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Unraveling Farmers' Purchasing Behavior of Solar Water Pumps Using the Theory of Planned Behavior

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Abstract.

India is an agricultural country with hottest temperature and moderate humidity, where it is believed that some states receive the maximum solar energy, one of them is the state of Rajasthan. The need for power has expanded over the past few decades' which is leading to significant increase in environmental degradation as even today, more than 70% of energy needs is fulfilled from fossil fuels. Higher dependence is resulting in higher cost and environmental degradation. Implementing solar pumps cannot only help us to overcome energy deficits but also increase agricultural productivity which help us to reduce pollution produced by thermal and diesel sources. The present study is based on first-hand information gathered from 498 farmers from five blocks of rural region of Rajasthan (India). To understand the factors influencing the behavior of farmers towards green technologies, theory of planned behavior model has been applied. Data were collected using questionnaire/schedules, the sample size was chosen using convenience sampling, and were then examined further using SPSS and AMOS. In order to understand the elements of the TPB model and predict farmers' behavioral intention towards adoption of solar water pumps, confirmatory factor analysis (CFA) and structural equation modelling (SEM) were applied in the study. The proposed research fills in the gap in the literature by performing an empirical study on farmer's adoption behavior and offering insight about variables influencing farmers purchase intention and behavior of farmers towards solar water pump. Results from the study will be more useful to the policy makers to design effective strategies in order to achieve energy sufficiency without adversely affecting the environment.

Keywords: carbon emission, agriculture, irrigation, solar water pump, TPB model, sustainable development.

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1. Introduction

India is an agricultural country with hottest temperature and moderate humidity, where it is believed that some states receive the maximum solar energy, one of them is the state of Rajasthan. The need for power has expanded over the past few decades' which is leading to significant increase in environmental degradation as even today, other than

70% of energy needs is fulfilled from fossil fuels. Higher dependence is resulting in higher cost & environmental degradation.

The way that governments respond to the twin issues of climate change and energy security will determine the long-term viability of the energy system. Coal and natural gas, two fossil fuels, will continue to be the predominant energy sources until 2030 and beyond [1]. The world's most plentiful energy source is solar energy. In addition to being a solution to the current energy issue, solar power is also a clean source of energy. Solar energy may be used effectively through photovoltaic generating[2]. In light of the fact that the consumer owns his power generation, solar systems appear to be useful. The importance of solar energy is highlighted by its usage in overflow irrigation, municipal water delivery, drip irrigation, and fish and poultry production [3]. India has 26 million groundwater pump sets that are powered mostly by diesel generators or electricity produced primarily in coal-fired power plants. Agriculture-related irrigation pumps require 12% of India's entire fuel usage, or more than 4 billion liters of diesel, and roughly 25% of the country's total energy, or 85 million tons of coal yearly [4]. Rajasthan has a lot of solar energy potential. Solar energy is appealing because it is plentiful and provides an alternative to fossil fuels, which provide the second-highest quantity of solar radiation in the globe with 325 bright days' year and 6-6.4 kwh/m2/sun radiation daily [5]. Implementing solar pumps cannot only help us to overcome energy deficits but also increase agricultural productivity which help us to reduce pollution produced by thermal and diesel sources.

2. Literature Review with Hypothetical Frame Work

One of the most polluted nations on the planet, India has some of the worst air quality in the world. Today's rapidly growing cities face significant challenges from air pollution and climate change [6]. Renewable energy is an excellent alternative in the situation since it may be employed as a standalone distributed generation system [7]. In 1992, the Ministry of New and Renewable Energy (MNRE) of the Government of India launched the Solar Pumping Program(MNRE). In Rajasthan, a solar pump irrigation programme was launched in 2010 with an 86% subsidy [8]. In Rajasthan, this percentage has recently decreased from 86 to 60 percent, according to a Ministry of New and Renewable Energy data.

Farmers who are producing crops for horticulture or agriculture and taking advantage of several initiatives for horticulture or agriculture under one roof are provided solar pumps [9]. The government is therefore making a lot of effort to close the hole left by

the recession. In order to control the factors that affect farmers' purchasing decisions, several research studies have been carried out. Farmers' understanding of solar energy products is vital in this regard. The two states with the most SWP installations in India were Andhra Pradesh and Chhattisgarhi. Rajasthan has a lot of solar energy potential; however, it ranks fourth in India. Very few studies have been carried out in Rajasthan, especially in rural areas [10]. Farmer procurement behavior is very important in this regard. It turns out that people who are concerned about the environment are willing to pay a higher price for using renewable energy than other people who are not as concerned. Theory of Rational Action, Theory of Planned Behavior, and the Health Belief Model are just a few of the ideas that emphasize human normal and health behavior [11]. Cost plays a crucial role in the decision to buy [12]. The study revealed that consumer price consciousness, buyer-seller relationships, and customer service all have a significant impact on the decision to acquire Butter Oil Substitute in the coffee roasting business [13].

2.1. TPB: Identifying Construct to incorporate into TPB

The theory of planned behavior is regarded as a deep-rooted postulator framework that offers empirical support to understand the cognitive determinants of consumer behavior [14]. According to the TPB model, subjective norm (SN), perceived behavioral control (PBC), and attitude toward the behavior are the three psychological factors that have the greatest influence on an individual's intention to act [15]. The awareness variable, which has optimistic 390 impact on intention to use RES, has a considerable impact on that intention [16]. The degree to which a person is conscious of environmental issues, supports attempts to solve them, or expresses a enthusiasm to individually contribute to give solutions can all be characterized as environmental concern [17].

2.1.1. Attitude

An individual's attitude is their assessment of a particular conduct and the results they anticipate from it [18]. The individual element that denotes a person's favorable or unfavorable feelings about the conduct is known as attitude toward the behavior. The behavioral ideas about these expected results and the evaluations of these expected outcomes are the purpose of Attitude toward Behavior [19]. The findings addressing farmers' attitudes about Photovoltaic Water Pumping System (PWPS) irrigation indicated that the majority of respondents had a favorable and positive attitude toward PWPS.

Both adopted and non-adopted responders recognize the significance of PWPS, which involves a one-time investment, no fuel demand, and superior technology to the electricity / diesel water pumping system [20].

H1: There is significant relationship between attitude and intention towards adoption of solar water pumps.

2.1.2. Moral Obligation

As a result, many research has attempted to enhance the theory's capacity to be interpreted by including additional variables in the TPB model. It has been proven that moral obligation (MO) can significantly improve the prediction of desire to act ethically [21]. Moral norms are the perceived moral duty or obligation to perform or refrain from performing a particular task, and they signify a person's conviction that a particular course of action is basically proper or bad. In studies on energy-saving behavior, moral standards have been utilized to extend the TPB, and the addition of the construct has boosted the theory's explanatory power [17].

H2: There is significant relationship between moral obligation and intention towards adoption of solar water pumps.

2.1.3. Knowledge of Eco-Friendly Product

An emerging idea in environmental marketing, eco-labels are a crucial source of knowledge for customers looking to buy ecologically responsible goods. Eco-labels offer details about goods that are less harmful to the environment and are a reliable way to build customer confidence in eco- friendly goods. Centered on the results of earlier studies on consumer awareness of eco-labels, it may remain concluded that consumer awareness of eco-labels influences attitudes toward and trust in energy-efficient appliances [22]. According to the literature, as one's educational level rises, so does one's understanding of environmentally friendly items. There is also a considerable relationship between knowledge of eco-friendly product. The complicated interrelationship between these two components is widely recognized, with local farmers' understanding of the environment, plants, soils, and biological processes frequently largely relying on sustainable biodiversity management. One area of agricultural production where this interplay has enormous practical benefit is in the arena of environmentally friendly products [23].

H3: There is significant relationship between knowledge of eco-friendly product and intention toward adoption of Solar water pumps.

2.1.4. Government Initiatives

Government programs Government support, subsidies, and financial assistance are used to describe government activities in any nation and they government subsidies have a favorable impact on the sales of renewable energy products [10]. The major findings show that in order to properly design and successfully implement government initiatives, policymakers and manufacturers of green energy appliances should consider determinants such as attitude, social influence, and purchase preferences (incentives/subsidized price) to encourage pro- environmental behavior [24].

H4: There is significant relationship between government initiatives and behavior towards adoption of solar water pumps.

3. Methodology

The theories of planned behavior model have been formulated by researchers to explain behaviors of individuals towards adoption of solar water pump. This is because individuals show various attitudes towards adoption of solar water pump. TPB model with seven factors (attitude, subjective norm, perceived behavioral control, intention, and government initiatives, among others) [25]. All components were evaluated using a five-point Likert scale, with the range being strongly disagree (1) to strongly agree (5), with the exception of demographic variables and existing established scales. A number of items were modified to meet the current research setting after being drawn from earlier studies. This study looked at ten different parameters, as shown in Figure 1.

The Amos 26 program was used to carry out the SEM study. The basic data used in this study were collected through survey responses using a factor analysis questionnaire. The sample scope for this study was 498 farmers from the five blocks of (Mauzamabad, Chaksu, Phulera, Phagi, and Jamwaramgarh) in the Jaipur district of Rajasthan. This study included 52 observable variables and 10 latent variables. Seven variables that failed the validity and reliability tests were deleted, leaving the remaining variables to be monitored. The 45 variables are indicators of 10 created latent variables.

4. Results & Discussion

1. (a) Reliability & Validity Check

Both a validity and reliability check were performed on the instrument employed before investigating the data to check the hypothesis. Reliability and validity checks were carried out using the AMOS and SPSS softwear [26].

TABLE 1: Constructs Cronbach Alpha Value.

S. No.	Construct	Abbreviation	Cronbach Alpha
1	Awareness	A	.93
2	Government Initiatives	GI	.95
3	Environmental Concern	EC	.94
4	Purchase Intention	PI	.74
5	Knowledge of Eco-friendly Product	KEP	.94
6	Moral Obligation	MO	.93
7	Attitude	AT	.94
8	Subjective Norm	SN	.95
9	Perceived Behavioral Control	PBC	.82
10	Perceived Cost	PC	.74
11	Availability of Substitute	SUA	.94
12	Purchase Behavior	PB	.94
13	All over Reliability	-	.93

A reliability metric called Cronbach's alpha is used to evaluate the dependability of survey instruments with Likert-type response sets. Higher values imply better reliability. Cronbach's alpha is a measure of dependability that spans from 0 to 1. The definition of an appropriate Cronbach's alpha factor is a topic of controversy in the literature, however to be on the safe side, an alpha coefficient of less than.7 should raise red flags. All Cronbach alpha values, however, are more significant and trustworthy, as shown in table 1

By computing the discriminant validity correlation indicator for each item (i.e., variable) and comparing the statistic with the correlation table value for n=498 at a significance level of = 0.05, the questionnaire items' validity was tested. Table 2 in the section below shows the outcome. MSV<AVE then the statistics meets the Discriminant Validity (Hair et al., 2011). The results of the current study's determination of the CR and AVE, MSV of each individual construct are displayed in table 1. It can be shown from table that all of the constructions meet the requirements for validity.

Table 2: AVE, CR and Discriminant Validity.

	CR	AV E	MS V	SU A	PB	PI	A	GI	EC	KE P	MO	AT	SN	PB C	PC
SU A	0.946	0.853	**0.461**	**0.924**											
PB	0.989	0.968	0.243	0.370	**0.984**										
PI	0.945	0.812	0.507	0.407	0.104	**0.901**									
A	0.901	0.699	0.548	0.547	0.410	0.532	**0.836**								
GI	0.963	0.839	0.448	0.485	0.309	0.543	0.660	**0.916**							
EC	0.948	0.822	0.402	0.506	0.317	0.480	0.561	0.615	**0.907**						
KE P	0.981	0.912	0.662	0.542	0.350	0.678	0.694	0.641	0.634	**0.955**					
M O	0.940	0.797	0.663	0.564	0.419	0.712	0.694	0.669	0.596	0.814	**0.893**				
AT	0.976	0.932	0.596	0.531	0.407	0.614	0.640	0.580	0.522	0.644	0.772	**0.966**			
SN	0.976	0.909	0.612	0.570	0.372	0.607	0.611	0.586	0.513	0.687	0.782	0.711	**0.954**		
PBC	0.883	0.667	0.563	0.567	0.433	0.551	0.617	0.591	0.536	0.680	0.750	0.662	0.690	**0.817**	
PC	0.813	0.618	0.596	0.679	0.493	0.569	0.740	0.608	0.562	0.702	0.772	0.716	0.705	0.694	**0.786**

The route diagram shown in Figure 1 demonstrates the relationships between latent variables and dependent variables. The ”Farmers adoption toward solar water pumps” (Intention) is represented by endogenous latent factors, exogenous latent variable Government Initiatives represents “the farmer’s behavior after the government efforts”(GI).

4.1. Goodness of Fit Estimation

We initially performed a CFA on the items of the 12 main variables to determine the discriminant validity. In the twelve-factor model, all items loaded on their intended constructs, and the results revealed strong fit. The findings of the goodness of fit test to the predictable model are presented in Table 3. Since CMIN value should be <3 is significand, the P value is significant at 0.05, the model fitting appears to be good. The RMSEA is 0.075, which suggests a satisfactory match because it is in the range of 0.05 and 0.08. Again indicating a strong match, the NFI and CFI are bigger than 0.9. AGFI and GFI values smaller than 0.9 but bigger than 0.5 which reflect that marginally good fit. Over all estimation of SEM model have passed the test of good fit model.

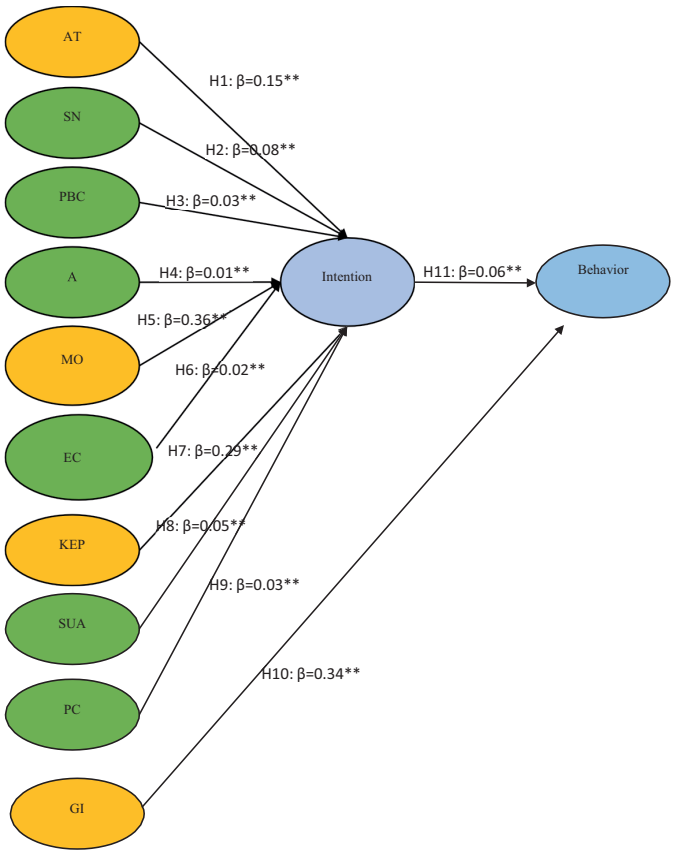

Figure 1: Model Specification.

TABLE 3: CFA Model Fit Values.

	Model						
DMIN/df	P Value	GFI	AGFI	NFI	CFI	RMSEA	P CLOSE
2.71	.000	.778	.775	.907	.931	.075	.000

4.2. Verification of SEM Relationship between the Construct

1. (a) i. To assess if the hypothesized routes are significant or not, the output of the hypothesis path's standardized regression weights are compared against the p-value. Table 4 illustrates the relationship between independent and dependent variables in relation to the hypothesis. By using the P value, every hypothesis has been categorized as either significant or not. The results show that the proposed model is consistent with the gathered sample data. As demonstrated by the standardized regression weight of 0.152 with a p value of 0, which is less than 0.05, attitude positively effects purchase intention. It is consistent with the results of earlier study. It demonstrates that attitudes do affect farmers' decisions to adopt solar water pumps.

ii. Moral obligation has a standardized regression weight of 0.363 and a p value of 0, which is less than 0.05, it positively predicts purchase intention. It is consistent with the results

of earlier study. It demonstrates that farmers' intentions to adoption of solar water pumps are influenced by their moral obligations.

1. (a) i. Government initiatives have a positive impact on intention since their standardized regression weight, which is 0.348 and has a p value less than 0.05, is 0. It is consistent with the results of earlier study. It demonstrates how government policies have an impact on farmers' Purchase behaviour of solar water pumps.

Table 4: Structural Model Results.

			Estimate	S.E.	C.R.	P
Intention	<—	Availability of Substitute	-0.05	0.054	-1.021	0.307
Intention	<—	Perceived Behavior Control	-0.032	0.048	-0.562	0.574
Intention	<—	Subjective Norm	0.082	0.055	1.411	0.158
Intention	<—	Attitude	0.152	0.056	2.666	0.008
Intention	<—	Moral Obligation	0.363	0.083	4.238	***
Intention	<—	Perceived Cost	-0.033	0.072	-0.441	0.66
Intention	<—	Knowledge of Eco Friendly Products	0.292	0.075	4.506	***
Intention	<—	Environmental Concern	0.024	0.055	0.53	0.596
Intention	<—	Awareness	-0.012	0.048	-0.218	0.827
Behavior	<—	Intention	-0.069	0.079	-1.346	0.178
Behavior	<—	Annual Income from Farming	0.068	0	1.589	0.112
Behavior	<—	Government Initiatives	0.348	0.075	6.748	***

5. Conclusion

Extensive literature is available on the adoption of green technologies world wide. But limited studies, especially related to farmer's behavior has been carried out in Indian context. Hence one of the significant contribution is understanding the key factors influencing the behavior of farmers

in the adoption of solar water pumps. It is already explained in previous studies that attitude, knowledge, Moral obligation, Social influence will positively influence the behavior of individual and the present study has also proved it in the context of Indian

farmers. Moral obligation among farmers and attitude towards green technologies can go a long way in the process of energy transition as it influences the intention of farmers. But the present study has found that Government policy has no impact on intention of farmers but directly influences the purchase behavior of farmers In Rajasthan's rural areas, the social acceptance of renewable energy is still not very encouraging. It is therefore clear from the study that adoption of Solar water pump plays a vital role in fighting battle against unemployment, Power deficit, Poverty and Environment degradation just by making the farmers adopt solar water pumps in their day today life. This in turn would help farmers to reduce the cost of production and improve their standard of living. But such changes may not be possible without government intervention and public policy. It is also observed that more than one lakh of application for solar pumps are kept pending by the government. Our study therefore, provides effective policy suggestion to achieve the above said objectives.

6. Limitation and Future Scope:

Our study has certain limitations in terms of sample size and geographical area. The study can be extended further to various states of India to know the factors influencing the adoption of solar water pumps. Inclusion of other variables influencing the intention and behavior of individuals can also be included to have better insights.

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