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Factors influencing Nigerian Farmers' Adoption of Solar Water Pumps for Agricultural Application

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Abstract

Farmers in many countries have at their disposal several options to control their energy expenditures of agriculture. One available choice that the farmers have not extensively adopted is the technology of solar energy for generation of electricity. The main objective of this research work was to have an idea of thelevel of farmers' adoption of solar-powered water pumps and the major factors that influence adoption behavior. The study therefore usedan extended UTAUT model to examine the adoption behavior of farmers regarding solar-powered pumps. A survey was used for the UTAUT model application. The study found that few farmers were found to use solar photovoltaic technology and solar equipment for farming. Decisions of farmers on adoption were found to be influenced by many factors including environmental change, economic benefits, government policies, awareness, costs of technology etc. It was observed that increasing the level of awareness and provision of government policies such as subsidies and incentives to reduce the costs of solar water pumps could increase farmers' level of adoption. From the results, the authorsinfer that farmers' lack of knowledge of new farming technologies and schemes resulted in some farmers not investing in solar-powered pumps.

Keywords: Agriculture, Farmers, Solar energy, solar water pumps, UTAUT,

1.0 Introduction

Agriculture as a branch of the economy of the world plays an important role in human life. The main goals of agriculture are to meet the needs of population for food and to provide raw materials for industries. One of the major challenges faced by farmers today is energy. Energy is considered one of the most rapid growing expenditures for farmers in Nigeria, diesel and

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electricity contributing for a significant proportion of the overallinput costs of farming. In the 1960s, the agricultural sector in Nigeria was the most important in terms of contributions to domestic production, foreign exchange earnings and employment. Agriculture in Nigeria in 1960's accounted for 60% of Gross Domestic Product (GDP). The situation remained almost the same for some time but later the story changed from 1970s where oil has been the principal foreign exchange earner of the economy and agriculture was down to 22.2% from 1980s [1]. The Nigerian government in 2015 planned to diversify its economy giving priority to agriculture and therefore came up with an initiative; The Green Alternative so as to boost agricultural activities and create employment in the country.Sustainable energy application such as solar energy in farmingcould reduce the high costs of electricity and fuels andcould further improve productivity.

1.1: Objectives

The following are the objectives of the study:

- To comprehend the factors influencing the behavioral intention to adopt solar-powered pumps in farming
- To study the efficiency of UTAUT model in solar water pumps adoption
- To provide new insight into adoption of solar-powered pumps in the framework of UTAUT model

1.2 The Study Gap

Previous studies were mostly on benefits of solar energy and solar equipment, not focusing on farmers and ranchers that mostly use petrol-powered water pumps in Nigeria and other countries. Those studies are yet to answer these questions; why wouldn't most farmers and ranchers in Nigeria use solar-powered water systems? What is preventing the widespread adoption of the available solar equipment in agriculture? The present study therefore focuses on understanding the factors that influence adoption behavior of farmers regarding solar-powered water pumps.

2.0 Energy and Farming

The modern day agriculture cannot be well developed without good supply of energy (electricity, oil and gas). Energy is inevitable component in developing economy, alleviating poverty and improving standard of living of people. It directly contributes to meet both basic needs and more highly advanced human needs. The modern day agriculture requires the use of energy which increases productivity, reduces cost of farming and saves time. Today, around the globe, in agricultural production and processing, it is recognized that energy is probably the second most important input next to land. Energy is needed at almost every level of the food value chain.But in Nigeria, the rural farmers have less access to energy to the tune of less than one percent of the total conventional energy supply in the country [2]. In Nigeria, farmers rely on petrol-powered

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generators for lighting and irrigation which is costly and also harmful to the environment. They also rely on firewood for cooking which affects the biodiversity. This shows that there is great deficiency of energy in rural areas in Nigeria.According to Energypedia, about 30% of global energy is consumed in the sector of agriculture and food. The primary agriculture consumes about 20% while food processing consumes about 40%. Agricultural value chain and food processing, therefore, significantly contributes to global energy consumption.

2.1Solar-Powered Irrigation

Irrigation is crucial for productive agriculture, increasing productivity and also protects the yields from drought. Conventionally, farmers use water-pump machines that use dirty fuel of diesel, oil or gas to pump out water from far or deep wells and open dams to irrigate their farmlands. Today, with the coming of solar-powered water pumps, farmers and ranchers in many countries of the world including U.S.A., Germany, Canada, France, India, China and the European Union (EU) have adopted solar energy for irrigation and the livestock watering system [3]. Using solar-powered water pumps for irrigation promises to help achieve both efficient irrigation and increased productivity while at the same time being environmentally friendly.In India for instance, in order to encourage farmers to adopt solar energy for water for irrigating the farmlands, the government of the state of Rajasthan proposed a scheme of purchasing excess power generated by solar-powered water pumps at ₹3.14/kwh from which 1 million grid-connected solar-powered water pumps will be used under KUSUM program. Another 1.75 million standalone solar-powered water pumps to be installed across the state.States in India and some parts ofChina offer about 40% and 80% subsidies and incentives to farmers to encourage themuse solar-powered water pumpsfor irrigation. Countries such as Brazil, Dominican Republic, Tanzania and Ethiopia among others also came up in 2018 with a program for implementing 500,000 solar-powered water pumps in order to increase the level of solar application for agricultural use [4]. The United Nations Development Programme (UNDP) in 2020 came up with a project for ‘‘Promoting the use of solar technologies for agriculture and rural development in Cambodia and Myanmar’’ which was designed to build the resilience of smallholder farmers thereby promoting 7000 direct beneficiaries in Cambodia to adopt solar-powered pumping for irrigation and other agricultural practices. Fig 1 depicts the photo of the project in Cambodia.

Fig.1

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Source: UNDP programme in Cambodia, undp.png

3.0 Review of Related Literature and Hypotheses Development

3.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

To find out a more comprehensive acceptance model of information technology, Venkateshetal.in 2003 conducted an empirical study in which they reviewed related studies that included eight models of behavioral intentions i.e.; TRA, TAM, TPB, TAM-TPB, MPCU, MM, SCT and IDT. Therefore, UTAUT model came up by unifying these theories on user acceptance of technology. UTAUT model is therefore an integrated model which can explain about 70% of variance in technology user's intention. UTAUT is considered the most effective model for technology acceptance studies. UTAUT model consists of six major constructs, which include Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention, and Use Behavior. The model contains four determining components of intention and four moderators (gender, age, experience and voluntariness of use) [5]. According to UTAUT model, the four determining components of Behavioral Intention and Use Behavior are Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions and four moderators include gender, age, experience, and willingness to use the technology [6].The figure below clearly depicts UTAUT mode

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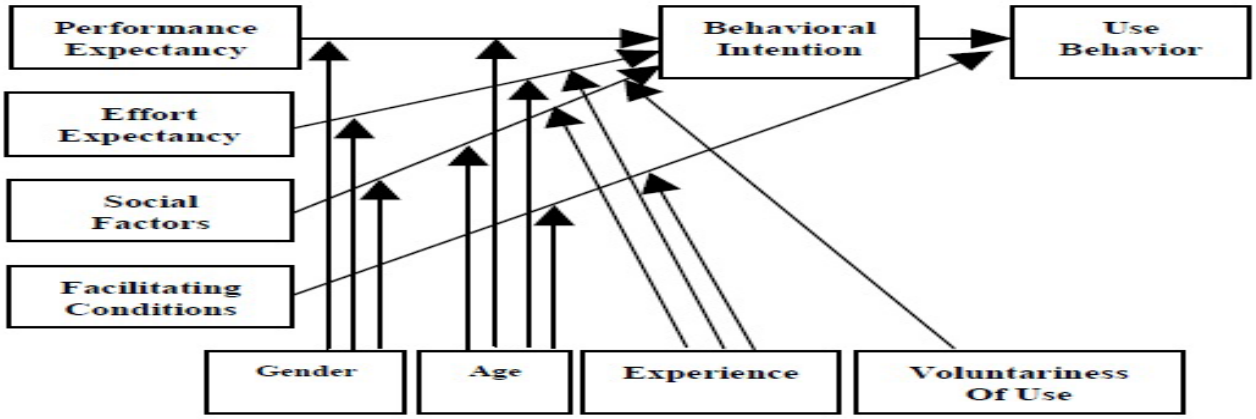
Fig.2: UTAUT Model



Source: Venkatesh et al., 2003.

3.1.1 Performance Expectancy (PE)

This is defined as the magnitude or extent to which the individuals believe that using the technologies will bring about performance benefits. This may also be viewed or considered as the perceived usefulness of the technologies.

H1: Performance Expectancy influences farmer's behavioral intention to adopt solar-powered pumps.

3.1.2 Effort Expectancy (EE)

Effort expectancy is defined as the amount of ease the individual will get as a result of using the technologies. In order words, individuals prefer equipment that requires less application of effort.

H2: Effort Expectancy positively influences farmer's behavioral intention to adopt solar-powered pumps in farming

3.1.3 Social Influence (SI)

Social influence refers to the extent at which the individuals believe that how important other people believe that the technologies should be used by others.

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H3: Social influence has a positive effect on farmer's intention to adopt solar-powered water pumps in farming

3.1.4 Perceived Cost of Technology (PC)

In a study conducted by AmanpreetKauretal, in rural areas of Punjab (India) on the adoption of solar-powered water pumps, stated that the most of the respondents (88.8 percent) confirmed that initial cost and maintenance cost are the forefront influencing variables in the non-adoption of solar-powered water pumps [7] Renewable energy sources are still not able to compete with conventional fuels in the market, gaps are reducing: there are some improvements in efficiency and the cost of renewable energy production have reduced the amount of investment to such a level needed for applications. However, there is again a need for huge capital investment, even though the costs have so far come down by more than 75% in the last few years [8]. In Ethiopia, many farmers think that solar energy technology is very expensive and difficult to manage but only those farmers that are well exposed or have good level of awareness of solar-powered water pumps express high interest to use them [9].

H4: Perceived cost negatively influence the Behavioral intention to adopt solar energy technology

3.1.5 Awareness Level about Technology (AWL)

The term 'awareness' according to information management principles, is a major factor for adoption or acceptance among the stakeholders. This means awareness involves informing the public about innovations and basic paradigms of a new system. In other words, awareness is the creation of knowledge, education, and consciousness among the public about the characteristics of a system [10]. According to a research conducted by Shareefet'al in 2011 on adoption of e-government services, awareness has a positive relation with adoption of e-government services [11]. Awareness plays an important role in the adoption of any technology. Sathye in 1999 in a research conducted on Australian customers on banking (online) stated that awareness of services and benefits of the use of banking services online gives new experiences to a lot of customers whereas low level of awareness is a major factor in influencing customers to turn away from adopting online banking services (technology). The study found that customers were not aware about the benefits, advantages and disadvantages associated with online banking technology [12]. Howcroftetal in a study also found that low level of awareness of banking services performed online and its associated benefits are the reasons behindconsumers' reluctance to use those online banking services available with banks [13].Bamisileet'al stated in their review of solar energy development in Nigeria that inadequate publicity given to renewable energy policies negatively influenced the development of solar and renewable energy technologies in the country [14]

H5: Awareness about solar-powered pumps used in farming positively influences farmers'

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behavioral intention to adopt solar-powered pumps

3.1.6 Behavioral Intention

Behavioral intentions are indicators which show whether customers have remained with or defected from an organization. Some behavioral intentions are favorable which include elements such as speaking positive statements about the service and recommending it to others, givingsome premium to the organization and expressing some level of loyalty to the organization while unfavorable behavioral intentions involves proscriptive morality that indicates what one should not perform[15].According to Theory of Reasoned Action, behavioral intention of an individual is jointly determined by their attitude and subjective norms related to the behavior in question. Again, Technology Acceptance Model postulates that the individuals' behavioral intention is determined by their attitude towards using the system [16]. This study therefore, behavioral intention is an indicator showing farmers' acceptance or rejection to use solar energy in farming.

H6: Behavioral intention influences farmers' adoption of solar technologies.

4.0 Methodology of the Study

The survey was basically carried out to study the factors influencing farmer's adoption behavior towards solar-powered pumps in Bade local government area of Yobe state in northern part of Nigeria. In order to generate a representative sample for the study, Multi-Stage sampling technique was used where 200 respondents were randomly selected from ten (10) wards of Bade LG area; 20 respondents from each ward. Considering the educational background of the rural farmers, who are mostly living in rural areas, questionnaires/schedules were designed and the farmers were guided to respond to the questions. All the 200 questionnaires/schedules were filled and the returned to the researchers. The respondents were asked to express their opinions on each item of the questionnaire/schedule using 9-Point Likert-type scale ranked from strongly agree to strongly disagree and coded from 1 to 9 respectively.

4.1Instrument Validity and Reliability

To ensure the validity and reliability of the questionnaire used to collect the data for the study, SPSS was used to find out the cronbach's alpha the result of which is given in the table below;

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4.1:Reliability Statistics

Items	Cronbach's Alpha
AWL1 AWL2 AWL3 AWL4	0.929
PC1 PC2 PC3 PC4	0.937
BI1 BI2 BI3 BI4	0.944
PE1 PE2 PE3 PE4	0.970
EE1 EE2 EE3 EE4	0.688
SI1 SI2 SI3 SI4	0.913

Source: SPSS Version 16

Based on the results from SPSS, the Cronbach'sAlpha above show that the items are valid for the study as it is greater than 0.6 threshold. The items of the questionnaire were extensively reviewed by experts from the field of the study and satisfied that the items were good for the research. Kaiser-Meyer-Olkin (KMO) was 0.93 which is within the required range.

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4.2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.805	.648	.639	3.43487	1.999

a. Predictors: (Constant), PC, AWL, SI, EE, PE
b. Dependent Variable: BI

Source: SPSS Version 16

5.0 Data Analysis and presentation of Results

In this study, the data generated using questionnaires/schedules have been run in SPSS in a coded manner in order to conduct a good statistical analysis that can test the formulated hypotheses and answer the research questions. Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) techniques have been applied through SPSS AMOS version 21.

5.1 Demographic Characteristics of the Respondents

Based on the survey demographic outcome in the ten wards of Bade local government area, it is found that most of the respondents were males (190, 95%) while (10, 5%) were females. Most of the respondents were young people with the ages of 21-40 years (160, 80%) and 40 participants (20%) were above 41 years. 15 participants (7.5%) had university degrees while 30 participants (15%) had secondary education. Most of the farmers (156, 78%) practiced both subsistence and commercial type of farming with average annual income of less than $5000 (140, 70%).

The authors conducted the test of structural equation modeling and also conducted estimation for the relationships in the model and all relationships were found to be sufficiently linear. Collinearity test was conducted to check if there was any problem of multicollinearity in the model. The outcome showed that no problem of multicollinearitywas present due to the fact that the value of VIF for all the variables was below the threshold value of 10. The path model has been illustrated in Fig.3, the values of fit indices CMIN=0.000 CFI = 1.000, GFI =1.000 and RMSEA = 0.606, showing that the model fitted the data absolutely well.

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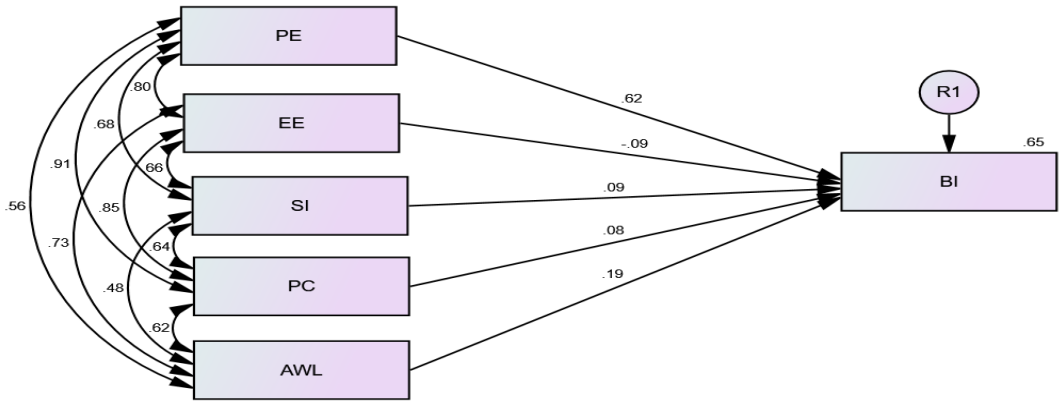
5.1 Modified UTAUT model



Source: Amos 21

5.1: Direct Effects (Group number 1 - Default model)

	AWL	PC	SI	EE	PE
BI	.207	.070	.111	-.117	.535

Source: Amos 21

5.2: Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
BI	.648

Source: Amos 21

The performance Expectancy (PE) is having a regression coefficient of 0.53 and probability level of 0.000 showing a significant impact on behavioral intention to adopt solar water pump. Effort Expectancy (EE) was found to be -0.117 coefficient showing that the lesser the effort required for operating the water pump, the higher the rate of Adoption which was also significant. Social Influence (SI) was having 0.111 coefficients with probability level of 0.000. Perceived cost (PC) was impacting behavioral intention by .070, though little impact but highly significant while awareness level (AWL) was contributing or impacting behavioral intention by 0.27 coefficients. It therefore shows a positive relationship between awareness level and

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behavioral intention; the higher the awareness level of farmers about solar water pumps, the higher the adoption level.

6.0 Conclusion

In conclusion, It is estimated that the predictors of Behavioral Intention (BI); performance expectancy, effort expectancy, social influence, awareness level and perceived cost of solar water pumpsexplain 64.8 percent of its variance that is 64.8% as seen in fig3 above. The results from the analyses show that, using the UTAUT model, farmers' adoption behavior of solar-powered pumps could be well studied. Furthermore, Applying the UTAUT model to predict farmers' adoption of solar-powered pumps for agricultural use showed that government incentives to reduce cost of the equipment will encourage adoption of solar water pumps by farmers. This is in line with results obtained by Vikas Kumar et al. in their research published in 2020 on adoption of solar energy in India. All factors contributing to increase level of awareness and reduce costs have an effect on behavioral intention to adopt solar-powered-water pumps. From the results of the study, the farmers are understood to have little knowledge about solar powered pumps, benefits to be derived from the use of the equipment and also if the usage of the equipment would require less efforts from them. Another thing worth considering is the perceived cost of the equipment which highly discourages the farmers to use the equipment. For these reasons, the authors recommend that;

- Governments at both the federal and state levels should be involved in providing some incentives to help reduce the high costs of these equipment so that the farmers would be able to own and use them to derive the benefits therein as it is done in Europe and some Asian countries
- The banks should also get involved in providing the farmers with soft loans at low interest rate and long period of repaymentto encourage them make use of solar related products. Such loans would motivate the farmers adopt such equipment in their farming practices.
- Governments, NGOs and International bodies should also supportby coming up with various awareness campaigns and programmes for those living in rural areas. Effects of climate change and energy transition programmes should be organized for such rural dwellers.

  Finally, this research work will serve as a tool for helping stakeholders, government departments and enterprises whole saddled with the responsibility of solar energy promotion and development by having an idea of the relationship among the factors that affect the adoption and application of solar energy equipment in agriculture in Nigeria.

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