Chandel, Nagaraju Naik, & Chandel, 2015; Valer, Melendez, Fedrizzi, Zilles, & de Moraes, 2016). The photovoltaic irrigation system is very simple to operate. Electricity is provided by photovoltaic array to drive surface motor pump, which pumps water out of a well into a reservoir (Hamidat, Benyoucef, & Hartani, 2003). Moreover, water tanks are used to store water and there is no need of batteries to store electricity (Rohit, Karve, & Khatri, 2013). The stored water is then utilized for irrigation purpose. Moreover, the water flows from the reservoir to crops by gravity force (Hamidat et al., 2003).

About 86% of the world’s population relies on rural agriculture for their livelihoods as stated by World Bank report (WB, 2008). However, hundreds and thousands of people are living in such places where agricultural activities are not possible due to lack of water. The scarcity of water has vital consequences for the development of human being, such as low agricultural productivity, especially in regions with irregular or low rainfall. Solar Water pumping can be a cost effective alternative under such circumstances as there exist complementarity between crop irrigation needs and solar irradiation. The periods of high water demand coincide with that of high solar irradiation. Therefore, PV water pumping can reduce the problem of water limitation (Valer et al., 2016).

Unfortunately, no serious steps have been taken to meet the increasing demand, and now Pakistan is facing an unprecedented crisis of energy. Currently, the supply falls short of demand that results in “load-shedding” which prevails all over the country. The energy situations of Pakistan reached to this level due to lack of planning and management, failure of the future forecast, insufficient installed capacity, the faulty distribution system of the power supply and lacking ability in the transmission system to transmit the load imposed are the key technical reasons for the shortage of electricity. Moreover, various political, financial and governance related issues halt the development and progress of the power sector (Rauf, Wang, Yuan, & Tan, 2015).

Agriculture is playing a significant role in the economic uplift of Pakistan by contributing 20.9% to GDP and providing job opportunities to 43.5% of the rural population (GOP, 2016). Almost 61% of the population dwells in rural areas (GOP, 2016), and most of them do not have access to electricity and natural gas. They are compelled to live without electricity for an extended period i.e. 12–14 h in cities and more than 16 h in rural areas (HDIP, 2011). In rural areas of developing countries, agriculture is dependent on rain and is negatively affected by the unavailability of water in summers (Chandel et
And this is the case with Pakistan. It is difficult for the farmers to maintain the production at its normal level due to vulnerable situation of electricity to operate the electricity driven pump and hence causes food security problem. Therefore, farmers need to go for alternative sources of energy for water pumping.

From the above discussion, it is clear that SWP is a better alternative to traditional water pump owing to the high prices of diesel and vulnerable situation of electricity in Pakistan. In the proposed study area currently farmers use traditional water pumps that either needs electricity or fossil fuels. The operational cost of this system is a major concern for smallholder farmers. Furthermore, the prices of fossil fuels are increasing rapidly and the situation of electricity is extremely bad particularly in rural areas because they have to suffer from 12 to 16 h of load-shedding which affect everyone and especially smallholder farmer who rely on electricity for irrigation. Therefore, to avoid the negative effects associated with traditional water pumping and to increase the income of the smallholder farmers from the available land and other resources, they need to go for solar water pumping. Therefore, this study is planned to explore the factors that influence the acceptance of SWP technology.

The research about the acceptance of SWP technology is new in Pakistan and limited studies are available which explores and confirms the determinants of SWP technology among rural farmers from a structured perspective. In our study, the research question is “what are the factors that influence farmer’s acceptance of SWP technology?”

In this study, a conceptual framework is applied to understand the barriers to SWP technology acceptance among rural farmers in northern Pakistan. Keeping in view the relatively low income, education and traditional use of technology by the farmers in northern Pakistan, the aim of this study is to identify and investigate factors that affect the acceptance of SWP technology. For this purpose, a Solar Water Pump Technology Acceptance Model (SWPTAM) was developed based on Technology Acceptance Model (TAM) (Davis, 1986). In addition, three other factors; “Facilitating Conditions (FC),” “Awareness (AW)” and “Cost Tolerance (CT)” were incorporated in the final model. The theoretical foundations of SWP technology acceptance have not been tested so far in Pakistan. Therefore, this study will make a significant contribution to literature by proposing and confirming SWP technology for the first time in the context of Pakistan.

The specific objectives of the study are (1) to developed a customize Technology Acceptance Model using TAM, TRA, and unified theory of acceptance and use of technology (UTAUT) theories to find the determinants of the acceptance of SWP technology; (2); and to employ survey method of research to test the customized SWP technology model. Authors are hopeful that this project would provide a better roadmap for understanding the success factors and post-implementation interventions contributing to the acceptance and assimilation of SWP technology in developing countries in general.

2. Conceptual framework and hypotheses

According to Alam et al. (2014), the transition from conventional energy to renewable is a socially dynamic process in which the perception of individual plays a key role. It is worth noting that the use of technology is largely influenced by multidimensional forces such as economic, social and regulatory (Bush, 2006; Garcia, Perez-Lugo, & Baiges, 2008; Leucht, Köbel, Laborgne, & Khomenko, 2010). Technology acceptance remained one of the important fields of study over the last two decades (Chuttur, 2009).

TAM is a pioneering theory that has been employed by various studies in the literature. Davis (1989) developed the TAM to identify the factors that cause technology and system failures. The theory proposed that two factors i.e. perceived ease of use (PEOU) and perceived usefulness (PU) to explain the motivation of users. The aforementioned two factors are considered important that
influence Attitudes (ATT) of users and eventually, Behavioral intention (BI) that determine the actual system use. Graphically, TAM can be shown in Figure 1.

In many studies, the original TAM has been extended to investigate the effects of external variables on internal beliefs, attitudes, and BIs. Moreover, some previous studies provided a comprehensive framework for the acceptance of new sustainable energy technologies (Midden & Huijts, 2009). For example, Molin, Aouden, and van Wee (2007) studied the acceptance of carbon capture and storage technologies, alternatively fueled cars such as biodiesel vehicles, hybrid vehicles, and hydrogen vehicles. Huijts, Molin, and Steg (2012) provided a framework for the acceptance of energy technology acceptance. Toft, Schuitema, and Thøgersen (2014) examined the acceptance of electricity from renewable sources. Gupta, Fischer, and Frewer (2011) studied the socio-psychological determinants of public acceptance of sustainable technologies. Finucane, Alhakami, Slovic, and Johnson (2000) examined the relationship between perceived risk and perceived benefits. The aforementioned studies show that TAM can be used as a comprehensive framework for the acceptance of energy technology.

The factors influencing the use of technology have been extensively studied. The technology acceptance behavior is explained by several models, including the theory of reasoned action (TRA) (Ajzen & Fishbein, 1975), TAM (Davis, 1989), the technology acceptance model 2 (TAM 2) (Venkatesh & Davis, 2000), Technology Acceptance Model 3 (TAM 3) (Venkatesh & Bala, 2008) and the UTAUT (Venkatesh, Morris, Davis, & Davis, 2003).

![Figure 1. Technology acceptance model.](source: Davis (1989)).

| Constructs                | Definition                                                                 | Theory   | References               |
|---------------------------|---------------------------------------------------------------------------|----------|--------------------------|
| Behavioral intention (BI)| An individual’s performing a conscious act, such as deciding to accept or (use) a technology | TAM      | Davis (1989)             |
| Perceived Usefulness (PU)| The degree to which a person believes that using a particular system would enhance his or her job performance | TAM      | Davis (1989)             |
| Perceived ease of use (PEOU)| The degree to which a person believes that using a particular system would be free of effort | TAM      | Davis (1989)             |
| Facilitating condition (FC)| The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system | UTAUT    | Venkatesh et al. (2003)  |
| Attitude towards using (AT)| An individual positive or negative feelings or appraisal about using technology | TRA      | Ajzen and Fishbein (1975) |
| Cost tolerance (CT)       | The willingness to afford the costs on specific products or services through considering one’s income and measuring the value of the product/service | STAM     | Chen and Chan (2014)     |
| Awareness (AW)            | The degree to which users are cognizant of the existing new technology its benefits and drawbacks and can keep track of updates on new technologies | TRA      | Ajzen and Fishbein (1975) |
TAM is widely used to explain the adoption process of technology (Lee, Cheung, & Chen, 2005). In renewable energy sector (Alam et al., 2014; Kardooni, Yusoff, & Kari, 2016), in commerce (Gefen, Karahanna, & Straub, 2003; Wu & Chen, 2005), in ICT organizations (Hsu & Lu, 2004; Van Der Heijden, 2000; Yang, Cai, Zhou, & Zhou, 2005), in healthcare field (Kuo, Liu, & Ma, 2013; Sezgin & Özkan-Yıldırım, 2015) and education fields (Al-Gahtani, 2016; Persico, Manca, & Pozzi, 2014).

From all the theoretical models mentioned above, a series of determinants were found for the adoption of SWP technology such as PU, PEOU, BI, FC, Awareness and CT. Table 1 shows model constructs and their definition.

2.1. PU and PEOU
The two constructs common in TAM, TAM 2, TAM 3 and STAM are PU and PEOU. PU can be defined as “The degree to which a person believes that using a particular system would enhance his/her job performance” (Davis, 1989). It is suggested by TAM that people will form a BI in which they have a positive attitude (AT) and will enhance their job performance. Similarly, PEOU is defined as “The degree to which a person believes that using a particular system would be free of effort” (Davis, 1989). It is hypothesized that PEOU has a significant effect on attitude, mainly based on intrinsic motivation, therefore easier the system the greater would be the perceived control.

The hypotheses related to factors PU, PEOU and AT in the proposed SWP model were developed as follows:

Hypothesis 1: PU will positively influence attitude toward using (AT) SWP.

Hypothesis 2: PEOU will positively influence attitude (AT) toward using SWP, and PU.

2.2. Facilitating conditions
This construct is taken from the UTAUT (Venkatesh et al., 2003). It is defined as “The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system” (Venkatesh et al., 2003). This construct is used to measure the perception of an individual to support his behavior. In Pakistan, low income, less education and lack of expertise among rural farmers are the major factors that hinder the development of advanced agricultural technology.

The facilitating condition (FC) in UTAUT has a direct influence on the actual acceptance of SWP technology. In the study area, the majority of the farmers was illiterate and had limited learning opportunities. Therefore, facilitating condition may be an optimal solution to promote the acceptance of SWP technology in northern Pakistan. Therefore, the possible solution to promote acceptance of SWP may be resource and technology availability. The hypothesized relations to FC in this study are;

Hypothesis 3: FC will influence PU positively.

Hypothesis 4: FC will influence PEOU positively.

2.3. Cost tolerance
Socio-economic status is considered important in acceptance of new technology as evident from several studies (Bina & Giaglis, 2005; Ho & Kwok, 2002). Chen and Chan (2014) proposed a model named “Senior Technology Acceptance Model (STAM)”. In this model, they indicated that economic factor was a crucial one for the acceptance of Gerontechnology among senior Chinese of Hong Kong. With respect to the economic status of Pakistan, the per capita income (e.g. $1512) is lower as compared to other developing countries, especially the rural farmers in northern part of Pakistan are the poorest segment of the society. They are greatly concerned with the cost of new technology or service and they need to think twice before making any decision that involves an investment of money.
In this research (CT) is used to determine the intention of the rural farmer when using SWP technology. The hypotheses related to CT is formulated as follows:

Hypothesis 5: CT has a positive effect on SWP acceptance, the higher the CT the higher will be the degree of PEOU.

Hypothesis 6: CT has a positive effect on SWP acceptance, the higher the CT the higher will be the degree of PU.

2.4. Awareness
Awareness is found to be one of the primary factors in technology acceptance by several studies (Ajzen & Fishbein, 1975; Zografakis et al., 2010). It is defined as “the degree to which users are cognizant of the existing new technology its benefits and drawbacks and can keep track of updates on new technologies”. Information gap plays a crucial role in new technology acceptance (Wüstenhagen, Wolsink, & Bürer, 2007; Zografakis et al., 2010). Effective marketing strategies are needed to stream useful information to end users and this information helps them to make informed decisions (Mirza, Ahmad, Harijan, & Majeed, 2009). It is wrong to assume that all products will sell themselves. Therefore, the hypotheses related to awareness is formulated as follows.

Hypothesis 7: Awareness positively influences PEOU.

Hypothesis 8: Awareness positively influences PU.

3. Methodology

3.1. Research design
In order to determine the important constructs in the solar water pump acceptance model for the rural farmer (SWPAMRF) a quantitative method with the structured questionnaire was applied. According to Newsted, Huff, and Munro (1998), the methodology for data collection, i.e. survey questionnaire was deemed appropriate and it is argued to be the most popular method utilized by the information system (IS) research community. As an empirical investigation, we developed sophisticated measurement tools to test the newly proposed theoretical model for predicting SWP technology acceptance by the rural farmers. The data was collected through a structured questionnaire by face-to-face interview to ensure accuracy and quality of the study. Moreover, questions of the survey were orally translated to farmers because of the lack of education among the farmer’s community.

3.2. Measurements
The questionnaire collected three pieces of information, (1) Demographic characteristics of the farmers; (2) exploration of the developed constructs in this study such as (AT, PU, PEOU, AW, FC, CT); (3) information related to environmental issues. Two different measurement scales were used nominal and ordinal. For the demographic information, the nominal scale was utilized, SPSS was employed for its analysis, while a 7-point Likert scale is used to determine respondent’s acceptance towards SWP, AMOS software would be used to identify the factors influencing the acceptance of SWP technology. According to Cox (1980), a researcher can use scale points between five and nine depending on the situation and purpose of the study. In this study, a 7-point scale is adopted because it is used and validated by many previous studies (Arning & Ziefle, 2007; Park, Han, Kim, Cho, & Park, 2013; Venkatesh et al., 2003). Moreover, it will also reduce the bias in responses. The 7-point scale in the questionnaire was defined as; “1” means “strongly disagree”, “2” “disagree”, “3” “somewhat disagree”, “4” “neither agree nor disagree”, “5” “somewhat agree”, “6” “Agree”, and “7” “strongly agree”. All of the items in the questionnaire were taken from previous studies to measure the variables.
3.3. Sampling and procedures
As the nature of the study is quantitative, simple random sampling technique was utilized to collect data. The data were collected from three regions (Zalamkot, Seray, and Perana) in northern areas of Khyber Pakhtunkhwa, Pakistan. The method of simple random sampling is an appropriate technique in this study because it is an unbiased survey technique, the average size of the sample can accurately represent the population, free from classification error, easy to conduct and suitable for situations where limited information is available about population. Moreover, cost and convenience of obtaining the desired sample size were also considered.

Initially, a pilot study was conducted on 30 farmers to check the validity of the items present in the questionnaire and identify potential problems in the wording and design of questions. The questionnaire was administered through a face-to-face interview method. To get a representative sample size, 450 farmers were interviewed. For the sample size determination, numerous studies such as Anderson and Gerbing (1988) stated that 100 to 150 respondents is the minimum sample size to get a satisfactory result while using SEM. Others recommend 400 respondents (Boomsma, 1982, 1983). As we went through the literature, it was found that many of the studies used sample size between 250 and 500 respondents.

3.4. Data analysis method (SEM)
The method of structural equation modeling (SEM) was employed utilizing Maximum likelihood method with AMOS 20. SEM is utilized because of its ability to investigate the relationship between latent (unobserved) and indicators (observed) variables (Bollen, 1989). The descriptive data was analyzed by using SPSS 16. The data was screened with the help of SPSS prior to performing SEM. According to Hair, Black, Babin, and Anderson (2010) SEM is a very useful technique that can test theoretical relationships, measurement models and can help explain multiple relationships. The SEM method is a multivariate statistical technique that is often utilized to confirm causal relationships among latent variables. The hypotheses of the study were tested with SEM by using AMOS 20 (Analysis of Moment Structures). The analysis consists of four steps, data coding, confirmatory factor analysis (CFA), model fit testing, and path analysis. The data coding is necessary to help in data entry and analysis. The measurement model was assessed by CFA that shows the relationship between measured variables and theoretical constructs. For model fit determination, different indices were used including $\chi^2$ value, $\chi^2$ to its degree of freedom ($c^2/df$), Root mean square error of approximation (RMSEA), Tucker-Lewis index (TLI), the goodness of fit index (GFI) and comparative fit index (CFI). Path analysis was utilized to evaluate the study’s hypotheses and to test the proposed structural model paths. The reliability statistics were calculated using Cronbach’s alpha.

4. Results and discussion
4.1. Demographic characteristic of the survey respondents
The respondent’s demographic characteristics are shown in Table 2. Most of the respondents (86.9%) were male and only 13.1% were female. The fact behind this is, in the northern area of Pakistan i.e. in Malakand Khyber Pakhtunkhwa, farming is considered solely a male business and females are not allowed to work in the fields openly with men, although some older women do work in remote areas, but their contribution to agricultural productivity is far less compared to males. In respect of age, most of the respondents fall in the age category of 40–49, approximately 42%. Joint family system prevailed in the area and around 70% of the respondents were living together with families, while only 30% were living alone. The situation of the areas with respect to education is not very impressive, nearly 53% of the respondents were illiterate and about 32% had only primary schooling. In addition, most of the farmers were poor (i.e. 45%) and their monthly income was between 20,000 and 30,000 Pakistani Rupees (PKR). Moreover, approximately, 86% of the farmers were married and about 81% were working full time although some also worked off-farm (18%). And lastly, the majority of the farmers (85%) were experienced farmers having farming experience of 10 years and above. The data was collected from rural areas of Malakand i.e. Zalamkot, Seray, and Perana.
Table 2. Demographic characteristic of the respondents

| Demographics          | Frequency | Valid percentage |
|-----------------------|-----------|------------------|
| **Gender**            |           |                  |
| Male                  | 391       | 86.9             |
| Female                | 59        | 13.1             |
| **Age**               |           |                  |
| 18–29                 | 38        | 8.4              |
| 30–39                 | 102       | 22.7             |
| 40–49                 | 192       | 42.7             |
| 50–59                 | 109       | 24.2             |
| 60 & above            | 9         | 2                |
| **Living arrangement**|           |                  |
| With family           | 316       | 70.2             |
| Alone                 | 134       | 29.8             |
| **Education**         |           |                  |
| Illiterate            | 240       | 53.3             |
| Primary               | 148       | 32.9             |
| High school           | 52        | 11.6             |
| College               | 6         | 1.3              |
| Graduate              | 4         | 0.9              |
| **Monthly income**    |           |                  |
| 10,000 & below        | 53        | 11.8             |
| 10,001–20,000         | 113       | 25.1             |
| 20,001–30,000         | 136       | 30.2             |
| 30,001–40,000         | 65        | 14.4             |
| 40,001–50,000         | 39        | 8.7              |
| 50,000 & above        | 44        | 9.8              |
| **Marital status**    |           |                  |
| Single                | 64        | 14.2             |
| Married               | 386       | 85.8             |
| **Work status**       |           |                  |
| Full time             | 368       | 81.8             |
| Part time             | 82        | 18.2             |
| **Off-farm work**     |           |                  |
| Yes                   | 81        | 18               |
| No                    | 369       | 82               |
| **Economic status**   |           |                  |
| Rich                  | 25        | 5.6              |
| Average               | 131       | 29.1             |
| Poor                  | 205       | 45.6             |
| Very poor             | 89        | 19.8             |
| **Farming experience**|           |                  |
| 1–3 years             | 11        | 2.4              |
| 4–6 years             | 21        | 4.7              |
| 7–9 years             | 32        | 7.1              |
| Above 10 years        | 386       | 85.8             |
4.2. Normality of the data
In SEM analysis, normality is one of the important assumptions. It means that the data should be normally distributed around the mean with no skewness or kurtosis. According to Tabachnick and Fidell (2001), it means all the variables have to be normally distributed, therefore, it is necessary to check and confirm this criterion well before analysis. To check for normality, the values of skewness and kurtosis were utilized. It is noted that absolute values of skewness should not be greater than 3 and kurtosis not greater than 10. The statistical software SPSS was applied on the data to find the skewness and kurtosis values. It was confirmed that both values skewness and kurtosis were well in range and there was no problem of normality. In addition, data was also checked for any missing values and it was confirmed that the data had not any missing values.

4.3. The assessment of measurement model
The SEM methodology is employed to find the determinants of SWP technology acceptance. The hypothesized model of this study consists of six constructs; Attitude towards SWP usage (AT), PEOU, PU, FC, CT and Awareness (AW). Before running the measurement model, it was deemed necessary to conduct a factor analysis such as exploratory factor analysis (EFA) to ensure the appropriateness of the items. At first, all the factors were extracted together, but there were either some cross loadings or low loadings. To avoid this problem, the constructs were entered two at a time and EFA was conducted, this fixed the issue of cross-loadings and finally finished with nice communalities and excellent pattern matrix. The numbers of factors extracted were fixed to six because it was proposed in the study. After this, CFA was conducted to check for measurement model fit as shown in Figure 2. In SEM analysis, the purpose is to check whether the data fits the model well or not? In other words to what extent does the data support the theoretical model. To determine the measurement model fit AMOS.20 was used. The various goodness of fit indices were utilized to examine the model fit. Hair, Bush, and Ortinau (2003) and Holmes-Smith, Coote, and Cunningham (2006) suggested using at
least three fit indices to obtain an overall picture of the model. This study also adopts those indices which are most commonly used in TAM research. These indices include, $\chi^2$ value, $\chi^2$ to its degrees of freedom, the GFI, CFI, TLI and the RMSEA. According to Hair, Anderson, Tatham, and Black (1995), the value of $\chi^2$ to its degrees of freedom indicates the model appropriateness. The GFI examines the amount of variance and co-variance together as pointed by Byrne (2012). The CFI compares the value of model covariance matrix to observed covariance. The RMSEA assists in correcting the tendency of the $\chi^2$ index to reject specified models. The value of $\chi^2$, $\chi^2$ to its degrees of freedom, GFI, CFI, TLI, and RMSEA were 266.976, 4.603, 0.926, 0.949, 0.920 and 0.090 respectively. All the fit indices suggest that data fits the theoretical model well (Hair et al., 2003).

The reliability and convergent validity of the measurement model are shown in Table 3. For the internal consistency of a psychometric test, Cronbach’s Alpha was calculated (Cronbach, 1951). According to Nunnally (1978) the minimum required level of Cronbach’s Alpha values is 0.70. All the values fulfill the minimum requirement while convergent validity measures the convergence between similar constructs. The factor loadings are deemed acceptable if the value is greater than 0.50 (Hair et al., 2010). As given in Table 3, all factor loadings were higher than the required level, which shows that all the factor loadings were significant. Therefore, the measurement model was deemed to achieve adequate convergent validity. In a nutshell, the appropriate level of model fit and adequate reliability and validity of the measurement model employs that the model in hand was appropriate for structural model analysis.

### 4.4. Assessment of the structural model

The next step in the analysis was the analysis of the structural model after the measurement model. The proposed hypothesized model was examined employing SEM with AMOS 20 as given in Figure 3. Various fit indices were used to assess the proposed structural model fit, such as $\chi^2$ (298.542), $\chi^2$ to its degrees of freedom (4.665), GFI (0.919), AGFI (0.867), CFI (0.943), TLI (0.918) and RMSEA (0.90). All the values of fit indices fall in the acceptance region (Brown, 2006; Hu & Bentler, 1999; Steiger, 2007), which shows that the proposed structural model adequately represented the hypothesized relationship. The result of the proposed structural model and hypotheses are given in Figure 3. In the theoretically proposed model, there were two kinds of constructs namely, exogenous constructs (i.e. FC, CT and awareness), and endogenous constructs (PEOU, PU, and attitude towards SWP usage). The results of the hypotheses testing are shown in Table 4. Seven hypotheses were accepted and one was rejected. The result indicates that PU has a positive and significant influence on using SWP.
technology ($\beta = 0.25, p < 0.001$) while PEOU had significantly positive effect on attitude ($\beta = 0.372, p < 0.001$). FC were found positive and insignificant on PU ($\beta = 0.099, p < 0.063$), significant and positive on PEOU ($\beta = 0.266, p < 0.001$). In terms of CT the effect was found significant and positive on PU ($\beta = 0.316, p < 0.001$) but were negative and insignificant on PEOU ($\beta = −0.052, p < 0.393$). The hypothesis that awareness positively influence PU and PEOU were supported and were found significant ($\beta = 0.368, p < 0.001$) and ($\beta = 0.33, p < 0.001$) respectively.

To the best of our knowledge, this is the first study to examine the influence of PU and PEOU on attitude towards SWP usage in the Pakistani context. The result indicates that both factors (PU and PEOU) were found important for the acceptance of SWP technology. This finding is in conformity with Liang and Yeh (2008), who argued that PU has proved to be an instrumental variable in explaining why most people adopt technology and due to this fact, the concept “has remained relatively unchanged since the inception of the research stream”. A similar conclusion was also found by Venkatesh et al. (2003) who supported that PU is an important factor in explaining the intention of the people who adopt technology. Han (2003) stressed the importance of PU when determining usage behavior of a technology. The similar result indicates that PEOU has significantly positive relationship towards usage of SWP technology. This result was expected because research in the past has shown that PEOU had a positive influence on new technology acceptance (Alam, Ali, & Mohd Jani, 2011; Loannou & Stephenson, 2010; Wiser & Pickle, 1997). It is argued that if PEOU was high then the acceptance of new technology would be higher. Moreover, the education level of the rural farmers is low so they would prefer simple technology that is easy to understand and operate. Therefore, to enhance the use and acceptance of SWP the suppliers and manufacturers need to provide consumer friendly products.

### Table 4. Hypotheses Testing of the SEM

| Hypothesis | Co-efficient | p-value | Results |
|------------|--------------|---------|---------|
| H1 AT ← PU | 0.25         | 0.001   | Supported |
| H2 AT ← PEOU | 0.372 | 0.001 | Supported |
| H3 PU ← FC | 0.099 | 0.063 | Supported |
| H4 PEOU ← FC | 0.266 | 0.001 | Supported |
| H5 PEOU ← CT | −0.052 | 0.393 | Not supported |
| H6 PU ← CT | 0.316 | 0.001 | Supported |
| H7 PEOU ← AW | 0.33 | 0.001 | Supported |
| H8 PU ← AW | 0.368 | 0.001 | Supported |
The result of the modeling indicated that the effect of FC on PU was positive and significant while FC on PEOU was also positive and significant. There can be one explanation for this. As this construct had been taken from the UTAUT put forward by Venkatesh et al. (2003). It is defined as “The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system”. As we know that in the northern area of Pakistan, most of the farmers are illiterate and do not have knowledge and access to modern tools & technology. If some new technology is introduced they need to be educated because they have no explicit knowledge of that technology. Moreover, there are no technical experts available to help them when they have some fault in their system, however, if there is someone, it is difficult to reach them due to infrastructural and communication problems. So it is necessary to provide them with suitable conditions which could lead to the acceptance of SWP technology and therefore, both the hypothesis was supported by the data.

Agricultural productivity in the study areas solely depends on rainwater and there is no alternative option available to rural farmers to irrigate their farms and is adversely affected in summer due to lack of water. However, in summer maximum solar radiation is available and the requirement of water can be met through the use of SWP. This is supported by literature as Hahn, Schmidt, Torres, and Torres (2000) argued that SWP is suitable for regions having high insolation level. For small scale irrigation purposes SWP is economically viable as compared to traditional pumps that are run on diesel (Abu-Aligh, 2011; Curtis, 2010; Eker, 2005). The majority of the farmers are smallholders and the acceptance can help conserve energy and mitigate climate changes. Similarly, in India, the SWP is gaining popularity and the acceptance rate is quite high among farmers from southern states, while other states are also in the process of implementing solar water pumping programs. The SWPs have great potential in providing water for small-scale irrigation and reduce environmental costs (Phuangpornpitak & Kumar, 2007; Purohit & Michaelowa, 2008). However, the initial cost of SWP is the main hindrance in its acceptance (Bhave, 1994; Hahn et al., 2000). PU was the most important factor and the hypothesis that Cost influence PU was supported, while the hypothesis for PEOU was not supported. There may be one possible explanation for that, in the study areas SWP had been installed with the help of an NGO who financed the major portion of investment while the owner of the land had to pay a minimum amount. However, this is not enough because the initial cost is high and the farmers are poor on average and are unable to pay the initial cost to install SWP technology.

Awareness is one of the most important factors in the adoption of a new technology (Garcia et al., 2008; Komendantova, Patt, Barras, & Battaglini, 2012; Rodrigues, Montañés, & Fueyo, 2010; Seyal & Rahim, 2006). This research adequately supports that the level of awareness had a positive influence on the intention towards the use of new technology. Both paths from awareness to PU and PEOU was supported and it was found that awareness had significant and positive effect on the SWP acceptance through the indirect effect of PU and PEOU. This result is in line with the perception of the people as both the paths are supported. This study is similar to Brohmann et al. (2007) they examine the factors that influence the acceptance of new and renewable energy technologies and concluded that public awareness plays a key role in technology acceptance. Devine-Wright (2005) also supported the importance of awareness in technology acceptance.

The majority of the people in the study area are poor and do not have access to other sources of employment, the availability of solar water pump can enhance their production and ultimately leads to higher income which would enhance their standard of living. This finding was supported by the literature. Burney, Woltering, Burke, Naylor, and Pasternak (2010) conducted a study in West Africa and concluded that the use of SWP for irrigation increases the income and nutritional intake of the household significantly. Similarly, Dhakal and Raut (2008) found that SWP was also very helpful in changing the lives of people. A project of PV water pumping was initiated by Group for rural infrastructure development Nepal (GRID Nepal) to supply water for agriculture as well as for drinking purposes to rural dwellers. The rural inhabitants were satisfied with the result because solar pumps
had provided them with clean drinking water and increased in agricultural productivity and hence improved their life standard.

5. Conclusion
This study proposed a technology acceptance framework to determine the factors that influence the acceptance of SWP technology in Malakand Pakistan. To achieve the desired objectives SEM was utilized on data collected from survey method through face to face interviews. This study examined SWPTAM for rural farmers based on TAM and UTAUT. Other factors such as CT, FC and awareness (AW) were incorporated due to low income and education of the rural farmers. This is the first study employing TAM in the context of Pakistan for the acceptance of SWP among rural farmers in northern Pakistan.

The study indicates that PU is an important factor influencing SWP usage. The factor PEOU was also found significant in determining the attitude of the rural farmers towards SWP usage. These results would be helpful in understanding the barriers that impede the acceptance of SWP. Similarly, results showed that awareness is also a crucial determinant of SWP usage. The policymakers need to pay attention to this. Therefore, this study has enhanced our understanding of the role of awareness in SWP usage in Malakand, Pakistan. It is anticipated that the adoption of SWP technology would increase the output of the farms and as well as the income of the rural farmers. This would lead to reduction of poverty and enhancing their living standard.

6. Recommendations
According to the aforementioned findings, some recommendations are put forward to encourage the rural farmers to use water pump

(1) Considering the low literacy rate prevailed in the areas, it is deemed necessary to arrange training programs for rural farmers and educate them about SWP usage.
(2) As indicated from the study most of the rural farmers are poor and do not have other employment opportunity, so the government, as well as the international non-governmental organizations (NGOs), need to provide financial assistance in installing the SWP.
(3) The rural farmers place a high value on credibility and trustworthiness of the system providers, the government needs to ensure this to enhance the acceptance of SWP technology.

7. Limitations of the study and future research
This is an empirical study and has certain limitations. First, the sample size consisted of the rural farmers in Zalamkot, Seray and Pirana areas of district Malakand which may not be representative for the entire region. To verify and generalize the findings, future studies need to focus on a more diversified and larger sample size. Second, regional diversity has not been taken into account; the data was collected only from one region having similar socio-economic and educational backgrounds due to monetary and time constraints. In addition, other behavioral factors should be incorporated in future research studies to better understand the factors that influence the acceptance of SWP. The authors are planning to conduct another study in the future when the adoption of SWP would have taken place. That paper would try to examine the impact of SWP technology on productivity, output and income of the rural farmers in northern area of Pakistan.

Supplementary material
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