

Factors Affecting Farmer's Decision of Adoption of Solar Powered Pumps

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Abstract: The power poverty as well as increase in fuel price impact the water provision to agricultural demand. Use of solar power for pumping of water is a hopeful discretion to current electric and fuel-based pumping technique. Solar powered pumps convert solar energy into electrical energy by using photo-voltaic technique. Solar powered technology gives a better solution to the farmers to rapid develop and self-dependent develop private off grid electricity generation technique. The benefit of solar water pumps is reducing a pollution and maintain clean environment. Indian government promoting this technology for farmers with different finance and subsidy schemes. The present research uses factor analysis to determine factors affecting farmers decision of adoption of solar powered pumps. By using the questionnaire survey was done through the Indian farmers. The study considered six important factors such as setup cost, beneficial scheme for product, resource availability, knowledge, Permanence and local environment. In addition, the study provides the various variables that impact on these factors. The main focus of the study on six determined factors compared to other factors such as quality of product, new technology, advertising and marketing, maintenance cost, availability, weather conditions, ease of installation which have less impact on decision of adoption of solar powered pumps.

Keywords: photo- voltaic technology, adoption of solar powered pumps, Indian farmers

1. Introduction-

The India is on the development path but to manage an impulse of progression highly, availability of continual power provision is needed. Every industry like manufacturing, education, agriculture and healthcare is highly depends on the electricity and fuel. There are numerous barricades to unlock the complete potentiality of India's power sector. Fuel availability is the major problem faced by every sector. Coal India ltd bounded the supply of coal to coal based thermal power plant, due to this rise reliance on outsourced coal. Hence power

generation cost increases. Indian agricultural sectors energy demand is approximately 20 percent of the total demand and 85 million tons of coal and nearly 4 billion liters of diesel is expending by agricultural sector in the form of fuel for fuel-operated water pumps (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019). Improper electric supply and high cost of electricity is challenging situation for farmers, leading in coarse irrigation. If a proper amount of water for irrigation is available as to when needed then it can be improving, 10 percent yield of crop (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019). The variation between electricity demand and supply probably rise in future. Solar energy has started playing a very peremptory role in reducing the use of fossil fuels. Solar powered based water pump for irrigation has been put foster as a part of confirmable energy portfolio for every country. In every country use of solar technology is started spreading and from 2010, the world has observed increase in solar energy system, capacity initiate as compare to previous four decades(Alvar Closas & Edwin Rap, 2017).

The main aim of solar powered pump is to raise the agricultural productivity by safe access to groundwater resources for farmers. In rural areas of India, there is vast opportunity for untapped solar off grid, give wide scope for providing a power and ability to take a place of the fossil fuel resources (Alvar Closas & Edwin Rap, 2017) (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019). In 1960's and 1970's solar pumping was previously used, but because of the high cost its expansion was restricted to little size(Alvar Closas & Edwin Rap, 2017). The ministry of new and renewable energy (MNRE) of the government of India was introduced a solar pumping program in the year 1992. Under the Jawaharlal Nehru National Solar Mission (JNNSM) around 0.147 million solar water pump has been installed in country till December 2017, still it is extremely small as compared to the around 30 million fuel and electric pumps presently initiate in the India. In past three years around more than 70% of solar powered pumps had been installed. At current for solar powered pump MNRE give 30% of capital subsidy to farmer. Whereas the 50-70% cost offer by the state government and remaining part of the amount has to be paid by farmers (Gupta, 2019).

Solar power has a keen ability to matchup the required energy needs with environmental safety and decreasing of pollution. Basic advantage of solar system is, consumers are the owner of their own power production. For drip irrigation, flood irrigation, residential water supply, poultry and fish farming solar energy product uses. Benefits such a no monthly electricity bills and cost of fuel makes a solar energy system more durable and secure. Solar energy is suitable for all geographical locations. It's also provides employment opportunity and decreasing the degradation of environment(Amanjot Singh Syan and Vikas Kumar & Hundal, 2019). The main aim of the paper is to determine and analyze a factor affecting farmer's decision of adoption of solar powered pump.

1.1 Initiative by Indian government

India's second largest populated and area wise state is Maharashtra. It consumes 12 percent of India's electricity (Rajesh V. Kale & Sanjay D. Pohekar, 2012). Indian agriculture farms have 26 million traditional pumps this all are operated by consuming diesel and electricity but shortage of power and raise in fuel prices mainly influence the agriculture production and irrigation system. Hence to save the electricity and diesel, subsidies given by the government to farmer for

adoption of solar powered pumps (S.S. Chandel, M. Nagaraju Naik, & Rahul Chandel, 2015). Basic initiative taken by the government represents in terms of subsidies, support and financial help. Government subsidies positively impact the solar energy product sale. The main intension behind to provide subsidies is to promote solar energy product and aware the people about environmental effect. It is required to there should be a large advertisement to illuminate capable customers regarding the government schemes, policies and subsidies (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019).

The main aim is to accelerate crop production and decrease reliance on fuel for agriculture in the states like Tamil Nadu, Andhra Pradesh, Rajasthan, Uttar Pradesh, Maharashtra, Chhattisgarh, Madhya Pradesh, Bihar, Punjab and Himachal Pradesh. Different guidelines provided by the Indian government to the solar panel manufacturer as per international standard to assure outcomes quality (S.S. Chandel, M. Nagaraju Naik, & Rahul Chandel, 2015).

1.2 Working principle of solar power pump

Solar water pumping basically generates the power by using solar photovoltaic system. It converts the sunlight into the electricity to lift the water. Motor (A/C or D/C) connected to the photovoltaic panel. Motor converts the electricenergy provided by photovoltaic panel into mechanical energy and this mechanical energy is converted by the pump into the hydraulic energy.

1.3 Needs of solar powered pumps

Each and every human being is needed water for surviving. Agriculture required large scale of water for irrigation. Since a long time, water pump has been using for irrigation purpose. Basically, water pumps work on electricity or fuel and electricity is produced by using traditional fuels; electricity has been supplied from the national grids (Riya Rachel Mohan, 2018)(Mansur Aliyu, et al., 2018). Burning of the fossil fuels negatively impact on the environment. Many of the geographical locations where electricity does not available and there is the more requirement of water but solar power intensity is high in such a location. Heavily reliance on up on fossil fuels, the country is fourth rank in terms of emission of greenhouse gas (Sapan Thapar & Seema Sharma, 2020). The main problem in rural area is a load shedding, due to high load shedding problem it impacts on crop yield. To avoid the production losses and to increase the productivity it is required that agriculture sector adopt the solar powered pumps (Mansur Aliyu, et al., 2018). Solar powered pumps are proven technology for farmers for irrigation purpose. The mass growth in the photovoltaic industry decrease the price of photovoltaic modules and hence the price of pumps also reduced (Md. Nazmul Islam Sarkar & Himanghshu Ranjan Ghosh, 2017).

1.4 Advantages of solar powered pumps

Basically, solar powered pump is the reliable source of energy for irrigation water in remote places that are not joined to electricity grid or place with lack of supply of fuel and maintenance service.

Accessibility of water can improve with the help of solar powered pumps (Hans Hartung, & Lucie Pluschke). Solar powered pump also increases, stabilize and diversified production. It is separate from volatile fuel prices and costly fuel supply. Solar powered pump has environmental advantages such as no greenhouse gas emission, less pollution as compared to diesel pump and general benefit is easy to install and minimum maintenance cost (Pushpendra Kumar Singh Rathore, Shyam Sunder Das, & Durg Singh Chauhan, 2018).

1.5 Disadvantages of solar powered pumps

Initial investment cost of the solar powered pump relatively high and it need creative subsidies to beat these barricades to adoption especially for small scale farmers. Some specialized knowledge or service infrastructure to assure that the system work and are maintained effectively. Poor management and regulation bear the risk of wasteful water use and groundwater over abstraction as low energy cost. Some toxins and rare minerals are required during the production of photovoltaic panel and production of these panel create environmentally dangerous scrap. It is required to carefully disposed of panel to avoid, surrounding damage (Pushpendra Kumar Singh Rathore, Shyam Sunder Das, & Durg Singh Chauhan, 2018) (Hans Hartung, & Lucie Pluschke).

2. Literature Review

India is very aggressive in its targets to promote renewable energy In India, renewable energy has started to play an increasingly important role in increasing grid power, providing access to energy, reducing the consumption of traditional fuels (Annual report 2019-20, 2019-2021). The other countries are watching India's transition to clean energy. Many are ready to support the growth of renewable energies, especially at the expense of coal (Tongia & Samantha Gross, 2018).

Solar powered pumps for agriculture sector is cost-competitive as compared to conventional small-scale water energy sources requirements for pumping. With the continuing rise in fossil fuels Cost and fall in solar cell peak watt costs due to mass production, the solar powered should be made more economical in the future. Water pumping systems operated by PV have Livestock and agricultural applications are becoming attractive in remote areas with restricted access to traditional electricity (S.S. Chandel, M. Nagaraju Naik, & Rahul Chandel, 2015).

One possible obstacle for the expansion and production of solar powered pumps in country poverty of information and awareness. A lack of awareness of emerging energy developments may be a deterrent to people dialogue and making decision on sustainable strategies. The majority of individuals remain unaware of the presence of solar irrigation. Crowd are not sure of the cost advantages, the environmental benefits, improved solar powered pump efficiency, and this adds to adverse views of solar powered pumps. This is largely attributed to a lack of knowledge and proximity to renewable sources of energy. Some farmers have awareness about the solar powered pumps are reluctant in investing this technology. The main reason is lack of information and resources. Hence the government should take some positive steps to create awareness in rural area about the solar powered pumps (Pushpendra Kumar Singh Rathore, Shyam Sunder Das, & Durg Singh Chauhan, 2018).

Solar powered pump has number of advantages as well as some disadvantages like initiation cost, maintenance cost and investment cost, this are very large but are occurred only at starting. And other is electricity generation at night is not possible to solar powered pump but battery backup provision resolves this problem (Vikas Kumar and Amanjot Singh Syan, Kaur, & Bikramjit Singh Hundal, 2019).And also if farmers do not receive subsidized electricity for irrigation, they get the electricity directly from the overhead lines without the need for a measurement. Unauthorized connections, uncollected bills are still in practice, making theft a problem of corruption as well as political interference (Mandhir Kumar Verma, V. Mukherjee, Vinod Kumar Yadav, & Santosh Ghosh, 2020).

The use of solar powered pumps helps to maintain the clean environment by reducing the pollutant. And also, utilization of solar powered pumps increases the farmland output (Mansur Aliyu, et al., 2018).

Solar powered technology gives a better solution to the farmers to rapid develop and self-dependent develop private off grid electricity generation technique. Off grid solar powered pumps for agriculture have been used for over 40 years. Hence this is not a totally new technology in agriculture still most of the farmers are not able to adopt this technology in their farm (Alvar Closas & Edwin Rap, 2017). Solar energy through a tracking system increases the pump productiveness to 79.4%. It is satisfying efficiency of the pump (Pavushetti Abhilash, Raghavan Nanda Kumar , & Raparathi Praveen Kumar, 2020).

In India there are very short number of researchers have analyzed different factor affecting the solar powered pump by using the primary data method (Sapan Thapar & Seema Sharma, 2020).

In Many publish paper it has been indicated, India has a large amount of solar resources as a result of geographical condition and locations. This large amount of resources provides the more elasticity to policy makers for the expansion of solar power in the country. The entire year large amount of solar energy creates it a feasible source to meet the energy requirement of the country (Gautam Raina & Sunanda Sinha, 2019).

In 2011 as per the survey performed by Bureau of Electrical Energy in India, there are almost 18 million pumps and 0.5 million new connection each annum is plant for irrigation purpose. Solar powered system implemented to water pumping systems is operated on the transformation of solar power into electrical energy by using the solar panels. For farmer solar powered system is a smart system and overcome the energy crisis (S. Senthil Kumar, et al., 2020).

The applicability of solar power for lifting water for irrigation of plants cannot be denied because of the interdependent between solar radiation and water demand of plants. The high intensity of the light, the more energy needed to provide irrigation water. In monsoon Irrigation is not feasible and also not necessary. The electricity supply has a maximum deficiency when the demand for irrigation is most(Prof.Mvon Oppen & Author links open overlay panelKiranChandwalker, 2001).

2.1 Research gap

To increase the awareness about use of solar pumps the ministry of new and renewable energy of India is backing the sales of solar pumps by providing financial subsidies and incentives. But still

farmers don't purchase solar powered pumps as lack of awareness by government in terms of subsidies and advantages of pumps. Therefore, government is filling these gaps by doing various awareness camps, advertisement, etc. Along with this various research studies are carried to study factors why farmers are not using SSP. But main outcome of so far research was the cost factor (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019).

3. Research Methodology

This study uses an appropriate sampling technique selected on the basis of sector and the objective of the study. After considering the factor that impact the farmers decision to adoption of solar powered pumps. After selecting the factor impact the farmers decision to adopt the solar powered pumps from available research work, the survey was conducted for the data collection from agricultural sector by using the questionnaire. A questionnaire was based on five-point Likert scale in it 1 indicate "Not Important" and 5 indicate "extremely important". This range of scale was considered because of easy in responding and also variety in data so it helps in data analysis. The questionnaire was answered by 250 farmers. The respondent was from the different district of Maharashtra such as Nashik, Pune, Kolhapur, Satara, Jalgaon, Solapur, Sanagli, Latur, Ahmednagar, Nagpur, Wardha etc. The research considers 17 factors that impacting the farmers decision to adopt solar powered pumps was considered carefully by taking the help of previous research available regarding topic.

The different factors considered for the study are-

1. Durability
2. Quality of Product
3. Government Schemes
4. Geographical Conditions
5. Payback Period
6. New Technology
7. Availability of Electricity
8. Price
9. Awareness
10. Advertising and Marketing
11. Maintenance Cost
12. Setup Cost
13. Availability
14. Ease of Installation
15. Herd Mentality
16. Weather Conditions
17. Orthodox Mindset

For analysis purpose factor analysis was chosen. Analysis and interpretation were performed using the IBM SPSS Statistics 21 software.

3.1 Problem Statement

In rural parts of India there are major problem of load shedding. Most of farmer's uses electrical or diesel pumps. As crops needs to be given water on time and if not is yields decreases. Along

with this Energy generating sources are changing drastically and world is moving towards renewable energy sources. So, farmers should also use solar powered pumps as to avoid losses and have access to electricity when need.

4. Analysis

The Factor analysis is a statistical tool used for the analysis purpose. It is given to find out minimal factors after being lowered from a collection of a greater number of factors. The Factor analysis support to extract covariance from all the measured variables and analyses them to present the variables a common score. The factor analysis support in explaining and have the findings which are not simple to be discover just by decreasing a big set of variables into a minimal factor which are interpretable.

In this research study factor analysis followed by varimax rotation was completed for 17 factors using IBM SPSS statistics 21.

4.1 Data Analysis-

4.1.1 Appropriateness and Adequacy of Data

The Bartlett's and KMO Test suggests the appropriateness of data. Generally, a greater value of the KMO considered of sampling adequacy depicts that the correlation amongst the combine of variables could be explained by alternative variables and also offers the appropriateness of the factor analysis. The desirable value for the KMO statistics is higher than 0.5. This value indicates sufficient correlations (Amal & Umarali, 2017). The null hypothesis rejects by the Bartlett's test of sphericity. Where the null hypothesis is means that the population correlation matrix is an identity matrix. As shown in table 1, the approximately chi-square statistics is 2211.008 with 136 degree of freedom, and it is significant at a level of 0.05.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.674
Bartlett's Test of Sphericity	Approx. Chi-Square	2211.008
	df	136
	Sig.	.000

As shown in table 1, the KMO measure of sampling adequacy has given a value of 0.674. it is greater than 0.5. This confirms the appropriateness and adequacy of the data model and confirms that considering the factor analysis is suitable for analyzing the correlation.

4.1.2 Variance Explained by the Factors

This shows the proportion of variance that is simplify by each factor. The eigen values of the factors are decreasing in their magnitude when we shift from factor 1-17. The first factor represents the largest variance, therefore it is taken into account for the highest eigenvalue, and the next factor is taken into account with most of the remaining variance possible, and so on. The total variance accounted for all 17 factors in 100%. The total variance interprets by the top 6 factors in 74.132%. The first factor is $(5.955 / 17) \times 100 = 35.031\%$ of the variance. The second

factor is $(1.765 / 17) \times 100 = 10.384\%$ of the variance. Similarly, the next factor, which is the third factor, is accounted for with 8.161% of the variance, the fourth factor with a variance of 7.773% the fifth factor with a variance of 6.717% and the last major factor that is sixth factor with variance of 6.066%. The first six factors are accounted for with a combined variance of 74.132% of the total variance. The rest of the factors are excluded from the study due to the low value of variance and low eigenvalues.

4.1.3 Rotating the Variables – Component Matrix

The rotation of the component matrix helps determine or establish what exactly the components represent. The varimax rotation is most commonly used. The Varimax rotation achieves simplicity and improves interpretability. Here we look at a high cut-of-score, also known as the 0.730 threshold, to identify the factors.

Table 2: Rotated Component Matrix

	Component					
	1	2	3	4	5	6
Durability	.031	-.128	-.005	.178	.875	-.084
Quality_of_Product	.294	.574	.381	.303	-.017	-.228
Government_Schemes	.234	.747	-.180	-.018	.098	-.167
Geographical_Conditions	.003	-.137	-.120	.014	-.058	.908
Payback_Period	-.015	.731	.244	.073	-.214	.064
New_Technology	.407	.541	.109	.368	-.007	-.071
Availability_of_Electricity	.148	.121	.861	-.050	-.110	-.178
Price	.837	.158	.189	.123	-.041	-.108
Awareness	.114	.254	-.042	.773	.153	.105
Advertising_and_Marketing	.703	.266	.254	-.332	.161	-.027
Maintenance_Cost	.825	-.025	.048	.146	-.013	-.109
Setup_Cost	.735	.302	-.081	.171	-.262	.132
Availability	.326	-.392	.130	.436	-.484	-.261
Ease_of_Installation	.658	-.017	.327	.338	.170	.071
Herd_Mentallity	.397	.020	.455	.551	.055	-.126
Weather_Conditions	.466	.037	.576	.280	.253	.340
Orthodox_Mindset	.654	.371	.224	.251	-.009	.274

The interpretation is completed by identifying the variables that have high loads on the same factor. This factor can then be named and interpreted by identifying the variables that have a high load on it. As can be seen in Table 2, the variables with a high loading on the factors (loading greater than the limit of 0.730) are shown in bold. There are 6 variables that have a high loading on factor 1: Price and Setup Cost.

There are also two variables: Government Schemes and Payback Period have a high load for factor 2. The variable Availability of Electricity has a high load for factor 3. The variable Awareness has a high load for factor 4. The variable Durability has high loading for factor 5. The

variable Geographical Conditions has high loading for factor 6. In addition, no variable has a high loading on a factor and therefore we consider the variables with high loading.

4.1.4 Identifying the Factors

As mentioned earlier and shown in Table 2, there are 6 factors that affect a farmer's decision of adoption of solar powered pumps. Each factor consists of variables that are loaded onto this factor. The 6 factors are then identified and named as part of the respective loaded variable. The factors are discussed in detail here.

The first factor to be identified is price. This factor is strongly related to 2 variables. As shown in Table 2, the variables are price of solar powered pumps with an Impact of 0.837 and Setup Cost of solar powered pump with an Impact of 0.735, Since all variables revolve around price and are price-centric, the factor is known as overall cost. The second factor that is identified is Government Schemes and payback period. This factor is strongly related to two variables. As shown in Table 2, the variables are Government Schemes with an impact of 0.747 and Payback Period with an impact of 0.731. These variables mainly focus on government scheme and payback period. Hence the factor is called a beneficial scheme for product. The third factor was identified and called Resource availability. The factor is strongly related to one variable, namely the Availability of Electricity with a load of 0.861. Often times, the Resource availability considered an important parameter in adoption of product. The fourth factor identified is Awareness. It is heavily loaded by a variable that is an Awareness with a load of 0.773. The knowledge is important factor while adopting the product. The fifth factor identified and named is Permanence of solar powered pumps. It is heavily loaded by 1 variable, namely durability with a load of 0.875. Permanence indicates the ability of product to withstand without requiring excessive maintenance. The sixth and last factor identified and named is Local environment. It is heavily loaded by 1 variable, namely Geographical Conditions with a load of 0.908. Local environment is considered while selecting the product such as solar powered pumps.

5. Discussion

After completion of factor analysis, there are 6 identified factors that impact on adoption of solar powered pumps. These factors are considered by the farmers to go advance and adopt the solar powered pumps. Each and every factor has their own important.

The first factor identified is Setup Cost. The setup cost involved installation cost and investment cost are large but are incurred only once at starting stage. Hence in long term perspective it offers more reliability than diesel and electric pumps (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019) The second factor identified is beneficial scheme for product. The Ministry of New and Renewable Energy gives a financial subsidy around 30% to farms owners for adopt the solar powered pumps and State government provides 50-70% of the pump cost. And remaining part of the cost is to be paid by the farm owners (Gupta, 2019).

The other factors which are found to be success factors for adoption of solar powered pumps are Resource availability, knowledge, Permanence and Local environment. Keeping in mind the inadequacy of electric power in rural and remote areas in maximum of the parts of country. Hence solar powered pumps are comfortably fit in such areas and proper designed solar powered

pump results in long term cost saving as compare to traditional water pump system. In summer maximum water required for agricultural sector and also maximum solar power available in summer by taking this advantage solar powered pumps can meet requirement of water (S.S. Chandel, M. Nagaraju Naik, & Rahul Chandel, 2015). Now a day's people do believe in increase in climate issue and they are agreed to put efforts to change this issue. They are more known about the environmental dissipation. So, they are started to shift towards renewable products. The main benefits of solar powered pumps are cost effective, reliable, Eco-friendly and it also offers the self-dependency to the farmers. Solar powered pumps are fitted for all the geographical condition. Solar energy-based pumps having huge potential to grow in India especially in rural area and also great potential to replace the traditional powered pumps (Amanjot Singh Syan and Vikas Kumar & Hundal, 2019).

5.1 Drawbacks and Scope for further research

The research governed was for Indian farmers. The study determined important factors that may be considered as a factor for adoption of solar powered pumps by Indian farmers. This study determined an important factor considered while adoption of solar powered pumps. But it does not indicate the ways to improve the factors. Research is depending on primary survey; hence study faces some limitations. This research is limited only to the state of Maharashtra, so the conclusion cannot be universal. The respondent understanding of one place may change from another place of country. Therefore, such studies can be conducted with large samples and large geographic areas to improve the generalizability of the conclusion. In addition, longitudinal studies with a similar framework can be conducted to examine the place of information exposure in behavioral changes over time.

6. Conclusion

Solar powered pumps system has benefited agricultural sector around the world. It has helped agricultural sector around the world to reduce problems such as power shortage and increase in fuel costs that affect the agriculture output. Solar powered pumps are a trustable and economic feasible replacement to electric operated and traditional fuel operated water pumps for irrigation of agricultural crops. The current study has given the factors that affects the farmers decision to adopt the solar powered pumps. It was determined that setup cost as a factor, it consist the variables such as price of solar powered pump, it's maintenance and servicing cost and installation cost impact the most on adoption of solar powered pumps in Indian agriculture sector. The next important factor determined is beneficial scheme for product. This consists variables like government scheme and payback period. The remaining important factors determined through this study are resource availability, knowledge, Permanence and local environment. The main focus in improving this factor so it impacts positively on farmers decision of adoption of solar powered pumps. The study considered some factors it does not mean other factors and variables are not important but more important given to the determined factors that are highly effective for decision of adoption of solar powered pumps in agriculture sector of India.

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