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Assessing the Farmers' Perceptions towards the use of Humanure in Tharaka Nithi and Kajiado Counties for Agricultural Sustainability

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Abstract: *In response to escalating global concerns about environmental degradation and resource scarcity, the effective management of human waste termed humanure is crucial, especially in urban environments. This study explores the factors affecting the uptake of the Urine Diversion Dry Toilet (UDDT), in this study termed Green Toilet Systems (GTS), comprehensively assessing the factors influencing adoption from deposition of faeces in the UDDT to the final humanure output.*

The research conducted in Kajiado and Tharaka Nithi counties seeks to assess the factors influencing the uptake of GTS technology in Kenya, with a focus on factors such as gender, design, attitude, awareness, and perceptions.Purposive sampling was used in this study to choose the target populationof 341 respondents through semi-structured qualitative interview guides. The study employed quantitative analysis including descriptive, regression, and correlational analysis methods. A substantial 75% of the 335 respondents were unaware of the GTS technology, with varied levels of exposure across the two counties and demographic groups.Correlation analysis between female respondents and GTS technology acceptance indicated statistical significance (p= 0.737) implying a weak correlation. Additionally, regression analysis on farmers' perceptions of human manure yielded a p-value of 0.172, surpassing the conventional. In conclusion, the study provides valuable insights into the awareness, uptake, usability, and perceptions surrounding GTS technology, highlighting the need for targeted awareness campaigns and addressing cultural barriers for broader acceptance and sustainable implementation of GTS technology in Kenya.

1. INTRODUCTION

1.1 Background and Justification for the Research

In the wake of growing global concerns about environmental degradation and resource scarcity, the effective management of human waste sometimes termed humanure is crucial, especially in urban environments (Hallett et al., 2017). Poor sanitation poses a significant threat to the well-being and health of the populace in developing countries(Corvalán et al., 2003). Disease incidences, severe health problems, and even deaths are linked to a lack of safe sanitation facilities and unsafe hygiene practices. According to (Fotio&Nguea, 2022) 2.4 billion people, the majority of whom are in developing countries, lack access to safe sanitation facilities, exposing them to the risk of communicable diseases such as diarrhoea, cholera, dysentery and typhoid. In a bid to bridge the gap in the adoption of safe sanitation facilities, and to encourage safe hygiene practices, safe sanitation facilities have been designed and availed in the global market(Shah et al., 2013). Ecosan, a short form for Ecological Sanitationtoilets have emerged as a sanitation system that is less environmentally damaging than other toilet systems (Nienhuys, 2012).

This study explores the factors affecting the uptake of the Urine Diversion Dry Toilet (UDDT), in this study termed Green Toilet Systems (GTS), comprehensively assessing the factors influencing adoption from deposition of faeces in the UDDT to the final humanure output.GTS has emerged as a significant facility for the safe disposal of human excreta. This technology separates urine and solid

excreta, enabling their treatment through decomposition. The decomposed excreta, after undergoing the decomposition process, is intended for use in agricultural practices, thereby closing the loop and promoting a circular economy concept within the water, sanitation, and hygiene (WASH) sector(Aalto &Bodjawah, 2015).

The GTS is relatively hygienic and more suitable for human waste management and resource recovery, yet its uptake is still significantly low in Kenya compared with other countries (Kamau & Njiru, 2018). One of the possible reasons for the low uptake is the current design of the facilities, which among others, lack the toilet hole opening and closing mechanisms, and design precautions that limit exposure of the users to the human excreta. Further, unpublished reports from a section of users suggest that the design of GTS urine/faecal drop holes is more suited to male users as opposed to female users.

GTS functions on the principle that fresh urine has no smell, and the adoption of a sanitation system that separates faeces from urine ensures not only affordable but safe human waste disposal(Devkota & Bastien, 2019). However, appreciating the fact that there are different cultural, and religious beliefs, the usage of these systems dictates the quality of the end product produced. In Nepal for instance, the acceptance levels of GTS are high among the participants who had greater awareness, with the younger participants being the majority (Devkota & Bastien, 2019). In South Africa, older users did not fully embrace the usage of the GTS, with many parents discouraging their children from using it. In Uganda, there has been awareness created of the benefits of GTS, but the acceptability is still unclear (Kamuteera et al., 2013). In Kenya, the uptake and usage of GTS facilities are low, especially amongst the younger users, despite the high levels of awareness.

Tharaka Nithi and Kajiado counties, the identified research areas, present a good opportunity for human faecal waste management and resource recovery, owing to the ease of identification of farmers, the peri-urban nature (Kajiado), the relatively high populations, and the presence of farmers in either of the counties. In Tharaka Nithi County, about 88% of the population uses pit latrines, with about 76% sanitation coverage (County Government of Tharaka Nithi, 2023). Kajiado County, with a population of 1,117,840 people has just about 40% household toilet coverage. 94% of those who lack sanitation coverage resort to open-field defecation(County Government Of Kajiado, 2018). It is on this background that a study on the uptake and acceptability of the GTS technology and final products is recommended in these two counties.

1.2 Problem Statement

Despite its numerous benefits, the adoption of GTS, and particularly the UDDTs technology has not been widespread in Kenya. UDDTs have the potential to contribute to improving sanitation coverage and resource recovery goals. However, several glaring shortcomings hinder their adaptation. One such challenge is the proper use of UDDT facilities. Users must be educated and trained on how to correctly utilize the technology to maximize its benefits. Without proper understanding and adherence to usage guidelines, the effectiveness of the system may be compromised. The other hindrance to widespread adoption is the lack of treatment facilities. Proper treatment of the collected waste is essential to ensure that it is safe for use in agriculture. Without access to treatment facilities, the viability and safety of the final product may be questionable, reducing the acceptance of the GTS-treated humanure as an alternative to inorganic fertilizers.

The perception and acceptance of the end product by farmers and other users also play a significant role in the adoption of UDDTs. Socio-cultural and economic factors, as well as demographic considerations, can influence people's opinions and willingness to adopt the technology. Additionally, factors such as the design and user-friendliness of the system, the fertility level of human waste compared to inorganic fertilizers, and the potential effects on food crops can impact acceptance.

To address concerns related to the quality and safety of the end product, testing of the treated waste is crucial. Conducting tests to ensure the quality and effectiveness of the decomposed excreta assures

users of its suitability for agricultural purposes. Experimenting in agricultural fields can serve as a practical demonstration of the value of the treated waste and provide a basis for advocating for its use to a broader audience.

Challenges related to the operation and maintenance of GTS can impede adoption and lead to system abandonment. To address this, on-site treatment of faecal matter has been introduced as a potential solution. By incorporating techniques such as the introduction of black soldier flies to aid in digesting the waste, the handling and management of faecal waste can be significantly improved.

Concisely, the adoption of UDDT and other green toilet system technologies faces various challenges that need to be addressed for widespread acceptance. These challenges include promoting proper use, establishing treatment facilities, gaining acceptance of the end product, conducting testing for quality assurance, and addressing operational and maintenance challenges. By addressing these concerns, GTS can realize the potential to achieve sanitation coverage goals, and resource recovery, and promote a circular economy within the WASH sector.

1.3 Justification

To achieve the Millennium Development Goals of reducing the global population without access to proper sanitation, it is essential to shift towards holistic approaches that prioritize economically viable closed-loop ecological sanitation systems over costly end-of-pipe technologies (Mkhize et al., 2017). The GTSs, also known as "sustainable toilets" for their resource recycling, water efficiency, and micro-pollutant isolation features, have yet to see widespread adoption. This limited usage can be attributed to certain drawbacks, including the associated high maintenance requirements.

GTS presents a viable substitute for pit latrines in areas with challenging soil conditions, flooding, or limited space. These toilets signify a significant paradigm shift by transforming human excreta from a hazardous waste that could lead to pollution into a valuable organic fertilizer rich in nutrients. This transition follows a closed-loop approach, promoting sustainability and resource recovery (Elledge et al., 2020).

Conducting comprehensive research on the adoption and implementation of the GTS is justified to address barriers hindering their widespread use. The research aims to identify adoption challenges and analyze the acceptance of GTS-produced humanure among farmers and users. The research will provide insights to develop interventions for proper use, treatment facilities, and improved acceptance. The findings will contribute to achieving sanitation coverage and resource recovery goals, promoting sustainable agriculture and sanitation practices within the WASH sector.

1.4 Objectives of the study

1.4.1 General Objective

To assess the factors influencing the uptake of the Green Toilet System (GTS) in Kenya, with a focus on factors such as gender, design, attitude, awareness, and perceptions.

1.4.2 Specific Objectives

1. To assess the levels of GTS technology awareness and adoption across different demographic groups in Kajiado and Tharaka Nithi counties.
2. To identify design factors influencing the usability of GTS technology and explore the correlation between exposure and reported difficulties in usage.
3. To analyze the relationship between gender and the likelihood of GTS technology adoption, considering morphology and acceptance factors.
4. To examine farmers' perceptions regarding the use of humanure in agriculture and identify factors influencing acceptance or rejection.

1.5 Conceptual Framework

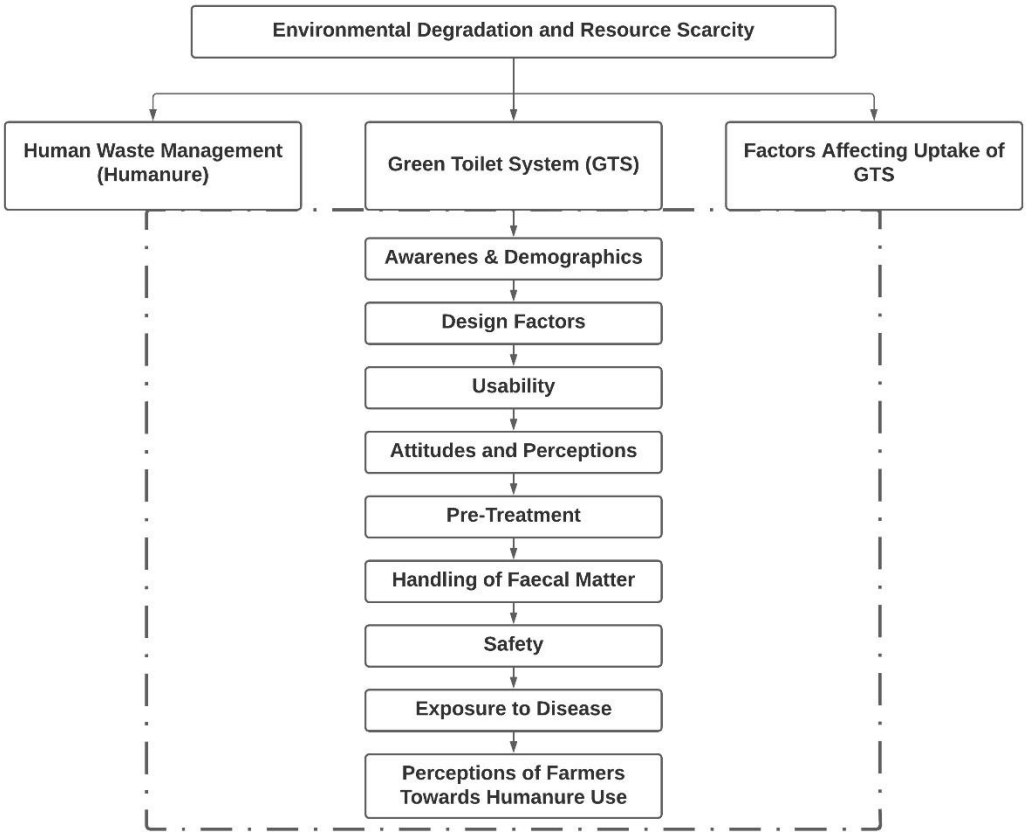

Figure1. *Conceptual Framwork of the Research Study and Variables*

The conceptual framework of the study Figure1outlines the interrelationships between the various independent and dependent variables which are outlined inTable 1. Placing environmental degradation and resource scarcity at the top of the conceptual framework provides a rationale for the study to explain why effective human waste management as represented by the GTS is cruicial for combating global environmental challenges. The research concetualises that awareness levels and design factors influence the usability of GTS technology which in turn affect individuals perceptions of safety and satisfaction. Demographic factors may also impact awareness, adoption and other dependent variables.

This conceptiual framework helps visualize the key components of the study and how they interact, providing a foundation for data analysis and interpretation.

Table 1: The Research Study Variables

Independent Variables	Mediating Variables	Dependent Variables
Awareness and Addoption Levels	Usability of GTS Technology	Safety of Faecal Matter Handling
Design Factors		Satisfaction with GTS Safety
Demographic Factors		Exposure to Communicable Diseases
		Farmers Perceptions of Humanure Use

2. Literature Review

2.1. Design Factors and Usability of GTS

The design of the GTS sanitation facilities is such that the collected urine and faeces never come into contact. Two designs are currently in use, the difference being the number of vaults where faeces are stored. Elledge et al. (2020) noted that consideration of gender while designing sanitation systems could influence its usability. Devkota & Bastien (2019)identified several reasons that led to the failures of the GTS projects. The study established that the first-time users used to one-drop systems

were hesitant to adopt the system. Furthermore, the user preferences for the sanitation facility depended on its location. Many users prefer squatting systems in their homes (Devkota & Bastien, 2019). In their study, (Mkhize et al., 2017)established that the VIP toilets were preferred by the older generation, citing less responsibility during their usage. They further found out that the adult users were not comfortable with the small size of the sanitation facilities, which made their use uncomfortable, whereas the young children often missed the right hole when using them.

2.2. Impact of Gender Difference on the Use of GTS

Hygiene needs of keeping the latrines clean and useable, and socializing children into using the latrines are often the responsibility of women and girls. Despite the gender perspective on ecological sanitation having not been fully explored; women's involvement in food production especially kitchen gardening and the potential economic benefits of small-scale commercial agriculture could make them supportive of ecological sanitation initiatives (Hannan & Andersson, 2002).

In response to menstrual concerns, a greater proportion of women who did not use UDDT systems (60%) reported feeling comfortable using their toilets compared to UDDT owners (40%). This discrepancy suggests a gender bias in the allocation of responsibilities. To address this issue, it is recommended to include appropriate devices in UDDTs to improve women's comfort and enable the use of UDDTs for bathing purposes (Hoko et al., 2010).

Female interviewees reported facing difficulties in separating urine from faecal matter while using the toilet. They expressed the challenge of getting close to the female urinary outlet to prevent urine from entering the faecal matter chamber, which could lead to floor contamination and potential contact with waste. These experiences highlight that women's perceptions, needs, and priorities in sanitation can differ significantly from those of men (Hoko et al., 2010). This issue is of particular interest due to the active involvement of women in food crop production and food security across various regions. Women's direct impact and reliance on increased soil nutrients through ecological sanitation systems for both rural and urban agriculture make it a crucial concern (Frone & Frone, 2014).

2.3. The relationship between awareness and proper usage of GTS

Studies have shown that fresh urine has no smell, and the adoption of a sanitation system that separates faeces from urine ensures not only affordable but safe human waste disposal (Devkota & Bastien, 2019). Appreciating the fact that there are different cultural, and religious beliefs, the usage of these systems will dictate the quality of the end product produced. Devkota & Bastien (2019) found that mishandling of human urine could result in cross-fecal contamination. The study further established that in Nepal, the acceptance levels of this system were high among the participants who had greater awareness, with the younger participants being the majority. Like in Nepal, the older generation in South Africa according to Mkhize et al. (2017) disregarded the use of the UDDTs, with many parents discouraging their children from using them. According to a study by (Kamuteera et al., 2013), the majority of the users in Rukungiri Uganda were trained during the installation of the UDDTs, but subsequent monitoring of the usage was not done, to check whether the users adhered to the best operational practice. The study further established that in rented apartments, landlords complained of improper use of the toilets by new tenants, which could be attributed to a lack of awareness. The findings of this study were in line with those of (Banamwana et al., 2022) which established that there was better utilization of the UDDT facilities by people who were aware of its existence and functionality. A post-evaluation audit conducted by (Pynnönen et al., 2012) in KenduBay established that the usage of the UDDTs facilities was low amongst the younger students, even though they had been trained on the usage.

2.4. Attitudes Associated with the Operation and Maintenance of Faecal Matter Treatment Plant

A minimum basic sanitation facility should enable the safe and appropriate removal of human waste, although this provision is good for UDDT technology sanitation, there are still contamination concerns. Despite knowing the potential human waste benefits, most communities in Kenya are reluctant to apply it due to attitudes about this process. Most Africans and in our case Kenyans have diverse perceptions on matters dealing with human waste. Others don't value work associated with the same even if it is well paying, while at the same time, the users feel that the UDDTs sanitation

facilities are for the second-class people in society(Mkhize et al., 2017). (Njagi et al., 2013) found out that more than half of those interviewed would engage in waste management but according to (Taouraout et al., 2019) slightly over 20% of the residents had the willingness to handle the faeces and urine. This is indicative of the participant's negative attitude toward handling faecal matter. The perceptions and attitudes toward the UDDT technology differ as per sex, level of education, ethnicity, sex and religious affiliations(Lamichhane, 2013).

2.5. Microbial Contamination and Nutrient Level in Treated Hu Manure

Human waste contains a wide range of microorganisms, including bacteria, viruses, protozoa, and helminths (parasitic worms). While some of these microorganisms are harmless or beneficial, Julian et al. (2018) argued that others can pose significant health risks if they contaminate food crops or water sources. The risk of microbial contamination in human waste manure depends on various factors, including the source of the waste, the treatment methods employed, and the handling and application practices. If human waste is not properly treated or if the treatment processes are insufficient, pathogens can survive and remain viable in the manure (Julian et al., 2018).

However, if well treated, human waste manure can contain significant levels of nutrients that can benefit soil fertility and support plant growth. Human waste contains essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), along with other secondary and micronutrients. These nutrients are derived from human diets and can be concentrated in faecal matter (Pettersson & Wikström, 2016). The nutrient levels in treated faecal matter can be adjusted or supplemented based on the specific needs of crops or soils. For example, additional nutrients may be added to achieve the desired nutrient balance to optimize the use of human manure while minimizing environmental impacts (Mnkeni& Austin, 2009).

To mitigate the risk of microbial contamination, proper sanitation and treatment of human waste are crucial. Treatment methods such as composting, anaerobic digestion, or aerobic treatment can effectively reduce the levels of pathogens in human waste. Farmers, agricultural workers, and policymakers need to prioritize appropriate treatment methods and best practices to ensure the safe and responsible use of human waste as fertilizer while minimizing the risks of microbial contamination.

3. METHODOLOGY

3.1. Research Design

The research employed a descriptive research design. Descriptive research design aims to systematically obtain information that describes a situation, a phenomenon, or a population. Significantly, it seeks to answer the when, where, what, and how components of research, rather than why (Akhtar et al., 2016). Moreover, descriptive research design is intended to explain the occurrence of one or more variables. The design is often applicable to studies that seek to describe a piece of evidence or a set of observations.

The overall objective of the research is to assess the factors influencing the uptakeof GTS in Kenya, with a focus on factors such as gender, design, attitude, awareness, and perceptions. The descriptive research design links the factors with the dependent variable, which is the uptake of the GTS in Kenya. Moreover, descriptive research design justifies the choice of the study area, the timing of the study, and the phenomenon of the study. For instance, descriptive research design is best suited to explain the relevance of GTS at a time when the policy direction in Kenya promotes the circular economy and resource recovery. Further, the application of the descriptive research design enables ease of reporting of the experience of the target population as they handle and accept the faecal matter and humanure respectively.

3.2. Data Collection and Research Approach

The research employed a mixed design approach, which includes both qualitative and quantitative approaches. In the qualitative approach, the sources of data used are secondary and primary data. Primary data is generated as firsthand information from the fieldwork. Such information was obtained through observations, key informant interviews and focus group discussions administered to the

sampled respondents. Secondary data was generated from literature reviews, case studies, reports, records, journals, academic thesis, projects, books as well as relevant websites.

3.3. Research Area, Sampling Strategy and Target Population

3.3.1. Study Area

The research was conducted in Kajiado and Tharaka Nithi counties as shown in Figure2. Tharaka Nithi County is one of the 47 Counties in Kenya and covers an area of 2,662.1 Km^2. The County is subdivided into four administrative sub-counties including Tharaka South (Chiakariga sub-county) where data was collected based on purposive sampling. According to Tharaka Nithi County CIDP (2018-2022), over 87.7% of the county population uses pit latrines. Sanitation coverage is 76%. To improve public health and welfare, there is a need to secure exhausters and construct more receptacle tanks in urban areas. This will improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally(County Government of Tharaka Nithi, 2023).

Kajiado County is a county in Kenya. As of 2019, Kajiado County spanned an area of 21,292.7 km^2, with a recorded population of 1,117,840. Although access to water in Kajiado County is at 66.2%, there exist great disparities between the rural coverage and the urban coverage (2). For households located 30 minutes or more from their water source, (40% in rural areas) women or children may be required to collect water for over two hours to collect sufficient water for a family of four. Also, more than half of the households (59.2%) do not have access to a toilet facility with 98.4% of those without access to a toilet defecating in the bush (Open defecation). Therefore, it is necessary for the communities in Kajiado County to access sustainable sanitation practices that require little or no use of water. GTS uses no water and facilitates the transition towards a circular economy(County Government Of Kajiado, 2018).

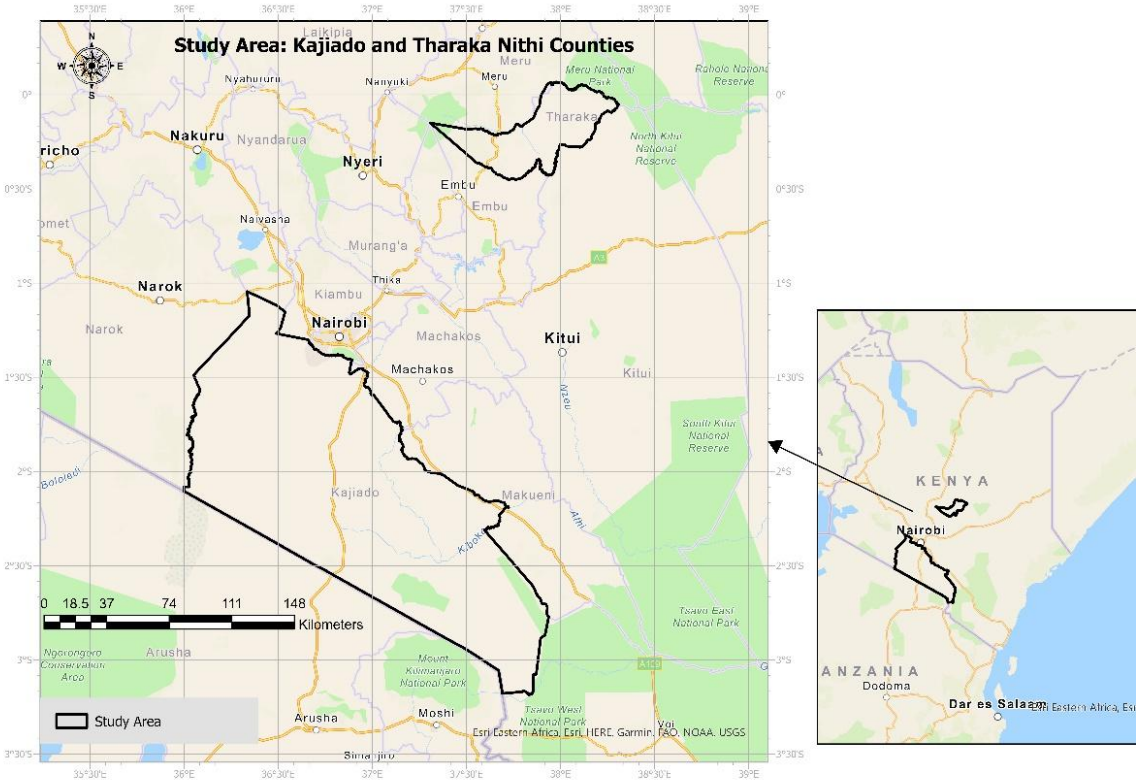

Figure2. *Study Area: Kajiado and Tharaka Nithi Counties*

3.3.2. Sampling Strategy

Purposive sampling was used in this study to choose the target population. Purposive sampling is a non-probability sampling strategy that involves the researcher specifically selecting a participant

based on their attributes that will be important in addressing the research objectives. It entails the identification and choice of people who are knowledgeable about the issue. This approach was chosen because its flexibility enabled the researchers to get data rapidly and affordably utilizing comparatively small samples(Neetij& Thapa, 2004).

3.3.3. Target Population

Usually, no statistical or calculation method is required to quantify the target population for small populations since it assumes that the researcher knows the research population(Asiamah et al., 2017). On this precept, the research team conducted a pre-survey study to determine the target population.

3.4. Data Collection

The research employed semi-structured qualitative interview guides to gather data from the target population. The decision to use qualitative semi-structured interview tools was made with the understanding that the tools allow respondents to expand on their comments in a way that quantitative survey approaches do not allow (Kallio et al., 2016). The questionnaires contained items linked to the variables under study. These variables are usability, attitudes, perceptions, and level of awareness. An observation guide was used to reinforce data collected through questionnaires.

3.5. Data Analysis

The study employed quantitative analysis methods, specifically utilizing descriptive, regression, and correlational analyses. Descriptive statistics was used to summarize datasets while correlational analysis was employed to show relationships between variables, demonstrating the associations between them. Regression analysis, on the other hand, was applied to delineate the impact of one variable on another, providing insights into the causal relationships within the dataset(Patrick et al., 2021).

3.6. Reliability and Validity

A reliability test ensures that the results are consistent. To ensure the reliability of data, the study employed the test-retest reliability test whereby two pilot studies to trial test the instruments were conducted at different times before the actual data collection(Chew et al., 2017). The research instrument was subjected to peer review.

3.7. Ethical Considerations

The study upholds the highest standards of integrity and ethical principles in all the stages, from data collection, analysis and results presentation. The whole process is guided by objectivity, and honesty, and is based on key ethical principles including; beneficence, autonomy justice, confidentiality and non-maleficence. Before engaging the participants during data collection, informed consent was sought from all participants. They were taken through the research instruments and the purpose of the research was explained to them by the researchers. A consent form was made available which the participants were required to read, ask questions and sign at will. Confidentiality of all respondents is assured and their participation in the research was out of an individual’s volition. The study is designed in a manner that does not collect infringing personal information from the participants(Östman & Turtiainen, 2016).

4. RESULTS AND DISCUSSION

4.1. Target Population Demographics

The study engaged a total of 341 respondents, encompassing diverse demographics from Tharaka Nithi County (217 respondents) and Kajiado County (121 respondents). In Tharaka Nithi County, the respondents were distributed across Chiakariga (97 respondents), Chuka in Igamba Ngombe 76 respondents, Tharaka South (40 respondents), and Tharaka North (4 respondents). Meanwhile, Kajiado County featured respondents primarily from Keekonyokie, Magadi, and Mosiro in Kajiado West Subcounty (121 respondents).

The study ensured a balanced representation across various demographic categories, including gender, occupation, age, education level, and monthly income. The study's comprehensive demographic

coverage aimed to capture a representative sample, ensuring diverse perspectives for a robust analysis of factors influencing the adoption of the Green Toilet System.

The gender distribution among the respondents was carefully balanced, with 174 females and 164 males participating in the study. This equal representation ensured that the study's findings would be reflective of the experiences, preferences, and perspectives of both genders, contributing to a comprehensive understanding of the factors influencing the adoption of the GTS. By including an equitable number of male and female respondents, the research aimed to mitigate gender-related biases and provide inclusive insights (Rubin & Manfre, 2014) representative of the broader community.

The survey meticulously examined the educational landscape of respondents to illuminate the impact of educational backgrounds on the acceptance of the GTS. The data revealed a diverse educational distribution among participants, with 98 individuals having completed secondary education, 77 holding tertiary qualifications, 75 having a primary education background, and 41 respondents having attained a university degree. Furthermore, 47 participants reported no formal education. This nuanced breakdown allowed for a nuanced understanding of the role education plays in shaping perceptions and preferences concerning sustainable sanitation solutions(Harilal, 2014). By scrutinizing the distinct perspectives emerging from various educational levels, the research aimed to inform targeted strategies for promoting GTS adoption across different educational backgrounds.

4.2. Relationship Between Awareness and Uptake of GTS Technology

Out of 335 respondents from the two counties, 75% were not aware of the green toilet system technology. Tharaka Nithi County had 2% exposure and Kajiado County 16%.

48.8% of respondents were male while 51.2% were female. out of the 174 females and 160 males interviewed only 6% and 8% were aware of the GTS technology respectively. 4 % of the farmers, 3.5% of the students, and 13 % of the institutional workers segregated by occupation were aware of the technology. The study's results are in line with the findings of Pynnönen et al. (2012), which established that the usage of the UDDT facilities was low amongst the younger respondents, even though they had been trained on the usage.

Based on the levels of education, the awareness percentage of the respondents was: tertiary 11 %, university 20%, secondary 4%, and primary 4%. On the level of income, 32% of those having an income of above Kshs 40,000, 11% of those with income of between 20,001-40,000, and 3% of those below Kshs 20,000 were exposed to the GTS technology. 5% of the respondents were non-committal about their levels of income.

Based on age, respondents aged above 50 years and below 18 Years were unaware of GTS technology. 18-30 years 6%, 31-40 years 9%, 40-50 years 9% were aware of GTS technology. According to Devkota & Bastien (2019), and Mkhize et al. (2017), the acceptance levels of this system were high among the participants who had greater awareness, with the younger participants being the majority. However, from the findings of this study, it emerged that there was a high awareness level among the respondents aged between 31 and 40 years.

4.3. Relationship Between Design Factors and Usability of GTS Technology

The study aimed to test the hypothesis that individuals highly exposed to GTS (rated 4 on the Likert scale) are more inclined to recommend the GTS design to others (also rated 4 on the Likert scale). The regression analysis revealed a significant association, with a P value of 0.01, supporting the hypothesis. Additionally, another regression analysis explored the correlation between the level of exposure to GTS and the reported difficulties in using the technology. The hypothesis posited that individuals with high exposure (rated 4) to GTS would encounter fewer difficulties (rated 1). The results indicated a significant relationship, with a P value of 0.003, aligning with the study hypothesis. The study findings suggest a positive correlation between exposure to GTS and the likelihood of recommending it. The lower P values signify a stronger statistical significance, reinforcing the robustness of the observed relationships. Furthermore, the study supports the notion that increased exposure to GTS is associated with a reduced likelihood of facing difficulties in its usage, indicating a potential learning effect or increased familiarity with the technology. The study findings agree with

previous studies by (Harilal, 2014) who analysed how the design of GTS toilets affected its acceptability and showed that poor design of UDDT was a barrier to GTS uptake.

4.4. Evaluating the Impact of Gender Differences on the Use of GTS

This objective was focused on evaluating the impact of gender differences on the use of GTS. One of the items under this objective evaluated the relationship between the gender of the user and their likelihood to embrace the GTS as influenced by their morphology. The analysis was based on the hypothesis that female users are more likely to reject GTS as it does not favour their morphology. Analysis of the correlation between the female participants' responses and the tendency to embrace the GTS yielded a p-value of 0.737. The correlation was conducted exclusively between the participants who had exposure to, or who had used the GTS facility at least once. The result ($p=0.737$) or $p>0.0737$ suggests a statistically insignificant outcome, suggesting a weak correlation between the gender of a user and the tendency to reject the GTS. Instead, the results suggest that no specific gender discriminates against GTS facilities based on their morphology. These results differ from earlier assertions by (Hoko et al., 2010), who argued that women and men differ in their preference for GTS based on their external excreta organ morphology. Similarly, an analysis of the relationship between user preference and the placing of the faecal and urinal holes yielded a p-value that is greater than 0.05 ($p=0.168$). This result rejects the hypothesis that the current design of the GTS, with the placing of the faecal and urinal holes, tends to favour men as opposed to women. This finding similarly differed with Hannan & Andersson (2002) view that the experiences highlight the fact that women's perceptions, needs, and priorities in sanitation can differ significantly from those of men with regards to the use of GTS.

4.5. Pre-Treatment of Faecal Matter to Improve the Safety of Its Handling

74 % of the respondents in Kajiado affirmed subjecting the faecal matter to pre-treatment methods to improve the safety of its handling while 25% did the same in Tharaka Nithi. 55 % of female respondents applied pre-treatment to improve the safety of its handling. All the men who regularly use GTS applied the pre-treatment on faecal matter.

62.5% of the total farmers, 66.7% of the total institutional workers and 57.1% of other professionals applied the pre-treatment methods to the faecal matter 60% of those within the age bracket of 18-30 years, 77.7% of those between 31-40 years and 50% of those between 41-50 years applied the pre-treatment to faecal matter.

In regards to the highest level of education, 66.7% of those with primary as the highest level of education, 25% of those with secondary, 50% of those with tertiary and 100% of those with university applied the faecal matter pre-treatment**.**

87.5% of those with income above 40,000, 50% of those with income between 20,001-40,000 60% of those with income below Kshs 20,000 and 50% of those with non-committal income applied the pre-treatment.

4.6. Attitudes associated with the operation and maintenance of a faecal matter treatment plant

23 respondents affirmed that they regularly use GTS technology out of the 335 interviewed. This sample population represents the respondents who have adopted the GTS technology and therefore are aware of the handling of faecal matter.

4.7. Extent GTS technology made the handling of faecal matter from the facility safe

On the safe handling of the faecal matter, 55 % of female and 75 % of male respondents affirmed that GTS has made the handling of faecal matter from the facility safe. In Kajiado county 74% and Tharaka Nithi 25% of respondents agreed that GTS has made the handling of faecal matter from the facility safe.

Based on occupation, 63% of farmers, 67% of institutional workers, and 57% of other professionals agreed that GTS has made the handling of faecal matter from the facility safe.

Based on age, 60% aged 18-30 years, 78% aged 31-40 years, and 50% aged 41-50 years respondents agreed that GTS has made the handling of faecal matter from the facility very safe.

Based on the level of education, 67% of primary education level, 25% of secondary, 50% of tertiary, and 100% of those with university agreed that GTS has made the handling of faecal matter from the facility safe. On the level of income, 60% of the respondents with a monthly income of below Kshs. 20,000 agreed that handling of the faecal matter has become easier with the use of GTS. Further, 88% of those in the income bracket of 20,001 to 40,000 responded in the positive that GTS has improved on the safety of handling of the faecal matter.

4.8. Safety of GTS Technology

Responding to the safety of the use of the GTS technology, 80% of the respondents from Kajiado, and 25% of the respondents from Tharaka Nithi indicated that they were very satisfied with the safety of the GTS technology. On the gender, 55% of females and 83% of males were very satisfied with the safety of the GTS technology. 63% of the farmers who were interviewed agreed that the GTS technology was safe to use. Further, 83% of the institutional workers affirmed their level of satisfaction with the safety of the GTS.

Based on the age bracket, 60% of the respondents aged 18-30, 89% aged 31-40 and 50% aged 41-50 years were very satisfied with the safety of the GTS technology. On the level of education, 67% of primary education level, 25% of secondary, 75% of tertiary 88% of university were very satisfied with the safety of the GTS technology.

60% of those below 20,000, 75% of those earning 20001-40000, 100% of those above 40,000, and 33% of those with non-committal income were very satisfied with the safety of the GTS technology.

4.9. Exposure to communicable diseases by those handling faecal matter from the GTS

50% of the respondents from both Kajiado and Tharaka Nithi said that handling GTS faecal matter could expose them or anyone to communicable diseases. 9% of females said that handlers of the GTS faecal matter are highly exposed to communicable diseases compared to 33% of males. 38% of the farmers and 16% of the institutional workers believed that faecal matter from GTS highly exposes the handlers to communicable diseases. Additionally, 30% of the respondents aged 18-30, 11% aged 21-40 and 33% aged 41-50 years believed that people who handle the GTS faecal matter are highly exposed to communicable diseases. Based on the level of education, 67% of primary education level, 25% of secondary, and 25% of tertiary believed that people who handle the GTS faecal matter are highly exposed to communicable diseases. 60% of those below 20,000, 13% of those above 40,000, and 17% of those with non-committal income said that the people who handle the GTS faecal matter are highly exposed to communicable diseases

4.10. Perceptions of Farmers towards the Adoption of Humanure for Agricultural Use

The regression analysis on farmers' perceptions of human manure yielded a p-value of 0.172, surpassing the conventional significance level of 0.05. Consequently, the initial hypothesis suggesting that farmers will likely find human manure acceptable was rejected. This outcome echoes the observations made by Mkhize et al. (2017), who contended that a substantial proportion of communities in Kenya exhibit reluctance to embrace the use of human manure. Despite being aware of the advantages associated with its utilization, negative attitudes toward handling human manure persist, hindering widespread acceptance. Furthermore, Taouraout et al. (2019) study aligns with our findings, revealing that a mere 20 percent of interviewed residents expressed a willingness to handle human manure and urine. This corroborates the broader sentiment that people generally harbour reservations about dealing with human waste, posing a significant challenge to adopting human manure as a viable agricultural resource. The discrepancy between awareness of the benefits and the actual acceptance of human manure underscores the deep-seated cultural and psychological barriers that impede its integration into farming practices. Understanding these factors is crucial for devising effective strategies to promote the sustainable use of human manure in agriculture.

5. Conclusions and Recommendations

5.1. Conclusions

In conclusion, the study revealed significant gaps in awareness and uptake of Green Toilet System (GTS) technology among respondents from Tharaka Nithi and Kajiado Counties. A substantial 75% of the 335 respondents were unaware of the GTS technology, with varied levels of exposure across

counties and demographic groups. Findings align with previous studies suggesting lower adoption among younger individuals, despite training efforts.The relationship between design factors and GTS technology's usability was explored, confirming a positive correlation between exposure and the likelihood of recommending the technology. Notably, higher exposure was associated with fewer reported difficulties, supporting the idea of a learning effect or increased familiarity with the technology.Gender differences were found to have a weak correlation with the acceptance of GTS, challenging earlier assertions that female users may reject the technology due to morphological factors. Similarly, the design of GTS, with faecal and urinal hole placement, did not favour men over women, contradicting previous views.The study delved into pre-treatment practices for faecal matter, revealing varying adoption rates across demographics. The majority of respondents believed GTS had positively impacted the safety of faecal matter handling, with some variations based on gender, occupation, age, education level, and income.Satisfaction with the safety of GTS technology was generally high, with notable differences across demographics. However, concerns about exposure to communicable diseases from handling GTS faecal matter were expressed by 50% of respondents.Farmers' perceptions of using human manure for agricultural purposes were explored, revealing a reluctance to adopt this practice despite awareness of its benefits. This reluctance, consistent with previous studies, underscores deep-rooted cultural and psychological barriers that must be addressed to promote sustainable human manure use in agriculture.In summary, the study provides valuable insights into the awareness, uptake, usability, and perceptions surrounding GTS technology, highlighting the need for targeted awareness campaigns and addressing cultural barriers for broader acceptance and sustainable implementation.

5.2. Recommendations

The study findings reveal gaps in the uptake and awareness of GTS technology hence a need for continual research, development and implementation of awareness campaigns focusing on institutional workers and students to enhance their understanding of humanure-based sanitation practices. The study findings also show that collaborating with agricultural extension services to further engage farmers in sustainable agricultural practices utilizing humanure, can foster environmental stewardship. Further, there is need for indepth research and advocating for the integration of humanure management practices in local and national sanitation policies, emphasizing the environmental and agricultural benefits. Lastly, the study finding highlight the importance of encouraging community-driven initiatives for the proper collection, treatment, and utilization of humanure, involving local leaders and influencers.

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