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Understanding People's Intentions Towards the Adoption of Biogas Technology: Applying the Diffusion of Innovation Theory and the Theory of Planned Behavior

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Abstract: The objective of the study was to investigate factors that influence people's intentions to adopt biogas technology in Malawi. The study adopted variables of the diffusion of innovation theory (DIT) (relative advantage, compatibility, complexity, and observability) and the theory of planned behavior (TPB) (subjective norms, perceived behavioral control, and attitude) to assess the intention. The study utilized a quantitative methodology, gathering primary data from 98 potential biogas adopters in five districts in Malawi using a questionnaire with a five-point Likert scale. After data collection, a reliability test was conducted to determine the questionnaire's reliability. A multiple regression analysis was performed to establish the relationship between independent and dependent variables. The subjective norms, perceived behavioral control, and attitude were taken as independent variables while the intention to adopt biogas technology was the dependent variable. The study's results indicated that only compatibility and subjective norms were significant predictors and independently contributed to predicting the individuals' intentions to adopt biogas technology. This will assist policy makers to provide technologies that will be compatible to people's culture and lifestyle, hence preventing the wasting of resources. At the same time, the involvement of important people in society will help to raise awareness of the importance of biogas technology.

Keywords: biogas; adoption; diffusion; innovation; relative advantage; compatibility; complexity; subjective norms; perceived behavioral control; attitude

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1. Introduction

In developing countries, people have traditionally depended on firewood and charcoal as their primary sources of fuel [1]. It is estimated that approximately 2.5 billion people residing in economically developing countries cook daily with solid fuels, such as crop residues, charcoal, coal, wood, and manure [2]. In Malawi, more than 97% of homes rely on firewood or charcoal for heating and cooking, placing Malawi among the countries with the highest dependence on biomass energy globally [3]. Hence, biogas technology has been recognized as a practical solution for combating deforestation and energy poverty in Malawi [4]. Despite being introduced approximately 20 years ago, Malawi's sustained use

of biogas digesters is almost non-existent [3]. To address the challenge, numerous research studies have been conducted to identify suitable biogas technology for Malawi, focusing on affordability and user-friendliness [5,6]. However, the situation has remained the same over the past years with an increased number of failed biogas systems. It is argued by Giffold and Nilsson [7] that the spreading of knowledge regarding the existence of technology cannot influence the behavior and patterns of people. Therefore, having suitable and acceptable technologies is not the only factor influencing a household's choice to accept a technology. The study's objective was to investigate the use of the diffusion of innovation and theory of planned behavior as models for adopting biogas technology and explore which factors in the models influence adoption. By understanding people's intentions towards adopting biogas technology, policymakers can design policies to encourage biogas adoption by understanding people's intentions through innovation diffusion. This will help avoid wastage of resources resulting from the promotion of inappropriate technologies, thereby enhancing their contribution to economic development. Furthermore, considering the involvement of influential people in a community and their mindset, the promotion of biogas will be easy since community leaders will facilitate awareness campaigns.

1.1. Theoretical Framework and Formulation of Hypothesis

It has been established that consumers' decision-making is a multi-faceted process with various social, psychological, and economic factors influencing a final purchase decision [8]. Scientists have proposed several study frameworks to understand the complicated nature of consumers' buying intentions [9]. For example, the theory of reasoned action, the self-efficacy theory, the theory of planned behavior, the social cognitive theory, and many others [10,11]. For the present study, two theories were used: the diffusion of innovations theory and the theory of planned behavior. These theories explain factors influencing human behavior and perceptions toward innovative technology [12]. For example, the diffusion of innovations theory emphasizes the importance of people's perceptions of innovation in terms of ease of use and compatibility with their knowledge and experiences as one of the factors influencing adoption [13]. On the other hand, the theory of planned behavior focuses on how people's values, beliefs, and norms influence their behaviors.

1.2. Theory of Innovation of Diffusion

The theory of innovation diffusion was introduced in 1958 by Rogers following his doctoral thesis at Iowa State University in the USA, which focused on the introduction of agricultural innovations. Rogers defines technological innovation as something perceived as new by an individual, with the adoption of innovation depending on the characteristics of that individual [14]. Technological innovation, according to Rogers, is something that a person perceives as novel; the degree to which this innovation is adopted depends on the individual's traits. According to the theory, an individual's inclination to purchase a new product or service is influenced by their perception of the product's innovative characteristics. These include compatibility, relative advantage, observability, complexity, and trialability.

Firstly, technology should have a relative advantage. Relative advantage is the extent to which an innovation is perceived to be better than to the concept it substitutes and it is frequently stated in terms of financial gain, social standing, or other advantages [13]. It can be evaluated by comparing the amount of money, time, and effort saved [15]. For biogas technology to be adopted, the users should first consider it to be better than other existing technologies or alternative sources of energy, such as charcoal and fuel wood. According to a study conducted in the USA, there were several perceived advantages and drawbacks to renewable energy technologies [16]. The study also found that short-term

benefits were outweighed by the long-term benefits of using renewable energy. Hence, it was recommended that for a technology to be adopted swiftly, it is necessary to emphasize the benefits of technology over people's current energy use, such as employment, self-sufficiency, and environmental and economic advantages. The study further recommended that apart from addressing relative advantages, relative disadvantages should also be considered. Another study conducted in Uganda on mini grids and renewable energy recommended that technology should be able to provide a reliable service to the users as unreliable services decrease relative advantage, leading to low adoption [17]. The study found that people preferred electricity from mini grids because it provided brighter light than kerosene lamps and offered health benefits compared to kerosene lamps and fuel wood. These people's perceptions increased the adoption of mini-grid technology. Based on these arguments, the first hypothesis was developed:

H1. *There is a significant relationship between relative advantage and people's intentions to adopt biogas technology.*

Secondly, innovation should have compatibility. Rogers et al. [13] defined compatibility as the extent to which an innovation is thought to be in line with the needs, prior experiences, and values of potential adopters. A more compatible idea is less uncertain for potential users and is better suited to the individual's life situation. Such compatibility enables people to interpret the novel concept in a way that makes it seem familiar. People are more likely to opt for biogas technology if it meets their energy needs and is in line with their beliefs and values. This means that individuals tend to evaluate whether technology will be suitable for their culture and requirements before embracing it. When they feel secure, they are more inclined to use biogas technology. Several studies have proven that compatibility had a positive significance with the adoption of technologies [18–20]. However, according to Silk et al. [16], most residents in Michigan did not consider alternative energy sources compatible with their lifestyle. One example is when a respondent declined to have a windmill in their backyard. The second hypothesis was developed based on the arguments mentioned above.

H2. *There is a significant relationship between compatibility and people's intentions to adopt biogas technology.*

The third characteristic of an innovation is complexity. Complexity is the degree to which a new idea is thought to be hard to understand and use [13]. Easy-to-use innovations have a higher chance of being adopted than difficult ones [21]. Based on the above arguments, the third hypothesis was devised.

H3. *There is a significant relationship between complexity and people's intentions to adopt biogas technology.*

Fourthly, technology should have trialability. Trialability refers to the degree to which an innovation can be tested before its final introduction [13]. If potential adopters can test an innovation before embracing it, the likelihood of it being adopted increases [16]. The technology should be tried and evaluated by the individuals before being fully adopted; if it is too hard, then it can be rejected [15]. Once an innovation is tried on a small scale and succeeds, people are willing to adopt it. Al-Gahtani [18] found a significant positive correlation between trialability and computer adoption and use. People are more likely to buy a product if they see a demonstration of its functionality before making a purchase [13,19]. Given the financial costs involved in adopting renewable energy initiatives, it is challenging

to implement trialability at the individual adoption level [16]. For this reason and because of the characteristics of biogas technology, trialability was excluded from the analysis, as it does not pertain to this technology [22].

Lastly, technology should have observability. The term "observability" describes how easily others can see the results of an innovation [13]. Individuals observing the technology may elicit positive or negative reactions, leading to either rejection or adoption. Diffusion of an innovation happens quickly when people can see the results and advantages [21]. Several studies have demonstrated a strong correlation between observability and people's intentions to adopt innovations [18,21]. Considering the arguments, the fourth hypothesis was developed.

H4. *There is significant relationship between Observability and the people's intentions to adopt biogas technology.*

1.3. Theory of Planned Behavior

Having suitable and acceptable technologies is not the only factor that can influence the household's decision to adopt technology. It is argued by Giffold and Nilsson [7] that the spreading of knowledge regarding the existence of technology cannot influence the behavior patterns of people. However, it is further urged that technology acceptance is highly influenced by the decisions of important people in a community, such as household heads. This assertion is supported by the Theory of Planned Behavior (TPB) developed by Icek Ajzen, which aims to predict and explicate human behavior toward the acceptance of technology [10]. The theory proposes that rather than focusing on teaching technical knowledge of a technology, it is significant to recognize the individual's beliefs and how the beliefs impact their intentions and actions. Ajzen also suggested that an individual's likelihood of adopting biogas technology is higher when they have a positive attitude and subjective norm towards the behavior, along with a strong sense of perceived control [23]. This theory assumes that if an individual has a more positive attitude and subjective norm toward a behavior, along with a high perceived behavioral control, the intention to perform that behavior will be stronger [10].

An individual's attitude towards behavior evaluates how positively or negatively they assess their performance. The individuals' attitude reflects whether they hold a positive or negative view towards a specific behavior or action. Within the theory of planned behavior, the concept of attitude is associated with the consumers' approach to embracing renewable energy, such as biogas technology [24]. According to Osei-Marfo et al. [23], people had a positive attitude regarding biogas technology, believing it would contribute to a reduction in atmospheric emissions, reduce the amount of waste that ends up in landfills, and provide renewable energy for domestic use. Consequently, this would lower the price of purchasing energy. As a result, respondents were interested in the environment's quality or improvement. Based on the above arguments, the fifth hypothesis was devised.

H5. *There is a significant relationship between attitude and the people's intentions to adopt biogas technology.*

Subjective norm is the individuals' subjective standards that involve their perception of the opinions of important people in their lives regarding whether they should engage in a particular behavior [10]. According to Irfan et al. [25], there is a relationship between subjective norms and the willingness of consumers to adopt renewable energy technologies. Subjective norms can be ascertained through the perceived influence of social pressure on an individual, prompting them to adopt certain behaviors and actions [24]. Malawi people live in a very close society, and the opinions of others can have an important impact on

their decision to adopt a technology. Based on the above arguments, the sixth hypothesis was devised.

H6. *There is a significant relationship between subjective norms and people's intentions to adopt biogas technology.*

The term perceived behavioral control (PBC) describes how someone feels about their capacity to carry out a specific behavior and how challenging it is [10]. It relates to an individual's belief about whether a specific behavior is easy or difficult [24]. The challenge of utilizing technology is one aspect that could influence customers' PBC [25]. According to Makki and Mosly [26], the consumer-friendly aspect of renewable energy products has a positive impact on the willingness of consumers to buy and use renewable energy. Items like solar panels can be easily installed and are likely to have a positive impact on how consumers feel about their ability to adopt green energy [24]. Consequently, the seventh hypothesis was developed using the following justifications:

H7. *There is a significant relationship between perceived behavioral control and people's intentions to adopt biogas technology.*

2. Materials and Methods

To collect data, the study used a survey design. In this study, the researcher compared several variables simultaneously using a cross-sectional methodology to gather data at a particular point in time [27]. Data were collected using close-ended, structured questionnaire. The questionnaire included questions which measured demographic variables, the theory of planned behavior variables (attitudes, subjective norms, and perceived behavioral control), and the diffusion of innovation theory (relative advantage, compatibility, observability, complexity). The questionnaire consisted of two sections. The first part of the questionnaire collected demographic information, including gender, education level, age, occupation, and monthly income. The second section collected data on variables related to the theory of planned behavior and the diffusion of innovation theory. The questionnaire used A 5-point Likert scale of 1 (strongly agree) to 5 (strongly disagree). To obtain validity in the study, the questionnaire was submitted to five (5) experts in the field of biogas technology from the Ministry of Energy [28]. The experts evaluated the degree of internal and external validity of collecting relevant data. Their observations were incorporated into the questionnaire before being used on the ground. After reviewing the questionnaire, a pilot research was carried out in January 2023 in Mchinji district in the central region on households with similar characteristics as the study sample but were not part of the sample population [29]. Piloting helped in determining whether the proposed methods or questionnaire were appropriate or too complicated. After the piloting, the questionnaire was corrected and questions reframed to ensure they were well understood by the respondents, and those that were irrelevant were deleted. Further, a Cronbach's alpha was calculated from the collected data to check if the multiple question Likert scale survey was reliable [30]. The consistency of the questionnaire was evaluated using reliability analysis. The questionnaire's reliability was evaluated through Cronbach's alpha score. Values typically 0.7 or higher are considered satisfactory [31].

The main study commenced in March 2023 and was completed in June 2023. Firstly, the study identified districts with biogas digesters that were either operational (referred to in this study as adopters, or non-operational, referred to as dis-adopters). Based on the above condition, the study identified 16 districts, namely Lilongwe, Rumphi, Nsanje, Salima, Ntcheu, Blantyre, Nkhatabay, Mangochi, Phalombe, Zomba, Machinga, Chiradzulu, Karonga, Dedza, Dowa, and Mzimba. Out of the 16 identified districts, 5 were selected for

the study using simple random sampling. The selected districts were Lilongwe, Salima, Mangochi, Machinga, and Dowa, as indicated in Figure 1. Identification of adopters and disadopters was performed through purposive sampling. For every household with a biogas digester, whether operational or non-operational, at least one household with biogas potential was selected [32,33]. A total of 98 potential adopters were surveyed. Before the survey, the research purpose and questionnaire were thoroughly explained to the respondents to ensure their understanding of the research questions and to provide accurate answers reflecting the collected data. Consent was sought from the respondents, and only those willing to take part in the research were interviewed. The research study was approved and followed the ethical guidelines of the National Commission for Science and Technology (NCST) before the commencement of the fieldwork. The respondents' demographic characteristics were analyzed using descriptive statistics. The hypotheses were tested using multiple regression techniques in IBM SPSS Statistics version 22 and were tested at a significance level of 5%. In this case, the intention to adopt biogas technology was regressed on relative advantage, observability, compatibility, complexity, attitude, subjective norm, and perceived behavioral control. The study had a limitation on the number of respondents. The study focused on neighbors of biogas digester users and disadopters. However, the limited number of digesters in the targeted districts resulted in a lower-than-expected response rate. According to Wang et al. [34], smaller sample sizes increase the likelihood of sampling errors. Therefore, a follow-up study with a larger sample size is necessary to make the findings more generalizable and reduce sampling errors.

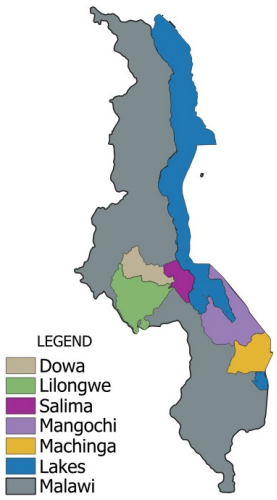

Figure 1. Map of Malawi depicting study areas.

3. Results

3.1. Respondent Descriptive Analysis

Table 1 displays the demographic features of the participants in the study. According to the findings, the age group of 31 to 40 had the most representation in the sample (52%), followed by the age group of 41 to 50 (28%). Considering gender, females comprised 52% and males comprised 48%. In terms of the education variable, 23% of the respondents were primary school dropouts, whereas 64% of the respondents reported having a secondary school certificate. Only 11% had reached a tertiary level of education. In terms of the employment variable, 39% of the respondents were farmers, and 47% of the respondents were business owners, constituting the largest representation of the study sample. An additional factor looked at in the study was the monthly earnings of respondents, with 79.59% making over 20,000 Malawi Kwacha. This was then followed by individuals earning 10,000–20,000 Malawi Kwacha monthly, making up 13.27% of all survey participants. On

land size, 63% had less than 2 ha of land, followed by those with 2–5 ha of land at 32%. Only 1% had land over 10 ha. Over 45.1% of the respondents had livestock of about 5–10, and 5.1% had over 10 livestock.

Table 1. Demographics of the study respondents.

	Attribute	Frequency	Percent
Age	21–30 years	11	11.22
	31–40 years	51	52.04
	41–50 years	28	28.57
	above 50	7	7.14
Gender	Male	47	47.96
	Female	51	52.04
Education	Primary	24	24.49
	Secondary	63	64.29
	Tertiary (Certificate, Diploma, Degree, Masters, PhD)	11	11.22
Occupation	Business	46	46.94
	Farmer	38	38.78
	Formal employment	10	10.2
	Unskilled labor	3	3.06
	Skilled labor	1	1.02
Monthly Income	Above 20,000 MWK	78	79.59
	10,000–20,000 MWK	13	13.27
	5000–10,000 MWK	6	6.12
	Less than 5000 MWK	1	1.02
Land Size	Less than 2 ha	62	63.9
	2–5 ha	31	32.0
	Above 10 ha	3	1
Number of Livestock	None	28	28.6
	1–5	44	45.4
	5–10	20	20.4
	Above 10	5	5.1

Source: Field survey (2023).

3.2. Reliability Test Results for Study Variables

The findings from the reliability analysis are outlined in Table 2. The results indicate that the values are considered satisfactory; therefore, the questionnaire was deemed reliable and consistent.

Table 2. Reliability results.

Attributes	Number of Variables (Questions)	Cronbach's Alpha Potential Adopters
Attitude	8	0.96
Subjective Norm	7	0.892
Perceived Behavior Control	12	0.904
Observability	6	0.824
Relative Advantage	11	0.954
Compatibility	7	0.776
Complexity	5	0.769
Dependent Variable—People's Intentions for the Adoption of Biogas Technology	3	0.744

3.3. Hypothesis Testing

The hypotheses were tested using multiple regression techniques in IBM SPSS Statistics version 22. The intention to adopt biogas technology was regressed on attitude, subjective norm, perceived behavioral control, relative advantage, compatibility, and complexity. Table 3 presents the analysis of the regression.

Table 3. Summary coefficients of attitude, subjective norms, perceived behavioral control and intention to adopt biogas technology.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.618	0.815		1.985	0.050	−0.002	3.238
	Subjective Norm	0.444	0.118	0.353	3.767	0.000	0.210	0.679
	Perceived Behavior Control	−0.051	0.189	−0.026	−0.269	0.789	−0.425	0.324
	Attitude	−0.060	0.183	−0.064	−0.326	0.745	−0.423	0.304
	Observability	0.043	0.161	0.041	0.269	0.788	−0.277	0.364
	Relative Advantage	0.411	0.235	0.425	1.747	0.084	−0.056	0.879
	Complexity	−0.129	0.130	−0.084	−0.996	0.322	−0.387	0.129
	Compatibility	−0.225	0.110	−0.165	−2.053	0.043	−0.443	−0.007

Dependent variable: intentional.

Table 3's findings demonstrate that all factors—aside from compatibility and subjective norm—have significance levels greater than 0.05, which strongly supports the acceptance of hypotheses H2 and H6. Table 4 explains the regression analysis.

Table 4. Summary of coefficients of the effect of demographics on intention to adopt biogas technology.

Parameter Estimates					
Parameter	B	Std. Error	95% Wald Confidence Interval		
			Lower	Upper	Sig.
(Intercept)	2.666	0.8734	0.954	4.378	0.002
Gender = Female	−0.415	0.1648	−0.738	−0.092	0.012
Gender = Male	0				
Age = 21–30 years	0.549	0.4193	−0.272	1.371	0.190
Age = 31–40 years	0.854	0.3382	0.192	1.517	0.012
Age = 41–50 years	0.815	0.3382	0.152	1.478	0.016
Age = Above 50	0				
Education = Primary	0.160	0.3715	−0.568	0.888	0.666
Education = Secondary	0.184	0.3018	−0.407	0.776	0.541
Education = Tertiary (Certificate, Diploma, Degree, Masters, PhD)	0				
Size of household = 1–4	0.380	0.3719	−0.349	1.109	0.307
Size of household = 5–8	0.023	0.3416	−0.646	0.693	0.946
Size of household = 3	0				
Occupation = Business	0.020	0.5046	−0.969	1.009	0.968
Occupation = Farmer	0.050	0.4971	−0.924	1.025	0.919
Occupation = Formal employment	0.477	0.5694	−0.639	1.593	0.402
Occupation = Unskilled labour	0.575	0.8895	−1.168	2.319	0.518
Occupation = Skilled labour	0				

Table 4. *Cont.*

Parameter Estimates					
Parameter	**B**	**Std. Error**	**95% Wald Confidence Interval**		
			Lower	**Upper**	**Sig.**
Number of livestock = None	−0.990	0.4239	−1.821	−0.159	0.020
Number of livestock = 1–5	−0.817	0.3996	−1.600	−0.034	0.041
Number of livestock = 5–10	−0.436	0.4107	−1.241	0.369	0.289
Number of livestock = Above 10 ha	0				
Land size = Less than 2 ha	0.404	0.4890	−0.555	1.362	0.409
Land size = 2–5 ha	0.220	0.4998	−0.759	1.200	0.660
Land size = Above 5	0				
Income = Less than 5000 MWK	−0.442	0.8007	−2.011	1.127	0.581
Income = 5000–10,000 MWK	−0.381	0.3946	−1.154	0.393	0.335
Income = 10,000–20,000 MWK	0.043	0.2479	−0.443	0.529	0.862
Income = Above 20,000 MWK	0				

Dependent variable: intentional.

Table 4 above indicates that all demographic characteristics, except gender (Female), age (31–50 years old), and number of livestock, did not affect biogas adoption intention. Gender, ($\beta = 0.012$, $p < 0.05$), age, (31–40 years, $\beta = 0.012$, $p < 0.05$, 41–50 years, $\beta = 0.016$, $p < 0.05$), and the number of livestock ($\beta = 0.0041$, $p < 0.05$) significantly affected the intention to adopt biogas technology.

4. Discussion

This study's primary goal was to determine the key elements affecting Malawi's adoption of biogas technology. This study adopted the diffusion of innovation theory and the theory of planned behavior as the main frameworks to explain adoption intention. The study hypothesized that relative advantage, compatibility, complexity, observability, attitude, subjective norm, and perceived behavioral control would significantly predict the intention to adopt biogas technology. The study revealed that only subjective norm and compatibility significantly predicted adoption intention.

4.1. Relationship Between Subjective Norm, Compatibility, and People's Intention to Adopt Biogas Technology

The findings of this study found that people's intentions to use biogas technology were significantly influenced by their family, friends, neighbors, community chiefs, politicians, and religious leaders. These results are in line with a related study carried out by Osei-Marfo et al. [23] which observed that respondents had respect for people considered important in their lives, and that their intentions to use biogas technology might have been impacted by these people's opinions. According to these findings, family members, friends, neighbors, community leaders, politicians, and church leaders all contribute to the dynamics when developing interventions aimed at persuading heads of households to embrace biogas technology. Community leaders play a significant role in raising awareness for adopting biogas technology by sensitizing people to the importance of using biogas technology. Villagers mainly rely on the village head to raise awareness about the importance of development efforts in improving social conditions and increasing villagers' participation in these initiatives [35]. Hence, there is a need to engage important community people when introducing new technologies. The study further found that technological compatibility predicted the adoption of technology in Malawi. The study supported H_2, which stated a significant relationship exists between compatibility and people's intentions to adopt biogas technology. This was consistent with the study by Alam et al. [36], which

demonstrated that compatibility was another significant predictor of solar technology adoption. The study above indicated that individuals who believe that solar technology aligns with their culture were more inclined to adopt it. This is the same with the current study where compatibility influenced people's intentions to use biogas technology.

4.2. Relationship Between Relative Advantage, Complexity, Observability, Attitude, Perceived Behavior Control, and People's Intentions to Adopt Biogas Technology

The findings of this study rejected hypotheses H1, H3, H4, H5, and H7. The study indicated negative relationships between relative advantage, complexity, observability, attitude, perceived behavior control, and people's intentions to adopt biogas technology. The primary factor behind the study's results is that potential adopters found biogas technology less reliable than other alternative energy sources. According to the study conducted by Kulugomba et al. [37] on the opportunities and barriers of biogas technology in Malawi, it was discovered that biogas adopters continued to use firewood and charcoal as biogas technology was not providing enough gas to cook Nsima (Malawi Staple food). Apart from the relative advantage, the study indicated that the rate of adoption of biogas technology is adversely correlated with complexity. This study agrees with the study that was conducted in Saudi Arabia [18] and Brazil [21]. This means that if technology is more complex, it might be more likely to be rejected than adopted. People's intentions to adopt biogas technology was negatively dependent upon observability. The results were in line with studies by Li et al. and Tapaninen et al. [19,20], who found that observability had no relationship to the adoption of innovation. According to Kulugomba et al. [37], most biogas systems installed in Malawi were installed as demonstration plants for people to learn and appreciate the use of biogas and develop an interest in adopting the technology. However, most systems were not fully functional and did not function as expected. Therefore, most potential users were not convinced that the technology was useful or important and were discouraged from adopting it. The results contradict the findings of Osei-Marfo et al. [23], who found that people had a positive attitude towards biogas technology. However, the current results observed that people had a negative attitude towards biogas technology, which led to a low uptake of the technology. The negative attitudes of people emanated from the poor performance of the installed biogas systems [37]. The study observed that there was a significant relationship between perceived behavioral control and people's intentions to adopt biogas technology. This was corroborated by a related study by Osei-Marfo et al. [23], which discovered that perceived control factors, such as the initial investment cost for installing a biogas plant, cultural issues, ongoing maintenance costs, and the capacity of service providers (human resource), negatively impacted household heads' intentions to adopt biogas technology.

To enhance relative advantage, complexity, observability, attitude, and perceived behavior control, the following measure should be carried out:

- Government and private institutions should conduct awareness campaigns to remove negative perceptions of biogas technology to enhance relative advantage;
- Research should be encouraged to develop easy, simple-to-operate, and maintainable technologies appropriate for the people of Malawi;
- Demonstration sites with well-operated systems should be set up to remove negative perceptions of the technology and instill confidence in people;
- Government and stakeholders should come up with programs and activities that will develop positive attitudes of people towards technology;
- Interventions to encourage people to adopt biogas technology should be identified;

- Proper education and awareness campaigns for the society on the benefits of biogas technology should be encouraged to enhance perceived behavior control in potential biogas adopters.

4.3. Relationship Between Demographic Characteristics and People's Intentions to Adopt Biogas Technology

Regarding demographic characteristics, the study results indicated that all demographic characteristics, except for gender, age and number of livestock, did not influence the adoption of biogas technology. In this study, women compared to men were more likely to adopt biogas technology. According to Uhunamure et al. [33], household gender had either a negative or positive effect on biogas adoption depending on gender tasks. Even though men have the majority of ownership, access, and control over home production resources and investment in Africa [33], this did not prevent women from embracing the technology. Further, women were the ones responsible for domestic energy supply, such as fuelwood collection; hence, embracing biogas technology was easier for them than men as it lessened their workload burden [38]. The study further observed that the number of livestock positively effects the adoption of biogas technology in Malawi. This is in line with findings from the study on the analysis of biogas technology adoption among households in Kilifi County [39], which found that all households that adopted biogas technology had cattle. This indicated that households with livestock are potential adopters of biogas technology as the main important basic material needed for the operation of biogas digester is readily available [40]. The study also observed that age had a positive effect on people's intentions to adopt biogas technology. Specifically, people who were 30 years and above had a positive chance of adopting biogas technology. Older individuals have additional income that may lead them to adopt capital-intensive technology more readily than younger individuals [41].

5. Conclusions

The study was aimed at investigating the use of the diffusion of innovation and the theory of planned behavior to identify factors that influence the adoption of biogas technology in Malawi. The study sought to generalize the effect of psychological constructs, such as relative advantage, compatibility, observability, complexity, beliefs, attitudes, subjective norms, and perceived behavioral control, on the intention to adopt biogas technology. The study results indicate that only compatibility and subjective norms significantly affect the intention to use biogas technology. So, to accelerate the intake of biogas technology, the systems promoted should be aligned with the culture, values, and requirements of the people. The system should also be observable, have a high relative advantage, and be less complex. Simultaneously, it is crucial to involve important community members from the beginning of the project when disseminating the technology. Further, perceived behavioral control factors, such as cultural beliefs, lack of funds, inadequate dung or water, labor shortages, shortages of spare parts, lack of livestock, ignorance of the advantages of biogas technology, and a lack of technical experts and maintenance services, should be minimized. The existence of these barriers would hinder the adoption of biogas technology in Malawi, so it is crucial to reduce or eliminate these barriers. By taking those measures, resource wastage will be minimized, thereby affecting economic growth.

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