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WOMEN INCLUSION AND ADOPTION OF SUSTAINABLE ENERGY SYSTEMS: THE CASE OF SOLAR AND BIO-GAS IN UGANDA

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Abstract
Access to affordable and reliable sustainable energy is key to development and achievement of the UN's Sustainable Energy for all by 2030 initiative. Females constitute the biggest percentage of the total population in Uganda. Women are the main users of energy through domestic chores. Women use women groups for inclusion in the general development of communities and households. Despite the apparent knowledge in sustainable energy, values and attitudes often fail to materialize in actual adoption of renewable energies. Whereas there are many women groups in Uganda, the level of sustainable energy systems adoption is still low and inadequate. This study investigated the relationship between inclusion of women in groups and sustainable energy systems adoption, the case of Solar and Bio-gas in Uganda. The study was underpinned by the social identity theory and the innovation diffusion theory. The study was cross sectional. 242 women groups were sampled for the study. Findings indicate that there is a positive relationship between women inclusion and adoption of sustainable energy systems. Women groups should be used for effective promotion and adoption of Sustainable Energy technologies. Information should be provided to women groups to encourage sustainable energy adoption.

Key words: *Women inclusion; sustainable energy; Energy adoption; Solar; Biogas*

Introduction

Power usage has grown highly in developing countries. The globe is constantly warming. Public concerns over greenhouse gas emissions and climate change are rising. Making good use of Renewable Energy is an urgent issue (Akinwale1 & Adepoju, 2019). Access to affordable and reliable sustainable energy is key on development agendas of different economies since it is in line global sustainable development goals (O'Driscoll, Claudy, & Peterson, 2012). Accelerating the adoption of renewable energy will fuel economic growth, create new employment

opportunities, enhance human welfare, and contribute to a climate safe future (Kamese, 2004). Besides Poverty alleviation and social up-liftment of rural communities is closely linked with the availability and use of energy. SE (sustainable Energy) adoption is in line with UN (United Nations) sustainable energy for all by 2030 and sustainable development goal 7 on energy access. SE adoption contributes to sustainable development in society.

Societal actors such as the media, policy makers, nongovernmental organizations, businesses have helped citizens to recognize their individual responsibility in the ecological crisis and have provided people with various rationales to "green" their lifestyles (Connolly & Prothero, 2008; Prothero et al., 2011). Despite the apparent knowledge in sustainable energy, values and attitudes often fail to materialize in actual adoption of renewable energies. This discrepancy is commonly referred to as the "attitude-behavior gap" (Peattie, 2001); "knowledge-action gap" and "value-action gap" (Naranjo-Gil, 2016). The unwillingness to adopt sustainable energy accentuates global warming and adversely affect the quality of life in the developing world (O'Driscoll et al., 2012; Prothero, McDonagh, & Dobscha, 2010). Acknowledge that the state has failed in the development sphere and the Non state actors are alternatives (NGOs and CBOs). Non –state actors are closer to the people in areas where poverty, deprivation, and exclusion are rampant (Cleary, 1997). It is contended that the non-state actors possess the potential to practice inclusion of women, have a bias on women and orphans, and empower the poor to overcome their debilitating conditions (Kwesiga, 2000). However, whereas women groups are many in Uganda, the level of sustainable energy systems adoption is still low and inadequate (Mugo & Wandere, 2016; Uganda Bureau of Statistics., 2016). The aim of this study was to examine the relationship between women inclusion and adoption of sustainable energy systems.

Sustainable energy systems Adoption

In light of finite global resources and climate change, adoption of renewable energy technologies provides one way to significantly reduce societies' dependence on fossil fuels and greenhouse gas emissions (O'Driscoll et al., 2012). Sustainable energy systems use energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs (Naranjo-Gil, 2016). Renewable / sustainable energy are used interchangeably in this article. Research shows that adoption of renewable energy technologies is proving problematic; research has neglected the challenges against adopting renewables (Bang, Ellinger, Hadjimarcou, & Traichal, 2000; Hansla, Gamble, Juliusson, & Gärling, 2008).

African countries cannot achieve economic and social development in the absence of adequate energy supplies. Therefore, access to sustainable energy is necessary for productive activities and essential services (O'Driscoll et al., 2012). Claudy, Michelsen, and O'Driscoll (2011); (Frederiks, KarenStenner, & ElizabethV.Hobman, 2015) note that renewable energy adoption is slow in many countries. With adequate knowledge of how to save energy and a professed desire to do so, many consumers still fail to take noticeable steps towards renewable energy adoption.

While the study of innovation adoption assumes that environmental change leads to innovation adoption, Uganda's sustainable energy innovations; have largely not been adopted by women. Studies show that public awareness and attributes regarding renewable energy for sustainable development is a very significant enabler to its adoption (Effendi & Courvisanos, 2012; Thong, 1999). In Uganda, only 6% of the total population is estimated to have access to hydro- electricity of which only 1% comprises the rural population (Adeyemi & Asere, 2014). Existing data further shows that solar energy resource in Uganda is available throughout the year but is under utilised (Kamese, 2004).

Theoretical Underpinning
The study was underpinned by two theories namely; Social Identity Theory and the innovation diffusion theory. These two theories were selected because they complement each other in explaining sustainable energy adoption.

Social Identity Theory
Social identity theory explains that part of a person's concept of self comes from the groups to which that person belongs (Tajfel, 1978, 1982). Thus social identity shapes the way people act together collectively, it creates and directs; it is a powerful social force. Moreover, social identity theory suggests that a social category to which an individual belongs and perceives to belong, provides a definition of their identity in terms of the defining attributes of the specific category; a self-definition as a part of the self-concept (Hogg & Terry, 2000). The social identity theory considers social identity and women inclusion as a factor for action and adoption. From this theory we obtained the independent variable of women inclusion. The dimensions of women inclusion are; social relations, social acceptance and social isolation. However, it does not consider the attributes of the innovation as a contributing factor, thus the introduction of the diffusion of innovations theory.

Diffusion of innovations theory
Diffusion of Innovations theory seeks to explain how, why, and at what rate new ideas and technology spread through cultures. Rogers (2003) Diffusion of innovations model contends that innovation attributes are primary determinants in the innovation adoption process. His five attributes include: relative advantage, compatibility, complexity, observability, and trialability. These sustainable energy attributes influence its adoption (Thong, 2015). Empirical and non-empirical studies have successfully used these five attributes in predicting innovation diffusion and adoption. According to Rogers (2003), 49 to 87 percent of variance of the rate of the adoption is explained by these five attributes (Rogers, 2003; Sahin, 2006). Attributes that greatly influence adoption are explained as; relative advantage, compatibility, trialability, and observability (Akinwale1 & Adepoju, 2019). From this theory we obtained the dependent variable of adoption. The dimensions of adoption are; intention to use and use (Faiers, Neame, & Cook, 2007).

Relationship between women inclusion and adoption of sustainable energy systems
Women are the main users of energy through domestic chores. The inclusion of women could provide valuable insights into the adoption, management and governance of the energy sector (Batliwala & Reddy, 2003; Gongera & Gicheru, 2016). The energy and gender nexus is based on the recognition of the differentiated needs and priorities of women and men with regards to energy stemming from gendered societal and cultural roles. Cecelski (2000) argues that without the active participation of women it is impossible to transition to Sustainable Energy. Okalebo and Hankins (1997) posit that women groups should focus on building networks that would allow women access funds that would enable them access the technologies like solar. Women groups act as powerful avenues for training women in various aspects of sustainable energy systems that facilitate its adoption (Cecelski, 2000; UNDP., 2016).

The concepts of inclusion and sustainable energy have been defined as being imperative to humanity and human development (Akella, Saini, & Sharma, 2009; Alnaser, Al-Kalak, & Al-Azraq, 1995; Effendi & Courvisanos, 2012; Fouquet, 2013; Sun & Nie, 2015; Zeb, Salar, Awan, Zaman, & Shahbaz, 2014). Fundamental transformation and sustainable energy is unlikely to occur in the absence of stakeholder inclusion in the decision making in energy use and policies (Dorian, Franssen, & Simbeck, 2006; Ricci, Bellaby, & Flynn, 2010). Balezentiene, Streimikiene, and Balezentis (2013) posit that women inclusion in sustainable energy generates a range of diversified opportunities such as biomass can enhance agricultural business if women

are engaged. For example in Czech Republic. Havlickova & Suchy's, (2010) analysis gave future prospects of sustainable energy adoption after women inclusion. (UNDP, 2016) documented its empirical research studies enlisting the role sustainable energy plays in poverty reduction, social progress, gender equality, enhanced resilience, economic growth and environmental sustainability. We derived the following hypothesis. ***H1:*** There is a positive relationship between women inclusion and adoption of sustainable energy systems

Methodology

This study adopted critical realism philosophy and a cross-sectional study design. A mixed method approach was applied to obtain data. The quantitative approach was selected because it allowed obtaining data from many respondents at a time and the qualitative was used to validate the information obtained in the quantitative approach. Statistical Package for the Social Sciences was used to analyze quantitative data.

The study was carried out in Uganda. The unit of inquiry was individual group women, whereas the unit of analysis was the women groups. They were 346 women groups in the three focus districts of Wakiso, Kayunga and Mukono (UWONET., 2018). Accordingly, the Krejcie and Morgan table was used for sample size of 242 respondents (Krejcie & Morgan, 1970). We obtained responses from 242 women groups out of 300 targeted. This means that the findings of this study are based on 81 % response. The study adopted both stratified and simple random sampling techniques to obtain the required number of respondents. After stratifying based on the district location of women groups, the actual respondents were randomly sampled. Stratified sampling technique was selected because it considered the homogeneity and heterogeneity within the population while simple random sampling gave each member an equal chance of being selected. Primary data was collected using a self-administered questionnaire from the respondents and twelve in-depth interviews. Four interviews were held for each of the three Districts.

Measuring instrument

The Social Inclusion Scale by Wilson and Secker (2015) was used to measure women inclusion. Adoption was measured using a scale by (Gaoa, Krogstiea, & Siau, 2011). These variables were subjected to a Likert Scale with a continuum 1-6 ranging from (1) strongly disagree to (6) strongly agree. This study adopted a 6-point likert scale because it helps in avoiding a common method bias that is associated with the middle point (Podsakoff, MacKenzie, & Podsakoff, 2003).

Analysis of the psychometric characteristics

The convergent validity, discriminant validity and internal consistency for SE adoption and women inclusion were calculated. Convergent validity was estimated by the average variance extracted (AVE) and composite reliability (CR). Values of AVE $\geq$ 0.50 and CR $\geq$ 0.70 were considered indicative of convergent validity. Discriminant validity was accepted when AV E was greater than the squared correlations between the other factors. The internal consistency of the factors was estimated with the standardized Cronbach's alpha coefficient, and was considered appropriate when a $\geq$ 0.70.Analyses were conducted using IBM SPSS Amos (v.20, SPSS) and SPSS Statistics (v.21). The SE Adoption AVE = 0.444, CR =.7513
Women inclusion AVE = .425, CR = .644

Regarding construct reliability of the instrument, Cronbachs Alpha Coefficient indices of study variables indicate .713 for women Inclusion with 25 items .714 for SE Adoption with 13 items. According to Cronbach (1951), results with a threshold of 0.7 and above qualify the study findings to be fit for generalization. In addition, the researcher adopted an expert judgment technique where instruments were adjusted based on the experts' views until a final instrument

that was used in the field (Neuman, 2006). The researchers addressed Common methods Bias (CMB) by procedural remedies.

Common Methods Bias

Common methods bias procedural remedies as recommended by Podsakoff et al. (2003) were taken into account at questionnaire development and data collection stage to overcome common method bias. The different procedural remedies applied include 1) adoptions of item scales that were previously developed and used in literature. The questionnaire items were adopted from previous scholars, with some modification to suit the study context.2) Double barreled questions were improved and deleted where necessary.3) used a 6 point Likert scales that minimized middle points that create bias. 4) The questionnaire was also given to more than one respondent in each women organization 5) interviews were used to triangulate data and validate the information obtained using the questionnaires.

Quantitative Results

Descriptive Statistics

Results indicated that the majority were single women (76%), followed by the married women (75%), then separated women (53%), divorced women (23%). The least were widows (16%). Thus married and single women had the highest composition in addition they exploit the networks in the women groups for development as informed in the study. The widows are relatively few because the deaths of men have reduced in Ugandan society. This also in line with the Uganda census statistics that shows that 9.7% women are widowed and 1.5% are divorced. So, the widows are the least in the Uganda (Uganda Bureau of Statistics., 2016).

Most of respondents were Diploma holders (45.6%), followed by Bachelors holders (23.4%), then certificate holders (23%). The least proportion was Master's holders (7.8%). This means that all women in groups have average education. This is in conformity with the national population statistics which shows that the literacy rate is 72.2% (Uganda Bureau of Statistics., 2016). The study analyzed the duration women had stayed on their employment and the majority of the respondents had 6-10 years (33.3%) experience followed by 11-15 years (27.9%), above 15 years (16.8%), 3-5 years (15.6%), and the least number were 1-2 years (6.17%). This means that membership to the women groups is majorly of people who are employed

Factor Analysis

Factor analysis was carried out in Table 1 for Women Inclusion and SE Adoption. All primary data from study variables underwent principal component analysis for factor loading using varimax rotation with Kaiser Normalization method for easy interpretation. Only items with Eigen values (>1.0) were ideal for Pearson correlation.

Insert Table 1 here

Factor analysis yielded three components which were interpreted as Social Acceptance (var =13.799%), Social Relations (var =10.098%), and Social Isolation (var =6.875%) explaining Women inclusion by 30.771%. Four item scales were loaded on the Social Acceptance component. A sample items are; you feel useful to your group and friends (.799), the group and friends understand you well (.772). Six item scales were loaded on the Social Relations component. The sample items are; you talk about your deepest problems in your group (.812), I don't miss having people around me (.773). Seven item scales were loaded on the Social Isolation component. Sample items are; I don't experience a general sense of emptiness (.761), I find my circle of friends and acquaintances too limited (.739)

Insert Table 2 here

Factor analysis yielded in Table 2, three components which were interpreted as SE Adoption (var =24.541%). Seven item scales were loaded on the SE Adoption component. Sample items were; The item with the highest loading in that order was Solar and gas energy become more affordable

over the last three years (.695), By using Solar and or gas energy, i save money on my monthly electricity bill (.686), By using clean energy, I can reduce my environmental impact (.671).

The relationship between women inclusion and adoption of sustainable energy systems
The study sought to verify the following hypothesis; ***H1:*** There is a positive relationship between women inclusion and adoption of sustainable energy systems. Results in the table 3 shows that there is a positive significant ($r = .441$, $p < .05$) relationship between Women Inclusion and SE Adoption. This implies that, when Women Inclusion is positively associated with SE Adoption, Women Inclusion and SE Adoption will change in the same direction given changes in one variable.

Insert Table 3 here
The fit indices for women inclusion; Isolation, Social Relations, and Social Acceptance
The fit indices for women inclusion; Isolation, Social Relations, and Social Acceptance are shown in Figure 2. All confirm acceptably good model fit. The critical ratios were all above 2.00 and p-values were less than 0.1 indicating existence of significant relationships between the constructs and the observed variable. The women inclusion model is in Figure 2.

Insert Figure 2 here
Fit indices for Adoption
The fit indices for Adoption as shown in Figure 1 confirm acceptably good model fit. The critical ratios were all above 6.00 and p-values were less than 0.1 indicating existence of significant relationships between the constructs and the observed variable. The model for Sustainable energy Adoption model is in Figure 1.

Insert Figure 1 here
Qualitative findings
The relationship between women inclusion and adoption of sustainable energy systems
The qualitative findings indicate a relationship between women inclusion and adoption of sustainable energy systems. Women acknowledged that during informal interactions in group meetings, information regarding social welfare is shared like the advantages of solar and bio-gas system. These talks encourage members to adopt sustainable energy systems. The respondents during in depth interviews emphasized that; *"The women groups bring us closer and we often make visits to our colleagues that help us to appreciate solar and bio-gas installations……."* Another informant asserted that*; "Friends in the women group explain to you the benefits and challenges with the system, which helps you to make an informed decision to install either bio-gas or solar. It all depends on your money and capacity……"*

Discussion
The relationship between women inclusion and adoption of sustainable energy systems
The findings indicate that there is a relationship between women inclusion and adoption of sustainable energy systems. This means that women inclusion is associated with SE adoption. Having women inclusion helps in the adoption of SE systems. This finding is supported by (Kurka & Blackwood, 2013) who assert that women inclusion can address emergent issues and uncertainties that enhance sustainability of energy resources adoption. In addition, Balezentiene et al. (2013) add that women inclusion exposes women to a range of diversified opportunities that come with sustainable energy which motivates their adoption. This is in line with the qualitative results that found out that groups bring women closer. They visit one another as colleagues and appreciate solar and bio-gas systems (Buchholz, Rametsteiner, Volk, & Luzadis, 2009). In the process the explanations given motivate them to adopt the SE systems. It was however noted that capacity to pay determines the actual adoption. The groups therefore

enhance the will but not the capacity to adopt sustainable energy. Whereas women are noted to be fundamental in SE adoption, their capacity to pay foe SE systems needs to be enhanced. SE adoption will go a long way in contributing to achieving the Sustainable goal 7 on sustainable access to energy.

Conclusion and implications

We conclude that there is a positive relationship between women inclusion and adoption of sustainable energy systems as indicated in findings of this study. Women groups should be sensitized to ensure SE adoption; because solar is freely available throughout the year in the tropics. Women organizations should be used for effective promotion of SE technologies and active lobbying for environmentally friendly energy sources. Information should be regularly provided to women groups to encourage SE adoption. The rural electrification agency should integrate SE in the women groups and provide relevant information to these women groups. SE energy subsidies should be provided to make SE systems affordable for sustainable development.

Regarding policy implications, different women groups should cooperate by sharing information and coordinate efforts in order to increase SE technology awareness. Women groups' work should complement government efforts to achieve The UN's Sustainable Energy for all by 2030 initiative and the specific Sustainable Development Goal 7, on sustainable energy access. Government should cause the integration of SE in the women groups. Flexible financing mechanisms are needed to enable women have access to and adopt renewable energy technologies. Attention should be paid to local context with respect to sources and patterns of income, attitudes to borrowing, availability of micro-credit agencies, and ability to repay over long and short term periods. These mechanisms should be for both end users and suppliers. Local and International financing institutions to put in place accessible financing mechanisms to catalyze both local and international private sectors into financing renewable energy projects (AU., 2009). Future studies may be longitudinal rather than cross-sectional in nature. Future research should also investigate how different personal values (such as benevolence or achievement) influence sustainable energy adoption.

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Table 1: Factor Analysis for Women Inclusion

	Component		
Rotated Component Matrix[a] for Women Inclusion	Social acceptance	Social Relations	Social Isolation
You feel useful to your group and friends	0.799		
The group and friends understand you well	0.772		
You feel listened to by your group members and friends always	0.700		
You feel you have a definite role in the group and among friends	0.549		
You talk about your deepest problems in your group		0.812	
I don't miss having people around me		0.773	
You know what's happening with group mates and friends		0.748	
There are enough people I feel close to		0.611	
There are many people I can trust completely in the group		0.606	
You are involved in a group not just for your personal interests		0.603	
I don't experience a general sense of emptiness			0.761
I find my circle of friends and acquaintances too limited			0.739
There are plenty of people I can lean on when I have problems in the group			0.716
I can call on my friends in the group whenever I need them			0.716
I don't miss the pleasure of the company of others in the group			0.645
I have a really close friend in the group			0.624
I don't often feel rejected			0.615
Eigen Values	**3.450**	**2.525**	**1.719**
% of Variance	**13.799**	**10.098**	**6.875**
Cumulative %	**13.799**	**23.897**	**30.771**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 16 iterations.

Table 2: **Factor Analysis for SE Adoption**

Rotated Component Matrix[a] for SE (sustainable energy) Adoption	Component 1
Solar and gas energy became more affordable over the last three years	0.695
By using Solar or gas energy, i save money on my monthly electricity bill	0.686
By using clean energy, I can reduce my environmental impact	0.671
Solar power and gas today is less expensive than the current retail rates provided by your electric utility	0.625
You always consider or investigate the environmental impact/sustainability of when making purchasing decisions of the type of energy to be used	0.603
You are more likely to consider environmental impact today (either of the product or the company that makes it) than you were 3 years ago	0.545
I would make this investment of solar /gas energy because it offers a potentially higher return than other options of the energy	0.542
Eigen Values	**3.190**
% of Variance	**24.541**
Cumulative %	**24.541**

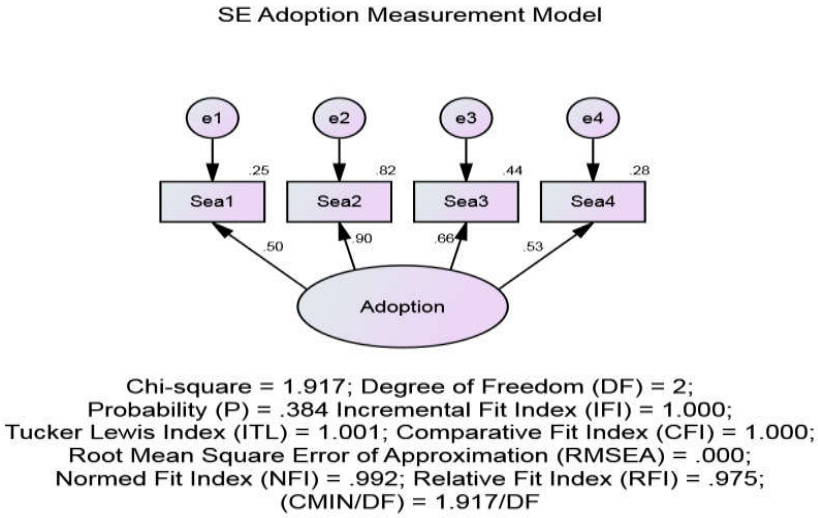
Extraction Method: Principal Component Analysis.
4 components extracted

Table 3: Correlations

	SE(Sustainable Energy) Adoption	Women Inclusion
SE Adoption	**.67**	
Women Inclusion	**.441****	**.65**

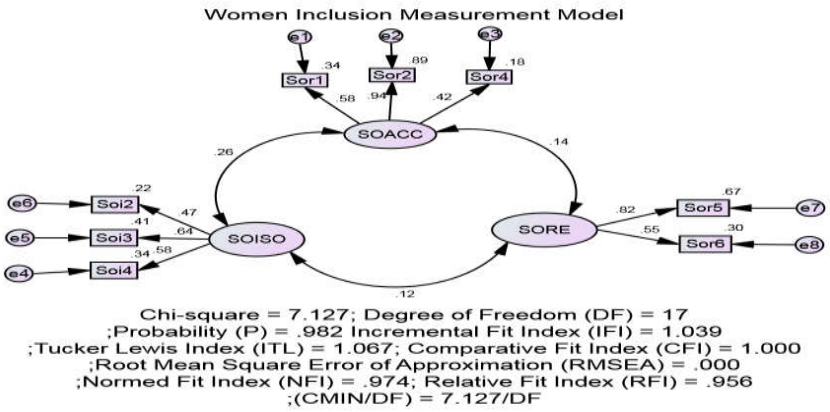
****. Correlation is significant at the 0.01 level (2-tailed).**

Figure 1: Sustainable energy Adoption model



AVE = 0.444, CR =.7513

Figure 2: Women inclusion model



AVE = .425, CR = .644