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Research article

Identifying the determinants of biomass briquettes adoption among urban and peri-urban households in Southwestern Uganda

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ABSTRACT

The use of clean cooking technologies, such as biomass briquettes, can reduce household air pollution, promote the use of plant-based waste, and contribute to the achievement of Sustainable Development Goal 7 (SDG 7): Affordable and Clean Energy. Understanding the factors that influence household adoption of biomass briquettes is therefore essential for designing effective interventions to encourage their uptake. In this study, we use the constructs of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) and Local Ecological Knowledge (LEK) to identify these determinants among urban and peri-urban areas in Southwestern Uganda. Through a cross-sectional survey, data from 387 households in Mbarara City South Division (urban) and Isingiro North County (peri-urban) were collected. The constructs were computed using factor analysis, after which they were included as regressors in logit models to identify the determinants of biomass briquette adoption. The results indicate that facilitating conditions (FC) and hedonic motivation (HM) are significantly associated with biomass briquette adoption, while households located in Mbarara City South Division and respondents with lower secondary education are more likely to adopt biomass briquettes. Local Ecological Knowledge (LEK) was not associated with adoption. Spatial robustness checks using Conley-adjusted standard errors further suggest a potential role for effort expectancy (EE), price value (PV), and social influence (SI), although these relationships were sensitive to the spatial specification employed. The findings highlight the importance of improving access to briquettes, strengthening user support, and enhancing the user experience to encourage adoption. Policies aimed at reducing practical barriers to use may therefore contribute to accelerating the transition towards cleaner cooking technologies.

1. Introduction

There is a need for households to adopt clean cooking technologies due to the numerous benefits they provide to users and the environment. These benefits are categorized into environmental, economic, social and health benefits [1–3]. Given the abundance of agricultural residues (i.e., plant-based waste materials which can be processed into biomass briquettes), biomass briquettes are a viable source of clean cooking energy in most Sub-Saharan African countries [4,5]. Examples of biomass briquettes are presented in Figs. 1 and 2. Biomass briquettes can be produced manually by households using locally available materials, particularly when access to or affordability of alternative cooking fuels

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is limited (Fig. 2). They can also be manufactured using briquetting machines (Fig. 3). The resulting briquettes are typically sold directly to end users at or near the production site.

The use of clean cooking technologies such as biomass briquettes reduces both indoor and outdoor air pollution, deforestation, and could lead to utilization of agricultural byproducts and household waste that would otherwise be discarded [6,7]. Moreover, biomass briquettes have proven to be cost-effective, considering the high calorific value when compared to traditional fuels such as charcoal and wood [8,9]. The problem of biodegradable waste mismanagement has been reported in cities in most countries in sub-Saharan Africa, including Uganda, and specifically in Mbarara City [10]. Converting solid biodegradable waste into briquettes has the potential to address the problem of waste management effectively, while contributing to SDG 7 "ensure access to affordable, reliable, sustainable and modern energy for all" [11]. Due to the use of charcoal and wood for cooking, Africa is overburdened by household air pollution, where $PM_{2.5}$ levels in the main cooking area are estimated at 500 $\mu g/m^3$ and above, exceeding the WHO guideline of 5 $\mu g/m^3$ [12–14]. A reduction in toxic compounds, such as CO, CO_2, and $PM_{2.5}$ produced by traditional cooking fuels can be achieved by adopting biomass briquettes [15,16], thereby reducing the burden of premature deaths in Africa that result from air pollution, estimated at 1.2 million deaths annually [17]. In East Africa, exposure to air pollution is the second leading risk factor for deaths, and in the year 2021 alone, it accounted for approximately 300,000 deaths in East Africa [18].

Some research on the adoption of biomass briquettes in Sub-Saharan Africa has already been done. A study by Mugabi & Kisakye [9], for example, found that low-income consumers preferred non-carbonized over carbonized briquettes, and that briquettes are a cost-effective option. However, users highlighted challenges associated with briquettes, such as a high ash content, briquettes breaking or crumbling easily, and not being easily accessible on the market. Yustas et al. [19] studied the adoption of briquette-making technology in Tanzania and found that briquettes were of poor quality in terms of users' expected energy needs and efficiency. Therefore, because of the direct competition from wood and charcoal, it was found to be hard to attract sales. In addition, they also found that there is poor coordination among stakeholders and a lack of enabling policies to facilitate the development of briquette-making technology. A study by Shaidi [7] on societal acceptance of briquettes in Dar es Salaam found varying acceptance levels (good acceptance to neutral) from those who knew about briquettes but had never used them. However, those who had used briquettes provided positive feedback, perceiving them as useful, easy to use, and compatible with the local community's cooking needs. Overall, these studies conclude that briquettes are a suitable clean energy source for cooking for households in sub-Saharan Africa. Existing studies have mainly used semi-structured questionnaires, scoping and literature reviews, and interviews to understand the acceptability and preferences of different briquette shape preferences [7,9,19]. These studies are limited in scope and provide little insight into the determinants of biomass briquette adoption using the adoption frameworks used in this study. To deepen our understanding of determinants of household adoption of biomass briquettes, this study adopts the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2), and the Local Ecological Knowledge (LEK) framework. The aim of this study is to formulate energy transition policy recommendations [20], as Uganda is struggling to implement these policies.



Fig. 2. Example of hand-made briquettes by households.

UTAUT2 is an extended technology-adoption framework that explains why individuals, especially consumers intend to adopt and use technologies by combining core determinants from the Unified Theory of Acceptance and Use of Technology (UTAUT) with added constructs such as enjoyment-related aspects (hedonic motivation), price value, and habit and experience. UTAUT2 was developed by Venkatesh et al.



Fig. 1. Biomass briquettes produced by a community group in Isingiro.



Fig. 3. Locally fabricated machine used to make briquettes in Southwestern Uganda.

[21] and has been used to study renewable energy acceptance and adoption [2,22–24]. Communities' adoption decisions of any technology, in our case biomass briquettes, are likely to be influenced by the constructs of the extended UTAUT2 [21,25]. However, few studies examine the perspectives of adopters and non-adopters at the household level. Neves et al. [25] used UTAUT2 to investigate sustainable technologies in five European countries, although the focus was not on cooking or a specific technology. They highlight the potential of integrating contextual factors such as financial, informational, privacy factors, and personal characteristics – to bridge knowledge and action in energy sustainability studies.

Local Ecological Knowledge (LEK) can and has also been used to inform policy recommendations linked to environmental sustainability. LEK refers to the understanding and insights that people in a specific community have about their local environment, developed through direct interaction, observation and experience over time[1] [26]. Contextualised knowledge generated by users through local observations and experiments has the potential to mutually bridge with established science to inform co-management. Such knowledge has the ability to deal with change adaptively, and highlights the importance of sharing management power and responsibility between the government and local resource users [27,28]. These assertions highlight that LEK could influence technology adoption decisions [29,30]. However, there are limited studies that explicitly mention and integrate LEK with the adoption of biomass briquettes and other clean cooking technologies. It is hypothesised that LEK influences technology adoption knowledge leading to action, but this has not yet been studied in detail.

Moreover, existing studies on clean cooking adoption have concentrated on typical urban areas, leaving out insights from peri-urban areas, which could also benefit from the advantages of clean cooking. This study could contribute to identifying how adoption differs in urban and peri-urban settings in Uganda, where households' socioeconomic status differs. To develop culturally appropriate, sustainable, and effective clean cooking solutions, communities should be seen as co-creators in energy transitions [31]. We identify this as a viable strategy to achieve the energy transition and promote sustainability. This study integrates UTAUT2 and LEK to identify constructs that determine the adoption of biomass briquettes in cooking using a logit regression model to recommend possible policy interventions.

The objective of this study is to evaluate the influence of UTAUT2 constructs (PE, EE, SI, FC, PV, HM, HE)[2] and LEK on household adoption decisions of biomass briquettes in Uganda. By achieving this, the study builds understanding how UTAUT-based factors and LEK determine the likelihood of household adoption of biomass briquettes for cooking in Uganda using a binary logit regression model.

In what follows, Section 2 explains the theories and conceptual model, and shows how UTAUT2 and LEK have been integrated to determine the adoption of biomass briquettes. Section 3 describes the materials, methods, and analytical approach used in this study. In Sections 4 and 5, the results are presented, interpreted, and discussed guided by the conceptual model. Implications and policy recommendations are also highlighted, and limitations are acknowledged. In Section 6, a conclusion to the study and direction for future studies is summarised.

2. Theory and conceptual model

This study adopts the UTAUT developed by Venkatesh et al. [32], a technology adoption framework used to explain how and why consumers intend to adopt or actually use technologies, in our case, biomass briquettes for cooking as shown in Fig. 4. The main constructs of the UTAUT are performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC). PE is the extent to which using a technology provides benefits to a consumer in performing certain activities. EE relates to the ease-of-use consumers attach to a technology. SI relates to the extent to which consumers perceive that others believe that they should use a particular technology. FC refer to consumers' perceptions of the resources and support available to perform a behaviour. PE, EE, and SI mostly influence behavioural intention to use technology, while FC determines technology use/adoption [21,32,33]. This framework was extended by Venkatesh et al. [21] to UTAUT2 with the addition of hedonic motivation, price value, and habit & experience constructs. The HM construct refers to enjoyment, fun, and pleasure and complements other constructs to assess the utility a consumer derives from using a product or technology. The PV construct relates to monetary costs, the cost structure, and this may have a significant effect on the users' adoption decisions. The HE construct relates to prior experience and behaviour, which are viewed as overall mechanisms and key drivers of behaviour in technology use. Moreover, HE could directly affect technology use by either weakening or limiting the strength of the relationship between behavioural intention and technology adoption [21,33,34].

This study uses a comprehensive list of statements beyond what we found in the existing study by Neves et al. [25] to assess the influence of the LEK construct. The statements also consider the local context as emphasised by most adoption studies [35,36]. We presume that there could be a link between ecological knowledge and taking action to address potential environmental concerns that may accrue from using unsustainable energy sources. This and the local context informed our LEK statements that combine knowledge with action to determine

[1] The term LEK is used interchangeably with Traditional Ecological Knowledge and Indigenous Ecological Knowledge i.e., knowledge systems built through long-term interaction with the local environment based on observation, experience, and adaptation to the local systems over generations [57,58].

[2] PE: Performance Expectancy, EE: Effort Expectancy, SI: Social Influence, FC: Facilitating conditions, PV: Price Value, HM: Hedonic Motivation, HE: Habit and Experience

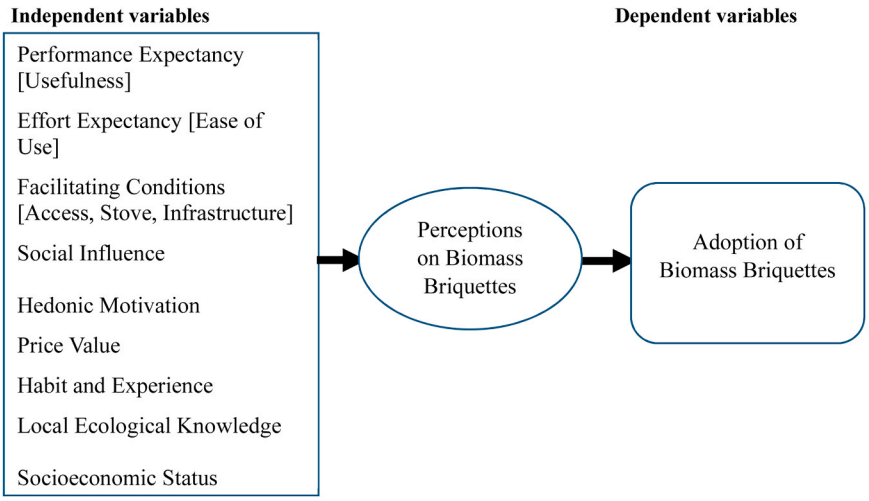

Fig. 4. Conceptual framework illustrating the influence of UTAUT2 and LEK on biomass briquette adoption. Source: developed by the authors, modified from Venkatesh et al. [21].

whether knowledge determines the adoption of biomass briquettes. In the context of this study, since biomass briquettes are not widely adopted yet, biomass briquettes are assessed as the "technology" which people could adopt or have started to adopt as an alternative source of energy for their cooking. The users and potential future users pay attention to functionality, cost, and knowledge-related aspects of any technology during or after using it [33]. This informs their decision to continue using it, abandon it, or recommend it to others and have others adopt it in the future.

3. Materials and methods

3.1. Study area

We performed a cross-sectional survey to collect data from women in households in Mbarara City South Division and Isingiro County North in Southwestern Uganda. We targeted women because of the significant role they play in cooking and other domestic-related activities in the household. For example, women perform more than 80% of the cooking-related activities in Sub-Saharan Africa [37–39], and in Uganda, 93% of the women are engaged in cooking-related activities [40]. Data collection areas were either urban (Mbarara City [shown in Fig. 5]) or peri-urban (Isingiro North). In Mbarara City South Division, five wards were selected because they had the highest population of women residents as our target population [41]. The biggest and most urban wards were selected based on the recent population census [41]. In Isingiro North County, two town councils (Isingiro and Kaberebere[shown in Fig. 6]) and two sub-counties (Masha and Birere) were selected [41].

In Uganda's local council structures, these two categories are at the same level but have different descriptions: the town council applies to peri-urban settings, and the sub-county applies to rural settings, although it may have some peri-urban areas. The specific wards that were sampled in Isingiro for this study were peri-urban and had a high population density. The wards that were typically rural or had low population density were excluded. In this study, Mbarara City is considered an urban area as shown in Fig. 2, while Isingiro North is considered a peri-urban area as shown in Fig. 6.

3.2. Sample size, survey structure, and administration

The sample size was determined using the sample size table established by Krejcie & Morgan, [42], which is guided by the target population. Based on the sample population of 68,000 females[3] in the two study areas, 382 participants were considered for the survey. Additional participants were surveyed to cater for a scenario where some surveys are excluded (e.g., due to incompleteness). The sample for each sub-enumeration area was determined based on the population of females as per the National Population and Housing Census conducted in 2024 [43]. *Appendix A* shows the distribution of participants across the selected wards and parishes. A proportionate sampling approach was employed, whereby the number of participants selected from each area was proportional to its population size. Consequently, 304 (79%) were recruited from Mbarara City South Division and 83 (21%) from Isingiro North County.

Households were randomly selected in Mbarara City South Division (urban) and Isingiro North Country (peri-urban), as shown in Fig. 7. The households were randomly selected from each ward following a random walk method as described by [44]. This method is applied to select households randomly, where the number of places between points was determined by random numbers, and the direction to move was determined by the enumerator in consultation with the first author. Only one woman in a household was interviewed i.e., the wife in the household, not the child, even if the child was above 18 years of age. The enumerators skipped 5–10 households to identify the next participant based on the settlement setting in each location. The number of households skipped was based on the distance between the households and the concentration of houses in each ward.

The survey questionnaire was structured in 4 parts: i) demographic information, ii) energy use practices, iii) UTAUT2, and iv) LEK. The demographic information included questions about location, age, number of household members, education, main occupation, main source of income, and estimated monthly income. Questions on energy use practices included questions about the current primary and secondary sources of energy for cooking, expenditure on energy, the location where cooking is done, and the gender of the person responsible for cooking. Questions also included preferred cooking time, number of hours spent on cooking per day, knowledge about clean cooking, and

[3] In this study, only females were prioritized because they do most of the cooking in households compared to their male counter parts. Literature shows that in Uganda, more than 82% of the cooking is done by females, 11% done by males, and 7% share cooking responsibilities [38]. A recent study shows that 93% of females do most of the cooking-related activities in households in Uganda [40]



Fig. 5. A view on Mbarara City (urban location).



Fig. 6. A view on Kaberebere located in Isingero - (a peri-urban location).

willingness to participate in cooking experiments using biomass briquettes. The UTAUT2 questions were based on the study of Neves et al. [25], considering the seven constructs. The LEK questions were modified and constructed from existing studies on biomass briquettes, charcoal and firewood use and their impact on the environment [9,45–48], including the study of Neves et al. [25]. Although the latter added it as a construct, they focused on being familiar with sustainable technologies, knowledge about energy topics and the environment, and how to select sustainable technologies. Our study integrates additional statements, which makes the LEK construct more comprehensive. For example, we include statements on shared cooking experiences, potential use of agricultural waste for energy, discussion on the sustainability of energy sources, recognition of environmental problems resulting from charcoal or firewood, and the community's support for the use of biomass briquettes. All survey items assessing UTAUT2 and LEK constructs were measured using a 7-point Likert scale from 1 "completely disagree" to 7 "completely agree".

The questionnaire was programmed in the KoboToolbox software. The survey was administered in Runyankole, the most spoken language in the Ankole region, and English was used for some participants who were more comfortable with English i.e, had higher education levels. The survey was done with the support of five local enumerators. Before the survey, these were trained during a 3-day session on how to select one female household member, following ethical procedures i.e., consenting and how to successfully administer a survey. The data was extracted as an Excel sheet, including all variables, and checked for completeness.

Participation was voluntary, and all study participants provided informed consent before completing the survey. The participants were free to withdraw from the study if they wished. All participants who provided consent fully participated in the survey by answering all the survey items. Participants who declined to provide informed consent were excluded. The principles of confidentiality and anonymity were prioritised during the study. The study received ethical approval from the Mbarara University of Science and Technology Research Ethics Committee (MUST-REC), reference number MUST-2023–1221. The study also received approval from the Uganda National Council of Science and Technology (UNCST), reference number SS2319ES.

3.3. Data analysis

We considered the logit regression as a suitable approach to identify the determinants of biomass briquettes adoption [49], with adoption (yes/no) as the dependent variable. We define adoption of biomass briquettes in this study as a household which uses or is familiar with the use of biomass briquettes as primary, secondary or tertiary cooking source. Hence, households which only use biomass briquettes as third or fourth cooking source are also considered adopters, because they have started using biomass briquettes and may increase their use in the future. The definition is premised on studies that highlight fuel stacking as a common practice in most Low-and Middle-Income Countries (LMICs), which imply that households use multiple clean cooking

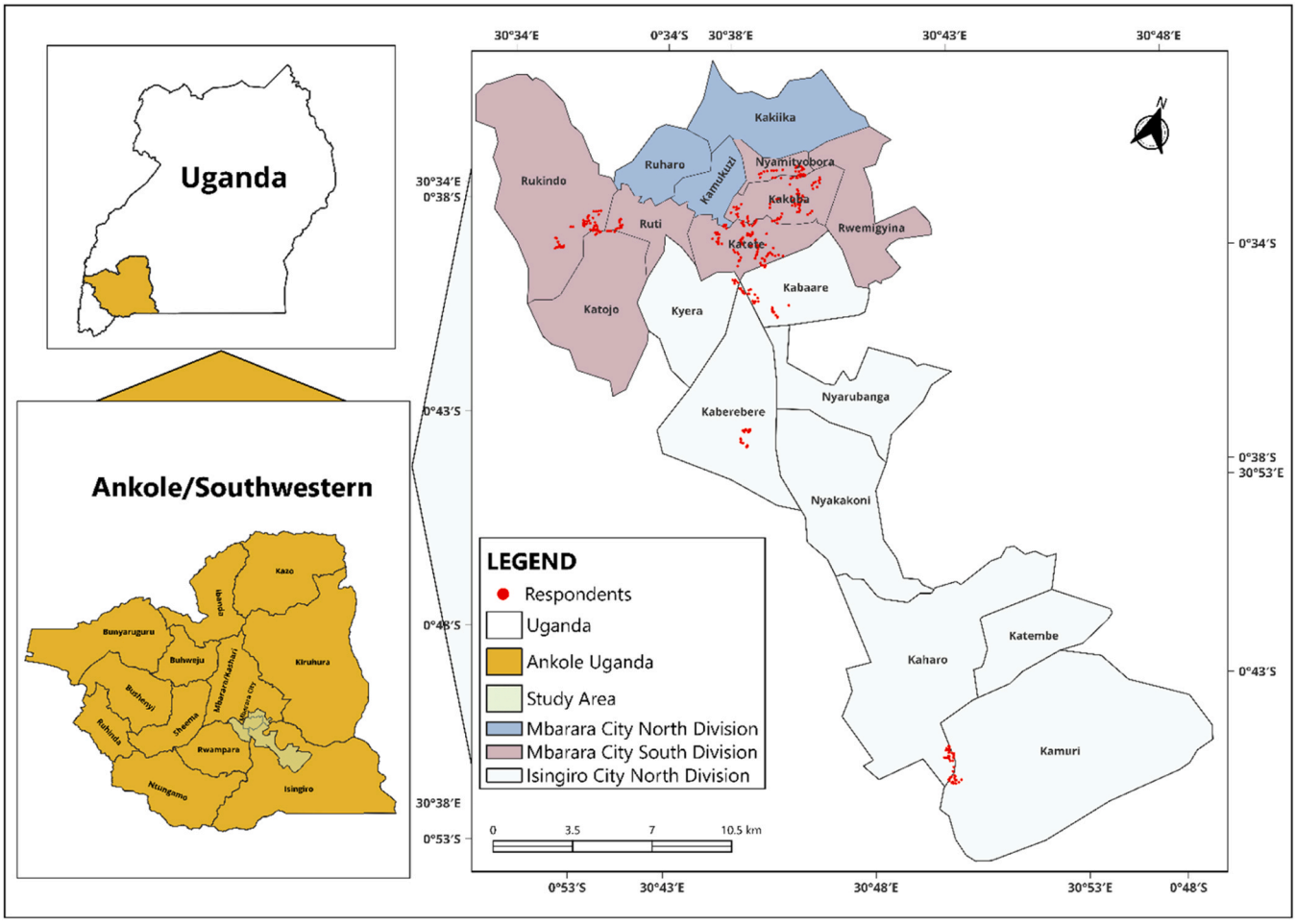

Fig. 7. Map showing the locations of households in Mbarara City South Division and Isingiro North County where data was collected. The map was drawn using ArcGIS, 2026.

technologies simultaneously [50,51]. Accordingly, the dependent variable captures whether a household has adopted and uses biomass briquettes, irrespective of the intensity of use. The results should therefore be interpreted as determinants of biomass briquette adoption and use rather than determinants of primary or exclusive biomass briquette reliance.

The analysis started by assessing the suitability items for each construct; we later refer each to as a "factor". A factor is a combination of different items which we considered to be homogeneous based on the survey using seven constructs of UTAUT2 and the LEK construct. This was achieved by conducting an Exploratory Factor Analysis (EFA) using R. In total, 38 items were subjected to EFA using Unweighted Least Squares (ULS). We used Kaiser-Meyer-Olkin (KMO) to test for factor adequacy, followed by Bartlett's test of sphericity. This step informed the exclusion of items based on test results below the threshold, i.e., factor loadings below 0.4 were considered to have no strong loading and were excluded, and communalities below 0.3 were excluded as well. This was to ensure that items within a construct are sufficiently correlated and accurately represent the construct. After excluding items with low communalities or factor loadings, construct scores were calculated as the mean of the retained items within each construct and used as explanatory variables in the regression models. Overall, KMO was 0.87 for all 38 items, and Bartlett's test was $\chi^2(703) = 10097.836$, $p < 0.001$. The results from KMO and Bartlett's tests indicated that the dataset (items within the variable) was sufficiently correlated and was suitable for factor analysis. There are 5 items which were flagged for removal due to either low communality or due to weak factor loadings. Thus, 33 items were retained. Reliability test i.e., Cronbach's alpha, was done for each construct, as shown in *Appendix B*. A binary logit regression model was used to (i) identify which core determinants or constructs of the UTAUT2 and LEK significantly influence adoption, and (ii) to understand how socio-demographics influence the adoption of biomass briquettes. Biomass briquette adoption is the dependent variable in our model and is coded as a binary variable, taking the value of 1 for participants using biomass briquettes as a primary, secondary or complementary source of energy, and 0 otherwise. Non-adopters are respondents who had not yet used biomass briquettes for cooking at the time of the survey.

Based on the above, we estimate the following model:

$$\text{logit}(\pi) = \text{logit}(P(Adoption = 1)) = \beta_0 + \beta_1 PE + \beta_2 EE + \beta_3 FC + \beta_4 SI + \beta_5 HM + \beta_6 PV + \beta_7 HE + \beta_8 LEK + \gamma X + \varepsilon$$

π means; Probability that Adoption = 1

P(Adoption = 1) = Probability that the household successfully Adopted biomass briquettes

logit(π) = Natural logarithm of the odds of adoption, which transforms probability values (0−1) into values from $-\infty$ to $+\infty$.

β_0 = Intercept or constant term (baseline log-odds when all predictors = 0)

$\beta_1 PE$ = Regression coefficients showing the effect of Performance Expectancy on adoption

$\beta_2 EE$= Regression coefficients showing the effect of Effort Expectancy on adoption

$\beta_3 FC$= Regression coefficients showing the effect of Facilitating Conditions on adoption

$\beta_4 SI$= Regression coefficients showing the effect of Social Influence on adoption

$\beta_5 HM$= Regression coefficients showing the effect of Hedonic Motivation on adoption

$\beta_6 PV$= Regression coefficients showing the effect of Price Value on adoption

$\beta_7 HE$= Regression coefficients showing the effect of Habit and Experience on adoption

$\beta_8 LEK$= Regression coefficients showing the effect of Local Ecological Knowledge on adoption

X is a vector of sociodemographic characteristics, including age, education level, household income, marital status, and location;

γis the vector of coefficients associated with sociodemographic variables

ε= Random error term/unexplained variation not captured by the predictors.

To account for the possibility that geographically proximate households exhibit similar adoption behaviour, we estimated the model using Conley adjusted standard errors with a distance cutoff of 15 km [52]. This approach does not affect the estimated coefficients but adjusts standard errors to account for spatial dependence among observations located near one another. The resulting estimates provide robustness check of whether the significance of the UTAUT2 constructs, and sociodemographic determinants remain unchanged after accounting for spatial correlation.

4. Results

4.1. Socio-demographic characteristics and household energy use in Mbarara and Isingiro

Appendix C provides a detailed overview of the socio-demographic characteristics of respondents and their household energy use. Of the 387 participants, 79% resided in Mbarara City South Division, while 21% lived in Isingiro North County, which is an outcome of the proportionate sampling. Most of the participants were married (75%). The participants' average age was 34 (SD = 10 years), with 75% of the study participants being 39 years or younger. The average household size was about 4 people (SD = 2 people). Self-employment was the main occupation, accounting for 67%, and 23% were unemployed. Business [shop/store/mobile trader] was the main source of income (60%), and 85% of the participants earned less than 300,000[4] Uganda shillings per month. Compared to the population statistics of the Ankole region, where this study was conducted, our sample has a similar household size (population average is 4.2). However, unemployment in the region is 14.7%, indicating that unemployment in our study sample is higher compared to the regional level [41].

Although 21% of the participants reported using biomass briquettes, their use was predominantly complementary, with few households relying on briquettes as a primary or secondary cooking fuel. The majority (60%) stated that they would likely adopt biomass briquettes, but were not sure when, 14% will likely adopt within 5 years, and 5% responded that they will never adopt. The participants who responded that they will never adopt biomass briquettes were asked why. They highlighted reasons such as not knowing how to use briquettes, not having sufficient information about them, and being comfortable with the current sources of energy. Other reasons included the limited access to briquettes, a lack of interest, and having no time to make the briquettes for themselves. Some of the previous users highlighted that the briquettes did not work well in terms of meeting their cooking expectations when they were previously used, and they also perceived them to be expensive compared to charcoal or wood. Concerns were raised that biomass briquettes were not seen as clean or convenient. The participants highlighted that briquettes can make the cooking place dirty, and that briquettes could smell in the house since some of the briquettes are made of cow dung. The study revealed that 53% of the participants rated their level of knowledge about biomass briquettes as low.

Regarding other energy sources, 83% of households relied on charcoal as the primary source of cooking energy, followed by firewood (13%). Charcoal remained the dominant secondary source of energy (44.7%) for these households, followed by LPG (19.1%). A small percentage used biomass briquettes as their primary source of energy (0.5%), a secondary source of energy (3.6%), although a 21% of the participants mentioned having adopted biomass briquettes as the third or fourth alternative. Compared to the Ankole region, a larger part of our sample uses charcoal as their primary source (83% vs 21.6%), because charcoal is more preferred to firwood in urban areas and peri-urban areas compared to typical rural settings. Firewood use is underrepresented in our sample (13% vs 71.8%), and this could be attributed to the fact that urban and peri-urban settings are likely to use charcoal rather than firewood. The use of LPG (3% vs 0.8), electricity (1% vs 1.7%) and other cooking energy sources (1% vs 4.1%) aligns relatively well with the population use rates [41]. Most households (68%) spent between 30,000 and 60,000 Uganda shillings per month on energy for their cooking. Indoor cooking accounted for 72% of households' cooking location, and 98% of the cooking was done by a female household member, with only 2% mentioning cooking as a shared responsibility. The energy use patterns reveal and confirm an indication of energy stacking among households in Mbarara and Isingiro. Although biomass briquettes are being used by 21.19% of the respondents, only 2 respondents (0.54%) use biomass briquettes as their primary energy source for cooking. Even as a second energy source, the adoption rate of biomass briquettes is limited (3.2%). The findings are closely related to the literature estimating energy stacking levels between 28% and 100% in Sub-Saharan Africa [53]. These findings also demonstrate that SDG 7 will probably be missed by a larger margin and explain why Sub-Saharan Africa's energy transition is so far behind.

4.2. Factor analysis results

Table 1 provides a detailed summary of the survey items used to measure each construct.[5] As explained in Section 3.2, exploratory factor analysis was done to categorise and reduce the 38 items to 8 factors. The factors are derived from the seven constructs of UTAUT2 and one construct of LEK. During this factor analysis, 5 items were removed: PE4, EE5, EE4, PV4 (due to no strong loading), and LEK1 (due to low communality). Out of the 38 UTAUT2 and LEK items, only 33 were fit for further analysis, as shown in Table 1. A combination of the 8 factors explains 71% of the observed variance. These 8 factors are the independent variables in the present study. We hypothesise that these factors explain households' adoption of biomass briquettes (dependent variable) for cooking.

[4] €1 *EUR* = Uganda shillings 4137 (Exchange rate as of Feb 2026)

[5] The seven constructs of UTAUT2 in this section are referred to as factors. LEK is another factor. In total, the analysis is based on these 8 factors.

Table 1
Constructs and their items with summary statistics (Mean, SD, Factor Loadings).

Construct	Item No	Item statement	Mean	SD	Factor Loading
Performance Expectancy (PE)	PE1	Using biomass briquettes is useful for daily life	4.51	0.98	0.89
	PE2	Using biomass briquettes helps accomplish cooking tasks more quickly than using firewood or charcoal	4.03	1.17	0.74
	PE3	Using biomass briquettes requires less cooking time compared to the use of firewood or charcoal	3.98	1.15	0.68
	PE4	Overall, using biomass briquettes could be beneficial to me[#]	_	_	_
Effort Expectancy (EE)	EE1	Learning how to use biomass briquettes is easy; the experience with using charcoal is sufficient	4.68	1.11	0.95
	EE2	It is easy to find a briquette supplier	3.25	1.36	0.92
	EE3	Biomass briquettes are available within a reasonable distance	3.3	1.43	0.94
	EE4	Using biomass briquettes requires less supervision (allowing me to do other tasks) compared to the use of charcoal or firewood[#]	_	_	_
	EE5	Using biomass briquettes requires little effort[#]	_	_	_
Social Influence (SI)	SI1	People who are important to me influence my decision to adopt or not to adopt biomass briquettes	4.38	1.44	0.89
	SI2	People who influence my behaviour think that I should adopt biomass briquettes	4.39	1.52	0.94
	SI3	People whose opinion I value influence my decision to adopt or not to adopt biomass briquettes	4.44	1.52	0.93
	SI4	Overall, people influence my decision to adopt or not to adopt biomass briquettes	4.48	1.47	0.93
	SI5	Brand or marketing mostly influence the choice of an energy source for cooking in my household	4.69	1.59	0.67
Facilitating Conditions (FC)	FC1	I have the equipment and auxiliaries needed to use biomass briquettes	4.41	1.36	0.72
	FC2	I have the knowledge necessary to use biomass briquettes	4.44	1.52	0.83
	FC3	Biomass briquettes are compatible with other cooking technologies I use (traditional cookstove)	4.7	1.24	0.78
	FC4	I can get help from others when I have difficulties using biomass briquettes	4.42	1.3	0.73
	FC5	Overall, all necessary conditions to support the use of biomass briquettes are present	4.47	1.33	0.76
Hedonic Motivation (HM)	HM1	Using biomass briquettes makes cooking more fun and enjoyable	4.51	1.12	0.97
	HM2	Using biomass briquettes makes cooking more entertaining	4.52	1.12	0.98
	HM3	Overall, the use of biomass briquettes makes the cooking experience more fulfilling	4.52	1.16	0.95
Price Value (PV)	PV1	Biomass briquettes are reasonably priced	4.26	0.84	0.95
	PV2	At the current price (Ug shs 1000–1500 per kg), biomass briquettes provide a good value	4.32	0.92	0.94
	PV3	Overall, biomass briquettes are affordable	4.41	0.95	0.86
	PV4	Government should subsidize the adoption of biomass briquettes[#]	_	_	_
Habit and Experience (HE)	HE1	I would be willing to try using biomass briquettes	5.48	1.32	0.71
	HE2	The use of biomass briquettes could become a habit for me	5.07	1.29	0.87
	HE3	I could get addicted to using biomass briquettes	4.9	1.32	0.91
	HE4	Using biomass briquettes could become natural to me	4.96	1.32	0.86
	HE5	I am (ready to start) using biomass briquettes, but only in combination with other energy sources (firewood, charcoal, LPG, electricity…)	5.13	1.35	0.73
	HE6	Overall, I am (ready to start) using biomass briquettes for all my cooking	4.8	1.44	0.74
Local Ecological Knowledge (LEK)	LEK1	Sharing of cooking experiences with local community will stimulate the adoption of biomass briquettes[#]	_	_	_
	LEK2	In my community, there is experience in using agricultural residues and organic waste to make biomass briquettes	4.34	1.51	0.65
	LEK3	I frequently observe environmental problems related to the use of firewood and charcoal	4.82	1.56	0.59
	LEK4	Within my community, we often have discussions on the sustainability of energy	4.15	1.57	0.86

(continued on next page)

Table 1 (*continued*)

Construct	Item No	Item statement	Mean	SD	Factor Loading
		resources used for cooking			
	LEK5	My community recognizes the environmental problems related to the use of firewood and charcoal	4.3	1.56	0.91
	LEK6	My community fully supports the use of biomass briquettes	4.36	1.59	0.85

[#] Items were excluded during factor analysis and logit regression because of low communality (below 0.3) or the score on test items was less than 0.4, the recommended factor loading threshold.

Table 2
Wilcoxon rank sum test for explanatory constructs, comparison between adopters and non-adopters of biomass briquettes.

Explanatory variables	Mean for adopters (n = 82)	Mean for non-adopters (n = 305)	Wilcoxon z-stat
PE	0.882	-0.251	9.551***
EE	0.890	-0.254	9.793***
FC	0.897	-0.253	9.998***
SI	0.091	-0.023	1.066
HM	0.757	-0.213	8.136***
PV	0.728	-0.208	9.121***
HE	0.474	-0.134	4.873***
LEK	0.135	-0.038	1.254

Notably, SI and LEK show no significant difference between adopters and non-adopters (z = 1.066 and 1.254, respectively), which is consistent with the logit results presented below. The Wilcoxon results thus provide initial descriptive evidence for the patterns confirmed by the regression analysis.

4.3. Logit regression results

To assess how adopters and non-adopters score differently in terms of the different constructs, we conducted Wilcoxon rank-sum tests. Table 2 shows the results of the Wilcoxon rank test for each of the constructs (all UTAUT2 constructs and LEK) included in our model, before presenting the results of the logistic regressions. The results show that adopters and non-adopters differ significantly for most of the constructs. Overall, adopters score differently from non-adopters, with the scores ranging from 0.091 to 0.897 (adopters) and −0.245–0.023 (non-adopters).

We run a logit model to assess the determining factors for biomass briquette adoption. We additionally control for sociodemographic information such as age group, income level, education, and whether the household is located in a peri-urban or urban area. The model accuracy is sufficient,[6] with the model making correct predictions in 85% of the cases.

Table 3 presents the model results. The results indicate that Facilitating Conditions (FC) and Hedonic Motivation (HM) were significantly associated with adoption. Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Habit & Experience (HE) and Local Ecological Knowledge (LEK) were not statistically significant in the model. This model further suggests that in addition to FC and HM, households where the female member was 45 years and above, or with lower secondary education, or were living in Mbarara City South Division, were more likely to adopt biomass briquettes.

[6] When a model predicts that a household has a 50% probability or higher of adoption biomass briquettes, we consider this prediction as 'Adopter' and vice versa. The model does this correctly in over 80% of cases.

Table 3
Factors explaining the likelihood of adopting biomass briquettes.

Variables	Model	OR (95% CI)
Performance Expectancy (PE)	-0.070	0.93 (0.63–1.36)
	(0.194)	
Effort Expectancy (EE)	0.291	1.34 (0.89–2.03)
	(0.211)	
Facilitating Conditions (FC)	0.937***	2.55 (1.70–3.90)
	(0.120)	
Social Influence (SI)	-0.202	0.82 (0.63–1.05)
	(0.128)	
Hedonic Motivation (HM)	0.470*	1.60 (1.08–2.40)
	(0.202)	
Price Value (PV)	0.347	1.42 (0.94–2.18)
	(0,214)	
Habit & Experience (HE)	0.046	1.05 (0.70–1.56)
	(0.2023)	
Local Ecological Knowledge (LEK)	-0.069	0.93 (0.68–1.28)
	(0.159)	
Age 25–34	0.595	1.81 (0.69–5.14)
	(0.509)	
Age 35–44	0.707	2.03 (0.69–6.28)
	(0.558)	
Age 45+	1.246*	3.48 (1.09–11.88)
	(0.607)	
Lower secondary	0.784*	2.19 (1.04–4.74)
	(0.386)	
Upper secondary	-0.270	0.76 (0.18–2.72)
	(0.686)	
Vocational	-0.734	0.48 (0.16–1.30)
	(0.528)	
University+	-0.529	0.59 (0.11–2.58)
	(0.798)	
Medium income (100k – 300k UgX)	-0.098	0.91 (0.46–1.80)
	(0.347)	
High Income (>300k UgX)	-0.280	0.76 (0.26–2.08)
	(0.523)	
Not married	0.516	1.68 (0.80–3.49)
	(0.375)	
Mbarara City South Division	1.186*	3.27 (1.23–10.08)
	(0.532)	
Observations	387	
Log Likelihood	-133.68	
AIC	307.36	
BIC	386.53	
Deviance	267.36	
Null Deviance	399.73	
Pseudo R2	0.331	

Notes: standard errors in brackets, stars for statistical significance *** p<. 001, ** p<.01, *p<.05. Detailed results are shown in *Appendix D*.

Table 3 shows that the presence of facilitating conditions (FC factor) is a significant associated with the adoption of biomass briquettes. According to the results in Table 3, the Hedonic Motivation (HM factor) is also a key determinant for the adoption of biomass briquettes. How joyful, entertaining, and fulfilling a cooking experience is, determines the adoption. These findings suggest that perceptions of an enjoyable cooking experience may be associated with higher adoption rates.

Although Price Value (PV) was not statistically significant in the conventional logit model (p = 0.105), the positive coefficient suggests that households perceiving biomass briquettes as affordable and offering good value may be more likely to adopt them. However, the evidence is insufficient to conclude that price value is associated of adoption

Surprisingly, five out of eight factors are not significant associated biomass briquette adoption. Considering the low values for the Variance Inflation Factors (VIFs) in *Appendix E*, this lack of significance is not attributable to multicollinearity.

For socio-economic characteristics, we find that participants who are over 45 years of age, or have a lower secondary educational level, or are living in Mbarara City are more likely to adopt biomass briquettes. There was no significant influence of marital status and income in this model. Participants with "Lower secondary" education in this study are more likely to adopt biomass briquettes, which can possibly be attributed to

the less time value they likely to attach to biomass briquettes use. Those with higher levels of education may likely attach a lot of value to their time, considering, for example, if both groups are to produce biomass briquettes themselves. There is also a possibility that participants with higher education are more aware of other alternatives like Liquefied Petroleum Gas (LPG), electricity, or income confounding and thus likely to adopt other alternatives than biomass briquettes.

A sensitivity analysis using Conley-adjusted standard errors with alternative distance cutoffs, i.e., 5 km, 10 km, and 15 km as shown in *Appendix X* showed that Facilitating Conditions remained significant throughout. The significance of EE, PV and SI depends on the spatial cutoff used in the Conley adjustment. These effects emerge at larger cutoff distances (10–15 km) but not consistently at smaller distances, suggesting that evidence for these associations is less robust than for facilitating conditions.

5. Discussion

Our study aimed at identifying the associated factors of UTAUT2 and LEK with the adoption of biomass briquettes for cooking in Uganda. Two factors out of eight i.e., Facilitating Conditions (FC) and Hedonic Motivation (HM), were found to be statistically significantly associated with adoption.

Respondents who have the equipment and knowledge necessary for using biomass briquettes are more likely to adopt. The results also highlight that compatibilities with other cooking methods enable biomass briquettes adoption. In communities where there are other users, there are possibilities that they can assist in helping those starting to adopt biomass briquettes. This highlights the importance of living close to those who have already adopted as one of the facilitating conditions. The FC factor included having equipment and auxiliaries, knowledge, compatibility with other cooking technologies, and the ease of getting help from others. A previous study by Neves et al. [25] also highlighted the FC factor as a determinant of technology adoption.

HM factor included biomass briquettes making cooking more enjoyable, more entertaining, and associated with a more fulfilling cooking experience. Our results here differ from those of Neves et al. [25], who found that HM was not statistically significant. However, we do not necessarily expect our results to align with those of Neves et al. [25] as their study was carried out in a very different context (five European countries) and did not focus on biomass briquette use, but instead focused on sustainable technologies. This may imply that, compared to developed countries, developing countries where women participants' views differ on how different factors determine their adoption. In another study conducted in Kenya, Osiolo [51] found that HM determines cooking technology adoption, particularly for improved stove adoption. This study has a more similar context to ours, and its results are thus more comparable.

PV included price-related statements such as biomass briquettes being reasonably priced, providing good value, and being generally affordable. Neves et al. [25] found this construct to be significant in only some of the countries they studied (Greece, Italy, United Kingdom, but not in Germany and Portugal). Other studies using UTAUT2 have found that cost is a barrier to technology adoption. We found that price value was not statistically significant in the conventional model, although the estimated coefficient was positive. The spatial robustness analysis produced mixed evidence, with significance emerging only under larger spatial cutoff distances. Consequently, the results suggest that affordability may play a role in adoption decisions, but the evidence is not sufficiently robust to conclude that price considerations are among the primary determinants of adoption. Nevertheless, given the low-income profile of the study population, the affordability of biomass briquettes is likely to remain an important consideration for future adoption. Household's decision to use a source of energy as a primary or secondary or third or fourth alternative is an evidenced of energy stacking as often referred to in literature [51,53–55].

Policymakers could intervene by ensuring that these items mentioned under each of the significant factors are facilitated and realised. Targeted interventions could include supporting cooking experiments and demonstrations in local communities, to enable communities to gain experience in using and believing that indeed, biomass briquettes cook efficiently. This is well aligned with some items of the FC and HM factors. While there may be no direct policy recommendations for HM, we believe that engaging users and non-users in biomass briquette cooking experiments and demonstrations could make them feel the enjoyment and fulfilment associated with using biomass briquettes and motivate adoption. For users, they could have an opportunity to share their experiences, challenges and co-create strategies to make cooking with biomass briquettes more enjoyable. For PV, much as this construct was not statistically associated with adoption in the conventional model, policymakers could provide necessary support to keep prices as low as possible for low-income households as affordability is highlighted as is one of the key determinants of adoption in literature. This can be achieved through providing financial incentives, training local manufacturers, and linking them to the market to ensure sustainability for both production and the market. Some of these interventions e.g., financial incentives and microfinancing, have been recommended for renewable energy technology adoption [23]. However, this support is very limited or not currently provided to producers by the government of Uganda and could hinder the realisation of SDG 7.

In our study, the LEK factor was not significantly associated with the adoption of biomass briquettes, and this could be attributed to the items we used to assess this factor. The statements were rather practical and application-oriented, referring to the environmental problems caused by overreliance on charcoal and firewood and whether their communities were taking any actions. Taking a closer look into the overall scores of the LEK construct, we find that 63% of the participants scored above 0.5, and half of these participants scored 0.7 or higher. This demonstrates that participants are aware of negative effects associated with polluting energy sources such as firewood or charcoal. Even when one is aware of the negative effects of using charcoal or wood on the environment, they do not necessarily act. Implying that awareness about the environment does not guarantee the adoption of biomass briquettes by households. This result could imply that even when the households and communities appreciate the problem that affects them, they perceive their agency to be low. Thus, they are unable to act or are less willing to innovate to contribute to sustainable environmental and resource use. This highlights the need to empower communities to act at the community level, which could encourage social participation in energy-related ecological problems. The positive side of these results is that, although the LEK construct was not statistically significant, the overall LEK scores indicate that respondents are aware of the environmental impacts of charcoal and firewood use. This suggests that knowledge is present within the community and could provide a foundation for future interventions promoting clean cooking technologies. With appropriate support and enabling conditions, this awareness may contribute to increased biomass briquettes adoption in the future.

Other factors, especially the original constructs of UTAUT which were not significant, are social influence (SI), performance expectancy (PE), and effort expectancy (EE). A study conducted by Apfel & Herbes, [23] among the SME entrepreneurs in Senegal also found that SI did not play a role in determining the adoption of renewable energy technologies. A related study on the adoption of different cookstoves in Kenya found that SI did not determine their adoption [51]. Another study that combined socio-cultural factors found that these factors do influence the adoption of renewable energy technologies [56]. The non-significance of PE and EE may be explained by the low familiarity with biomass briquettes in our sample respondents who have never used biomass briquettes cannot meaningfully evaluate their performance. This finding highlights that PE and EE may only become a relevant driver after first use or exposure through demonstrations. Although EE was not significant in the conventional model, significance emerged for some spatially

adjusted specifications, as shown in *Appendix F*. This finding suggests that ease of use, supplier availability, and physical access to briquettes may become more important once local spatial dynamics are considered. Since our results are dependent on the chosen spatial specification, we interpret the associations of EE with adoption as suggestive rather than conclusive evidence. Future research should further investigate whether access-related barriers become increasingly important as the biomass briquettes market matures. Similarly, SI was not significant in the conventional model. However, after accounting for spatial dynamics, particularly the largest cutoff, a negative association emerged, though it was not consistent across all robustness checks, as shown in *Appendix F*. Therefore, there is insufficient evidence to conclude that SI is negatively associated systematically with adoption. One possible explanation is that biomass briquettes have not yet reached a level of social visibility or acceptance where peer influence strongly affects adoption decisions. Further research is needed to clarify the role of social networks and community are associated with the diffusion of biomass briquettes.

The model shows that women living in Mbarara are more likely to adopt biomass briquettes compared to women living in peri-urban locations. Future research could investigate context-specific aspects to further explain this finding. The demographics revealed that priority should be given to peri-urban settings, given that the ever-increasing population in peri-urban areas rely on shrinking energy sources and needs alternative sources. Although urban households are associated with adoption biomass briquettes, adoption remains low. Adoption could be scaled up by intervening based on three significant factors identified in this study to achieve wider adoption of briquettes in urban settings. Since income was not statistically significant, if biomass briquettes meet the cooking needs of the users, people of different income groups, low, medium or high will likely adopt them, on the condition that they are perceived as affordable (PV factor).

5.1. Study limitations

We acknowledge that our study has limitations. We did not collect detailed information on frequency of use, duration of use, consumption volumes, stove type, combustion performance, or detailed quality assessments of biomass briquettes. Given the relatively low adoption rate within our sample, many respondents had limited direct experience with briquettes and would therefore have been unable to provide reliable information on several of these aspects. During data collection, we did not cluster data per ward, and it is not possible in the current study to cluster standard errors in each ward. However, we have accounted for spatial differences with varying cutoff distances, to strengthens the analysis. The biggest percentage of the participants use biomass briquettes as the 3rd or 4th alternative, usually described as energy stacking; we cannot conclude that the same factors are associated with the adoption of biomass briquettes for primary or secondary source of energy. Our analysis does not differentiate between different intensities of use and therefore does not identify the associations for primary or exclusive reliance on biomass briquettes. However, we are confident that whether used as the first, second or any other alternative, the experience and functionality might not differ, and the associations could remain the same. Since the adopters differ from non-adopters, we cannot be certain of causal relationships between the independent variables and adoption. Therefore, although our results reveal that higher values for FC and HM are associated with a higher likelihood of adoption of biomass briquette use, we cannot claim that influencing these factors through policy interventions will, with certainty, increase the adoption of biomass briquettes.

6. Conclusion

In this study, the determinants for household adoption of biomass briquettes in Uganda were assessed. Facilitating conditions emerged as the most robust determinant of biomass briquette adoption, while hedonic motivation was consistently associated with adoption across most model specifications. The spatial robustness analysis further suggests a potential role for effort expectancy and price value, although these relationships were sensitive to the choice of spatial cutoff distance. Urban households are more likely to adopt compared to those in peri-urban areas, although other contextual factors in urban settings, which were not explored in this study, could contribute to this outcome. Whereas we anticipated that LEK is associated with the adoption of biomass briquettes, our study concludes that LEK was not significant. Future research could investigate other items to build the LEK construct or study underlying explanations for this outcome.

Authors' contributions

Conceptualisation, methodology, data collection, formal analysis data curation, validation, interpretation, writing original draft, review, and editing (JA); conceptualisation, methodology, checking analysis output, review, editing, and supervision (CF, TC); validation, interpretation, analysis, interpretation, review and editing (CNN), conceptualisation, interpretation, review and editing (LE); methodology, data collection, review, editing, interpretation (CN), interpretation, review and editing (IK, TO, JVC).

CRediT authorship contribution statement

Justus Asasira: Writing – review & editing, Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Charlotte Fabri:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Laura Enthoven:** Writing – review & editing, Validation, Methodology, Conceptualization. **Tom Ogwang:** Writing – review & editing, Validation, Supervision. **Imelda Kemeza:** Writing – review & editing, Validation. **Constance Nakato Nakimuli:** Writing – review & editing, Validation, Formal analysis. **Calorine Natuhwera:** Writing – review & editing, Methodology, Data curation. **Jo Van Caneghem:** Writing – review & editing, Validation, Supervision. **Tine Compernolle:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization.

Ethical approvals

The study received ethical approvals from the Mbarara University of Science and Technology Research Ethics Committee (MUST-REC) under reference number MUST-2023–1221. The study also received approval from the Uganda National Council of Science and Technology (UNCST) under the reference SS2319ES.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Parishes and Wards where the survey was conducted

Enumeration Area	Wards	No. Participants
Mbarara City South Division	Katete	81
	Kakoba	91
	Ruti	21
	Rukindo	49
	Nyamityobora	62
Isingiro North County	**Wards**	
	Kamuri	16
	Kaharo	18
	Kaberebere South	10
	Kaberebere East	6
	Kaberebere West	4
	Parishes	
	Kyeera	10
	Kabaare	19
	Total	**388**

Appendix B. Cronbach's alpha

Construct	N_Complete Cases	Cronbach_Alpha
PE	387	0.708
EE	387	0.686
SI	387	0.919
FC	387	0.843
HM	387	0.937
PV	387	0.772
HE	387	0.893
LEK	387	0.849

Appendix C. Socio-demographic characteristics and household energy use in Mbarara and Isingiro

Variable	N	Percent
Marital Status	**387**	
Divorced/separated	24	6%
Married	292	75%
Single	50	13%
Widow	21	5%
Location	**387**	
Isingiro North County (rural/peri-urban)	83	21%
Mbarara City South Division (urban)	304	79%
Main Occupation	**387**	
Employed in private sector (private)	17	4%
Employed in public sector (government)	7	2%
Self employed	259	67%
Student	1	0%
Unemployed	88	23%
Working in the informal sector	15	4%
Source of Income	**387**	
Agricultural/on-farm work	32	8%
Business[shop/store/mobile trader]	231	60%
Casual employment	47	12%
Formal employment [professional]	21	5%
No income	34	9%
Remittances from relatives/friends	22	6%
Monthly Income	**387**	

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Variable	N	Percent
100,001–300,000shs	181	47%
300,001–500,000shs	41	11%
500,001–700,000shs	5	1%
700,001–900,000shs	2	1%
Above 900,001	11	3%
Less than 100,000shs	147	38%
Primary Source Energy	**387**	
Briquettes	2	1%
Charcoal	320	83%
Electricity	4	1%
Firewood	49	13%
LPG (gas)	12	3%
Secondary Energy Source	**387**	
Charcoal	173	45%
LPG (gas)	74	19%
Firewood	66	17%
Electricity	49	13%
Briquettes	14	3%
Biogas	2	1%
Others (Kerosene)	9	2%
Energy Expenditure	**387**	
120,000–150,000Ugshs	3	1%
30,000–60,000Ugshs	265	68%
60,000–90,000Ugshs	52	13%
90,000–120,000Ugshs	12	3%
Less than 30,000Ugshs	54	14%
More than 150,000Ugshs	1	0%
Cooking Location	**387**	
Both indoor and outdoor	35	9%
Indoor	242	63%
Outdoor	110	28%
Gender of Person Cooking	**387**	
Equally shared by both	8	2%
Female	379	98%
Knowledge about biomass briquettes		
High	97	25%
Medium	85	22%
Low	205	53%
Adoption of biomass briquettes	**387**	
Already using	82	21%
Likely to adopt within 1 year	34	9%
Likely to adopt within 2–5 years	19	5%
Likely to adopt but now sure when	233	60%
Will never adopt	19	5%

Appendix D. Model constructs +Demographics

Construct	Beta	SE_Beta	Beta.CI95	P	Sig
PE	-0.07	0.194	[-0.455, 0.309]	0.719	
EE	0.291	0.211	[-0.121, 0.71]	0.168037	
FC	0.937	0.21	[0.533, 1.361]	8.22E-06	***
SI	-0.202	0.128	[-0.457, 0.048]	0.115362	
HM	0.47	0.202	[0.08, 0.875]	0.019893	*
PV	0.347	0.214	[-0.065, 0.779]	0.104708	
HE	0.046	0.203	[-0.354, 0.444]	0.819462	
LEK	-0.069	0.159	[-0.382, 0.245]	0.663782	
AgeGroup25â€“34	0.595	0.509	[-0.371, 1.638]	0.242339	
AgeGroup35â€“44	0.707	0.558	[-0.364, 1.838]	0.205166	
AgeGroup45+	1.246	0.607	[0.082, 2.475]	0.03997	*
EducationLevel_collapsedLower_secondary	0.784	0.386	[0.038, 1.556]	0.042131	*
EducationLevel_collapsedUpper_secondary	-0.27	0.686	[-1.737, 1.002]	0.694324	
EducationLevel_collapsedVocational	-0.734	0.528	[-1.819, 0.265]	0.164168	
EducationLevel_collapsedUniversity_or_higher	-0.529	0.798	[-2.252, 0.946]	0.507311	
IncomeGroup_collapsedMedium_income_100k-300k	-0.098	0.347	[-0.779, 0.586]	0.777847	
IncomeGroup_collapsedHigh_income_>300k	-0.28	0.523	[-1.331, 0.73]	0.592027	
MaritalStatus2Not_married	0.516	0.375	[-0.226, 1.25]	0.168628	
Location2Mbarara City South Division	1.186	0.532	[0.204, 2.311]	0.025885	*

*** p<. 001, ** p<.01, *p<.05

Appendix E. Glm M1 VIFs

Factor	VIF
PE	1.371407
EE	1.31296
FC	1.434383
SI	1.254698
HM	1.764435
PV	1.20274
HE	1.693154
LEK	1.256582

Appendix F. Compared p-values for Conley spatially selected cutoff (5 km, 10 km and 15 km)

Variable	5 km Conley adjusted p-value	10 km Conley adjusted p-value	15 km Conley adjusted p-value
FC	<0.001	<0.001	<0.001
EE	0.067	0.009	0.004
SI	0.109	0.084	0.033
HM	0.065	0.008	0.003
PV	0.154	0.056	0.026
Age 35–44 years	0.071	0.056	0.031
Age ≥45 years	0.050	0.048	0.019
Lower secondary education	0.009	<0.001	<0.001
Vocational education	<0.001	<0.001	<0.001
University or Higher education	0.299	0.107	0.050
Not married	0.13	0.020	0.010
Location (urban)	0.010	0.001	0.001

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