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Envisioning sustainable sanitation planning: a unified approach of diffusion of innovation and theory of planned behavior in predicting ecosan toilet adoption in Arba Minch City, Ethiopia

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This study explores the adoption of ecological sanitation (ecosan) toilets in Arba Minch City, Ethiopia, using an integrated approach combining the diffusion of innovation (DOI) model and the Theory of Planned Behavior (TPB). The research aims to understand the complex associations between DOI variables (relative advantage, complexity, compatibility, trialability, and observability) and TPB constructs (attitude, subjective norm, and perceived behavioral control) in predicting residents' behavioral attitudes and intentions. Applying Structural Equation Modeling (SEM) and bootstrapping techniques, the study investigates direct and indirect effects, offering a comprehensive analysis of the adoption process. The objectives include examining the influence of TPB and DOI constructs on residents' intentions, unraveling direct and indirect effects on these intentions, and investigating variations among users of different toilet types in the city. The result of the study shows that attitude and perceived behavioral control are central to shaping intentions, aligning with TPB principles. Contextual factors like compatibility, relative advantage, and trayability reveal nuanced insights, deviating from conventional patterns. The study identifies attitude as a key moderator between DOI constructs and behavioral intention, enriching our understanding of the adoption process. In conclusion, the integrated DOI and TPB model provides nuanced perspectives on factors influencing behavioral attitudes and intentions toward ecosan toilet adoption. The crucial roles of perceived behavioral control and attitude underscore the importance of tailored interventions. The study's insights are relevant for policymakers, practitioners, and development organizations working on sustainable sanitation practices in urban areas, contributing to broader sustainable development objectives.

KEYWORDS

the theory of planned behavior, diffusion of innovation, ecological sanitation, attitude, mediating role, multi-level analysis, direct and indirect effects

1 Introduction

1.1 Global sanitation

Urbanization, a potent global force, underlies interconnected challenges like water scarcity, food insecurity, and pollution, stemming from assumptions and actions (Esrey, 2001). Annually, 2000 million tons of untreated human wastes pose a global challenge, particularly impacting developing world cities with individual disposal systems like latrines, causing groundwater pollution (Galloway et al., 2004). Around 95% of urban sewage is discharged into water bodies, adversely affecting aquatic life (Watson and Zakri, 2008). Progress in sub-Saharan Africa, including Ethiopia, has been slow, emphasizing technical and economic aspects rather than inter-sectionality (Andersson and Minoia, 2017). Despite increased access to improved sanitation, the global challenge persists for 2.3 billion, especially in rural areas, with only 54% of population access to sanitation facilities as of the year 2020 (WHO, 2017). Shockingly, two billion lack basic sanitation services, and 80% of global wastewater remains untreated (Blackett et al., 2014). As a result health damage, loss of productivity and absenteeism are common in most developing countries (Porcella et al., 2023).

WHO (2017) confirms unmet sanitation targets, with only 27% of the global population exposed to adequate sanitation since 1990. Approximately 1.8 billion rely on basic pit latrines, and over a billion practice open defecation (Dreibelbis et al., 2015; WHO, 2017). About 892 million individuals, mainly in rural areas, experience open defecation (WHO, 2017). Globally, about 2.7 billion people use decentralized sanitation, with 65% in Sub-Saharan Africa (Nakagiri et al., 2015). Developed regions favor water closet toilets, dating back to the 1880s, aiming to reduce sanitation-related diseases (Hoglund, 2001). Despite improved sanitation aiming to reduce disease transmission, both on-site and off-site systems face challenges (Kumwenda et al., 2017). Fundamental assumptions about unlimited resources and the environment's capacity drive linear flows of resources and waste in conventional sanitation systems (Esrey, 2001). Many traditional sanitation systems, typically characterized by linear end-of-pipe approaches, adversely affect sustainability by compromising human health and the natural environment through the disposal of waste and wastewater via multiple treatment steps (Junghanns and Beery, 2020). Designs like "flush and discharge" and "drop and store" technologies impose substantial costs on wastewater treatment plants (Esrey, 2001; Haq and Cambridge, 2012). The need for sustainable sanitation solutions is underscored by the growing emphasis on compatibility with global challenges like water scarcity and food insecurity (Langergraber and Muellegger, 2005; Harada, 2022).

Ecosan toilet systems address sanitation and resource recovery ecologically (Langergraber and Muellegger, 2005). According to Wilbur and Jones (2014) resource recovery, reuse and upkeep of important nutrients, energy and water resource are central to sustainable sanitation technology development (Wilbur and Jones, 2014). A shift toward decentralized wastewater treatment approaches and increased interest in composting toilets are part of a new paradigm (Anand and Apul, 2014). Studies highlight the potential of ecological sanitation technologies in recovering nutrients, particularly phosphorus, from regions with low sanitation coverage (Wilbur and Jones, 2014). The Sustainable Development Goals aimed at universal sanitation access by 2030, but challenges persist in Ethiopia due to insufficient local political commitment, budgetary constraints, and a low priority status within the health sector (Alemu et al., 2017). A communication deficit within the health system exacerbates the struggle (Alemu et al., 2017). The provision of enhanced sanitation facilities in Ethiopia faces obstacles in urban areas with operational inconsistencies and infrastructural issues (Strengthening Ethiopia's Urban Health Program, 2015). Sanitation challenges persist nationwide, with approximately 70 million people relying on unimproved facilities in 2021, indicating systemic issues related to organization, finance, and strategic implementation (Baye, 2021). Poor sanitation in Ethiopia stands as a substantial barrier to development, impacting health, education, gender equality, and overall socioeconomic progress (Baye, 2021).

1.2 Ecological sanitation

Ecological sanitation (ecosan) is a transformative method to water and sanitation management, embracing a circular nutrient flow and a "closed-loop-approach" that facilitates the return of excreta nutrients to the soil (Esrey, 2001; Simha and Ganesapillai, 2017). It also embodies a comprehensive and enduring strategy for sanitation, rooted in the principles of pollution prevention, hygienic treatment of human waste, and the utilization of urine and feces as valuable resources in agriculture (Banamwana et al., 2022a). Operating in 84 countries, ecosan has a global impact by reducing health risks, preventing pollution, and enhancing water and nutrient resource managements (Abarghaz et al., 2012; Rieck et al., 2012). Ecosan toilets, particularly urine diverting dry toilet (UDDTs) types, offer distinct advantages over conventional sanitation methods. They efficiently separate urine from feces, minimizing water usage and eliminating the need for deep pits or discharge. This separation not only addresses health concerns by reducing exposure to bacteria and pathogens but also supports environmental sustainability through odor mitigation using materials like ash, wood chips, or sawdust (Mnkeni and Austin, 2009; Haq and Cambridge, 2012). Ecosan significantly contributes to community health, environmental preservation, and the efficient recycling of nutrients for agricultural purposes (Schuen et al., 2009).

Ecosan latrines, with their ability to facilitate crop fertilization and overcome challenges such as water shortages, emerge as a superior option for regions grappling with traditional pit latrines and limited space (Kumwenda et al., 2017). The system also crucial to enhance users quality of life and health conditions (Banamwana et al., 2022b). Beyond rural applications, the potential of ecosan extends to the integration of waste management with urban human excreta, offering a holistic solution in developing countries (Haq and Cambridge, 2012). The benefits derived from adopting ecosan toilets encompass improved soil quality, reduced environmental pollution, and potential cost savings, emphasizing the system's versatility and adaptability (Simha et al., 2017). However, it is essential to acknowledge the challenges associated with ecosan, particularly in terms of socio-cultural and economic sustainability. Ecosan toilet may face issues such as expensive infrastructure, maintenance requirements, and negative user perceptions, which can

complicate widespread adoption (Wilbur and Jones, 2014). Economic analyses highlight the need for external financial support in Sub-Saharan Africa to scale up current ecosan schemes (Haq and Cambridge, 2012). Concerns about user-friendliness, especially for large families, impact the willingness to adopt ecosan toilets (Kc et al., 2020). Those challenges affect the diffusion and adaption process of the technology globally (Banamwana et al., 2022a).

Despite these challenges, ecosan determined to a sustainable wastewater management system than the conventional one. It requires lower investment, operates effectively in both centralized and decentralized modes, and serves as a transitional solution to onsite excreta management system (Larsen and Gujer, 2001). The reuse-oriented system effectively implemented, and assessed in various regions worldwide, employing enhanced technical and non-technical methodologies in both cold and temperate climates (Uddin et al., 2019). The unique aspect of urine separation in ecosan becomes particularly valuable for tailored waste fraction treatment and phosphorus recovery, addressing the challenges associated with finite phosphorus resources (Cordell et al., 2009). In summary, ecosan represents a comprehensive and adaptable solution with the potential to address pressing sanitation and resource management issues globally.

1.3 Perception and attitude of ecosan acceptance and diffusion

The acceptance and diffusion of ecosan technology involve a complex interplay of technical, cultural, and social factors. Cultural and social sustainability in ecosan recognizes the influence of cultural attitudes towards feces, shaped by religious beliefs and concepts of purity (Andersson and Minoia, 2017). This sustainability goes beyond awareness raising, aiming for practices aligned with cultural behaviors and beliefs. The diffusion of ecosan technology encompasses the decision-making process of users and the promotion and adoption of emerging technologies within a community (Rogers, 2003). In the context of ecosan, understanding diffusion entails measuring the rate at which innovations are adopted as well as the social system's function in promoting learning and generalization within interpersonal networks (Rogers, 2003). Despite the pressing need to address sanitation concerns, the limited implementation of ecosan technology emphasizes attitudinal aspects impacting family decisions (Dreibelbis et al., 2015). Ecosan's nuanced nature requires an exploration of perceptions and attitudes towards this sanitation technology (Wilbur and Jones, 2014), recognizing their crucial role in addressing diverse sanitation challenges (Ignacio et al., 2018). Studies on consumer attitudes towards ecosan across countries reveal a nuanced landscape, emphasizing the importance of understanding local contexts and cultural factors (Lienert et al., 2003; Lamichhane and Babcock, 2013).

Transitioning to sustainable sanitation involves considering perceptions alongside technological and economic factors (Widomski, Ladziak, and Lagod, 2018). The Sustainable Development Goals stress socio-cultural considerations for sanitation equity (Yamauchi, 2022), urging a deeper exploration of cultural perceptions and differences (Alhumoud and Madzikanda, 2010). Perceptions of modern sanitation systems, like UDDT, are shaped by adopters' experiences, highlighting the need to consider existing sanitation structures (Harada et al., 2010; Conroy and Mancl, 2022). Gender considerations play a pivotal role, emphasizing the importance of gender equity in both technical design and awareness-raising efforts (Dickin et al., 2018). Understanding hurdles and facilitators to the adoption of sanitation technologies, such as UDDTs, reveals a complex landscape encompassing beliefs, infrastructure, costs, and cultural values (Conroy and Mancl, 2022). Resistance in certain communities requires campaigns and initiatives to bridge cultural gaps (Abarghaz et al., 2012). Acceptance challenges encompass diverse factors, including training, construction quality, hygiene, and accessibility, perceived maintenance problems, safety concerns, costs, and cultural norms (Mkhize et al., 2017). Achieving acceptance demands a paradigm shift, integrating ecosan into local cultures and addressing rational fears associated with human excrement (Winblad and Simpson-Hebert, 2004).

The aim of this study is to clarify the connection between the diffusion of innovation model's latent variables and the behavioral attitudes and intentions of Arba Minch city dwellers with regard to the adoption of ecosan toilets. It also explores constructs of the theory of planned behavior, seeking to understand their impact on residents' intentions in embracing ecosan toilets in this Ethiopian urban setting. The research questions guiding this study focus on identifying the determinants of individuals' behavioral intentions regarding ecosan toilet adoption, understanding the contributions of TPB and DOI frameworks in this context, and assessing the mediating effects of attitudes in the relationship between DOI constructs and behavioral intentions. In addition, the research holds significant importance for several reasons. To begin with, it addresses a notable gap in the existing literature by integrating TPB and DOI frameworks in the context of ecosan toilet adoption in Ethiopia, offering a more comprehensive understanding of the factors influencing behavioral intentions compared to previous studies. Secondly, the study contributes to advancing Sustainable Development Goals (SDGs), particularly Goal 6 (Clean Water and Sanitation) and Goal 11 (Sustainable Cities and Communities), by investigating the determinants of ecosan toilet adoption, thus directly supporting these global goals. Lastly, the findings can inform policymakers, practitioners, and development organizations involved in sanitation initiatives in Arba Minch City and similar urban areas in Ethiopia, aiding in the design of targeted interventions and policies to promote the widespread adoption of ecosan toilets, thereby enhancing sanitation infrastructure and public health outcomes.

The methodological approach involves employing a quantitative research design, utilizing surveys and structured questionnaires to collect data from individuals in Arba Minch City, Ethiopia, including users of different types of toilets to ensure representation from diverse user groups. Data analysis includes applying statistical techniques such as structural equation modeling (SEM) and multi-group analysis to examine relationships between variables and test hypotheses. Additionally, bootstrapping methods are used to assess the mediating effects of attitudes in the relationship between DOI constructs and behavioral intentions. The study makes a theoretical contribution by integrating TPB and DOI frameworks to provide a

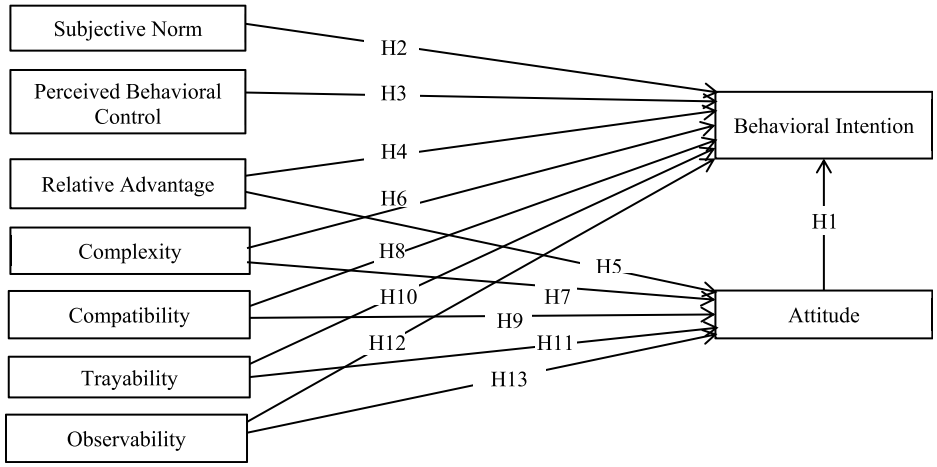

FIGURE 1
The combined models of theory of planned behavior and diffusion of innovation.

comprehensive understanding of factors influencing behavioral intentions in ecosan toilet adoption. By combining these frameworks, the study offers novel insights into the complex interplay between individual attitudes, perceptions of innovation attributes, and intentions to adopt sustainable sanitation practices. Furthermore, the examination of mediating effects contributes to advancing theoretical understanding by elucidating the role of attitudes as mediators in the relationship between DOI constructs and behavioral intentions, providing valuable insights for future research and theoretical development in the field of sustainable sanitation.

2 Theoretical background and hypothesis formulation

2.1 Integrated models of the theory of planned behavior and diffusion of innovation

The integrated model of the theory of planned behavior (TPB) and diffusion of innovations (DOI) provides a broader framework for studying users' perceptions and attitudes towards ecosan toilet adoption (see Figure 1). With regard to the technology adoption process, DOI focuses on the perceived features of the technology, emphasizing attributes like compatibility and complexity (Rogers, 1995a). Concurrently, TPB delves into variables influencing decision makers' intentions and behaviors, with key elements such as perceived control and attitude (Ajzen, 1991). These theories synergistically contribute to a holistic understanding of the adoption process (Acikgoz et al., 2023). By integrating TPB's emphasis on psychological aspects and DOI's focus on technical dimensions, the combined model enhances explanatory power in deciphering the complexities surrounding the interest to accept the new technology (Weigel et al., 2014). Notably, both TPB and DOI share a common interest in the decision maker's perceptions, reinforcing the idea that a dual examination of these models provides relatively acceptable decision to adopt the new technology (Weigel et al., 2014). Consequently, this integrated approach enriches our comprehension of users' choices and behaviors related to ecosan toilet adoption.

2.2 The theory of planned behavior

The theory of planned behavior (TPB) emerges as a pivotal theory in comprehending users' perceptions and attitudes towards ecosan toilet use, showcasing its versatility and effectiveness in behavior-related studies (Ajzen, 2020). TPB's selection is underscored by its unique advantages, positioning it as the optimal model for predicting and influencing behavior, particularly due to its incorporation of social factors through the integration of social norms into the model (Al Breiki et al., 2023). According to TPB, a person behavior is a manifestation of intention; itself shaped by attitude, subjective norm, and perceived control (Ajzen, 1991). The three major constructs of the theory of planned behavior, namely, perceived behavioral control, social norms, and attitudes, stand out as the major determinant to predict intentions and consumers' interests and buying behavior (Yeğin and Ikram, 2022).

Evolving from Ajzen and Fishbein (1975) the theory of reasoned action (TRA), TPB extends its predictive power to encompass intentions, a concept validated in numerous studies forecasting purchase or adoption intentions (Alzahrani et al., 2017). Introduced by Ajzen (1991), the variable of perceived control enriches TPB, as it is integral to predicting behavior based on attitude, subjective norms, and perceived control over the behavior (Ajzen, 1991). In various contexts TPB has proven its efficacy through extensive empirical research, establishing itself as an extension of TRA and overcoming its limitations by accounting for situations where volitional control is incomplete (Zhou et al., 2013). TPB's incorporation of perceived behavioral control becomes particularly relevant in situations where individuals require resources, skills, and opportunities to execute a certain behavior, acknowledging problems and challenges based on resource accessibility (Hansen and Jensen, 2008).

2.2.1 Behavioral intention

The theory of planned behavior (TPB), a widely applied concept, theorizes that an individual intention mostly shaped by the three constructs of the model which includes attitude, subjective norm and perceived behavioral control (Ajzen, 1991). In the context of understanding users' attitudes towards ecosan toilet use, attitude emerges as a crucial factor influencing intentions to adopt technologies (Ajzen and Fishbein, 1980; Park and Chen, 2007). TPB predicts behavioral intention through a combination of perceived control and behavioral attitude, the former emphasis on the correlation between resources and perceived control (Taylor and Todd, 1995; Elwalda et al., 2016). The theory of planned behavior suggests that a more favorable attitude, coupled with heightened perceived behavioral control, strengthens an individual inclination to carry out a certain behavior (Ajzen and Fishbein, 1980). Behavioral intention, as defined by Ajzen (1991), denotes a person willingness to perform a certain behavior and influenced by cognitive issues of attitude, subjective norms, and perceived behavioral control. In this study, these factors directly predict behavioral intention, with attitude reflecting consumers' inclination to purchase a product (Han et al., 2017). A study by Wang et al. (2016) strong purchase intentions predicts actual purchase behavior. This nuanced understanding within the TPB framework provides valuable insights into the complex dynamics shaping users' decisions regarding ecosan toilet use (Aroral et al., 2022).

2.2.2 Attitude

According to the theory of planned behavior (TPB), attitude stands out as a crucial element influencing users' attitudes toward ecosan toilet use, representing the evaluation of behavioral intention regarding product adoption (Ajzen, 2020). Behavioral beliefs, connecting behavior and expected outcomes, directly impact the adoption process (Zhang et al., 2013). Shalender and Sharma (2021) identified that compared with subjective norm and perceived behavioral control, attitude is the most important elements of TPB and subjective norm is the least construct of the theory. Ajzen and Fishbein (1980) highlight the complex interplay between attitude and behavioral intention, defining attitude as the set of feelings a person develops concerning a behavior, while behavioral intention indicates readiness to perform that behavior. Studies by De Groot and Steg (2007), and Yang (2012) underscore the significant impact of attitude on consumers' intentions and behaviors, extending to ecological purchase intention, where a positive product image leads to environmentally conscious purchase intentions (Khurana et al., 2020). Grounded in reasoned action theory, attitude is directly associated with adoption intention in a behavior (Ajzen and Fishbein, 1980). Dasgupta and Sahay (2011) reinforce the direct effect of attitude on adoption behavior, emphasizing that user' actions and responses to a new technology influenced by their attitudes. The study aims to confirm the following hypothesis.

H1: The attitude of toilet users exhibits a positive association with the behavioral intention to adopt ecosan toilets.

2.2.3 Subjective norm

Subjective norm (SN), is one elements of the theory of planned behavior (TPB) influencing users' attitudes toward ecosan toilet use, measures the importance individuals or groups place on adopting new technology (Ignacio et al., 2018). SN reflects the effect of collective influences on users' decisions regarding technology use, signifying that technology acceptance or rejection depends on these influences (Yeğin and Ikram, 2022). It represents a person's perception of what significant others, like relatives and friends, assume them to do, creating social pressure that influences behavior (Yeğin and Ikram, 2022). In the TPB context, SN refers to social pressures influencing a person's choice to carry out a behavior, involving the acceptance of this pressure in determining how the behavior is executed (Moon, 2020). It is a pivotal variable significantly influencing behavioral intention, with high social pressures increasing the intention to do a specific action (Chen and Tung, 2014). Ajzen (1991) emphasizes that SN involves perceived social pressure from significant individuals in a person's life, manifesting in subjective normative beliefs aligned with their expectations, serving as motivators for adopting new behaviors (Ajzen, 2020). SN, as a dynamic interplay of societal expectations and personal standards, is a crucial determinant in understanding users' inclinations and decisions regarding the adoption of ecosan toilets. The study aims to validate the subsequent hypothesis.

H2: Subjective norm of toilet users exhibits a positive association with the behavioral intention to adopt ecosan toilets.

2.2.4 Perceived behavioral control

Perceived Behavioral Control (PBC), a major construct within the theory of planned behavior (TPB), is pivotal in shaping users' attitudes toward ecosan toilet use (Ignacio et al., 2018). Representing the resources, skills, experiences, and opportunities influencing behavior, TPB suggests that adequate resources and opportunities enhance users' PBC, thereby mitigating hindrances to technology adoption (Ignacio et al., 2018). Ajzen (1991) defines PBC as the easiness or challenge of exhibiting a particular behavior, encompassing both internal factors like self-efficacy and external factors like economic conditions or time (Taylor and Todd, 1995). While Kaplan et al. (2016) suggest PBC as the lowest necessary determinant, Cheung and To (2017) challenge this notion, highlighting its positive effects on consumers' trust and behavioral intention based on online customer reviews (Elwalda et al., 2016). Various studies, including Lee and Kozar (2008), confirm PBC's dynamic influence on individuals' adoption of diverse applications and technologies. In essence, PBC emerges as a dynamic and influential factor shaping users' decisions regarding ecosan toilet use, reflecting the interplay of internal and external resources. The study aims to validate hypotheses regarding PBC's role in users' attitudes toward ecosan toilets.

H3: The perceived behavioral control of toilet users is positively associated with their intention to adopt ecosan toilets.

2.3 Diffusion of innovation

Diffusion of innovation (DOI), a theory employed to understand users' attitudes toward ecosan toilet use, is defined by Dillon and Moriss (1996) as the spread of innovations based on features like relative advantage, compatibility, complexity, trialability, and observability. Rogers (2003) synthesizes diffusion studies, highlighting that the relative advantage, simplicity, and

compatibility of an innovation significantly influence adoption decisions. DOI theory identifies these five innovation characteristics—relative advantage, compatibility, complexity, trialability, and observability—as crucial in the perception of potential adopters (Driessen and Hillebrand, 2002). DOI determine a new technology could be a concept, or an entity considered as new, and diffusion as the communication process over time within a social system (Rogers, 2003). DOI establishes a connection between perceived innovations attributes (PIC) and adoption, categorizing them as crucial factors in the innovation adoption process. The theory has been instrumental in predicting and explaining customer behaviors related to innovation adoption, providing a robust framework for comprehending how innovations spread within a social context and influencing users' decisions and attitudes toward adopting innovations like ecosan toilets (Vargo et al., 2020).

2.3.1 Relative advantage

Relative advantage (RA), a key construct in the Theory of diffusion of innovation (DOI) influencing users' attitudes toward ecosan toilet use, denotes the perceived superiority of the new innovation over the traditional one (Rogers, 2003; Al Rahmi et al., 2019). It considers economic, social, and technical dimensions, assessing how the innovation is viewed as superior (Scott et al., 2008). Innovations with a clear advantage are more likely to be adopted and implemented (Rogers, 2003). The economic profitability and other dimensions contribute to the degree of relative advantage, with the nature of the innovation influencing adopters' priorities (Rogers, 2003). The communication of relative advantage is fundamental in the diffusion process, serving as a crucial predictor of the innovation's adoption rate (Rogers, 2003). As indicated by Rogers (1995a) in the theory of DOI, relative advantages have a positive association with a person's relative benefit of the innovation process. Studies suggest there is a positive association between comparative benefits of an innovation on consumers' attitude (Min et al., 2019). However, some studies observe an indirect influence, while others find no effect on attitude and behavioral intention (Ashinze et al., 2021). Tornatzky and Klein (1982) highlight the significant role of comparative benefit in influencing innovation adoption. In essence, relative advantage emerges as a dynamic and multifaceted construct within DOI, serving as a linchpin in users' assessments of the perceived benefits and superiority of adopting innovations such as ecosan toilets, and this study explores the positive association between the relative advantage of ecosan toilets and the intention to adopt them.

H4: Toilet users' opinions on the relative advantage of the ecosan toilet have a positive impact on their intention to adopt it.

H5: Toilet users' perception on the relative advantage of ecosan toilet has a direct influence on their attitude.

2.3.2 Complexity

Complexity, a pivotal construct within the Theory of diffusion of innovation (DOI) influencing users' attitudes toward ecosan toilet use, denotes the perceived difficulty in understanding and using innovations (Scott et al., 2008; Al Rahmi et al., 2019). Rogers categorizes innovations on a complexity-simplicity continuum, emphasizing that when key players view innovations as simple to use, they are more readily adopted (Rogers, 2003). Innovations demanding mental effort or those that are hard to understand tend to face rejection, making complexity a vital consideration in the proposed research model (Makanyeza, 2017). The inverse relationship between the complexity of a new technology and its acceptance level is emphasized, hindering the rate of adoption when perceived as complex (Rogers, 2003). In the framework of innovation adoption, complexity is defined as the level of a person can comprehend the new technology with limited effort, directly impacting adoption rates (Moon, 2020). A lower level simplicity and challenge serves as a possible difficulty to adoption, negatively influencing adoption rates (Aroral et al., 2022). In essence, complexity emerges as a critical factor influencing users' decisions and attitudes toward ecosan toilets, reflecting the interplay between ease of use and the likelihood of successful adoption. Therefore, the study aims to confirm the following hypothesis.

H6: Toilet users' opinions about the complexity of ecosan toilet negatively influence their intention to adopt it.

H7: Toilet users' opinions on the complexity of ecosan toilet negatively influence their attitude.

2.3.3 Compatibility

Compatibility in DOI, concerning users' attitudes toward ecosan toilets, is the alignment of innovation with adopters' values and habits (Rogers, 1995b). This alignment shapes perceptions and attitudes (Min et al., 2019). According to Jiang et al. (2021) there is a direct association between compatibility with attitude and intention. Compatibility, according to Scott et al. (2008), refers to how good the new technology compatible with adopters' beliefs, past practices, and wants. Greater compatibility consistently increases adoption likelihood. As a DOI construct, it gauges alignment with past experiences and current values (Kim and Ammeter, 2014), fitting into consumers' lifestyles (Labrecque et al., 2017). Rogers (2003) emphasizes that compatibility reflects how well innovations meet consumer needs and align with beliefs and values. High compatibility, reflecting consumer value theory, increases the likelihood of adoption by meeting consumer's needs and wants (Han et al., 2017). The study aims to validate compatibility's impact on users' attitudes toward adopting ecosan toilets.

H8: The compatibility of ecosan toilet positively influences the adoption intention of various toilet users.

H9: Users' positive perceptions of the compatibility of the ecosan toilet contribute to their attitude toward ecosan toilet.

2.3.4 Observability

Observability, a key DOI construct in understanding users' attitudes towards ecosan toilets, refers to the extent to which the outcomes of the new technology are manifest by others (Al-Rahmi et al., 2019). Rogers (1995b) highlights its role in adoption, with visible benefits making innovation more likely to be adopted. Studies indicate a direct outcome on an individual behavioral intention to

adopt an innovation tools (Ali et al., 2019). However, conflicting findings, like Ahn and Park (2022), show no association with attitude. Observable results, termed visibility, impact the diffusion process, contributing to familiarity and word-of-mouth spread (Moon, 2020). Scott et al. (2008) notes it as the level to which the new technology outcomes are apparent. Peer observation motivates adoption, enhancing familiarity and accelerating the diffusion process (Moon, 2020). Aligning with Rogers (2003), easily observed positive outcomes make innovation more adoptable. The study aimed to validate observability's role in shaping users' attitudes towards adopting ecosan toilets.

H10: Observability of ecosan toilet positively influences the adoption intention of existing toilet users.

H11: Observability of ecosan toilet positively impacts the attitude of present toilet users towards ecosan.

2.3.5 Trialability

Trialability, a major construct in the diffusion of innovation (DOI) theory concerning users' attitudes toward ecosan toilets, refers to the belief that individuals need to experience the innovation before deciding to adopt it (Rogers, 2003). Innovations with trialability involve less perceived uncertainty for potential adopters, allowing learning through experience (Al-Rahmi et al., 2019). Rogers emphasizes it as the level to which new technology may be investigated with on a limited basis, positively correlating with its adoption rate (Rogers, 2003). High trialability is associated with swift adoption, as potential consumers can experiment with the product easily, facilitating reinvention (Moon, 2020). Scott et al. (2008) underscores that trialability is crucial; making innovations that can be tried before full implementation more appealing. Positive pre-purchase experiences contribute to a positive attitude and increased adoption rates. However, as innovations become widely adopted, trialability becomes less critical, influenced by experiences and word of mouth from early adopters (Aroral et al., 2022). The study aims to confirm trialability's impact on users' attitudes toward adopting ecosan toilets.

H12: Trialability of ecosan toilet positively influences the adoption intention of existing toilet users.

H13: Trialability of the ecosan toilet positively influences the attitude of existing users toward ecosan.

2.3.6 The mediating role of attitude

The mediating role of attitude within the theory of diffusion of innovation (DOI) is crucial in understanding the effect of different constructs on adoption intention. Studies by Aroral et al. (2022) and Chukwuma (2023) identify attitude as a significant mediator between perceived innovation attributes (PICs), such as relative advantage, compatibility, complexity, trialability, and observability, and adoption intention. Moon (2020) suggests that PICs act as psychological markers influencing adoption attitudes and, subsequently, adoption intention when mediated through attitudes. Previous research by Damanpour and Schneider (2009) recognizes the direct impact of PICs on behavioral intention, while Chou et al. (2012) argue that modeling PICs as indirect influencers through attitude provides a more effective representation. Rogers (2003) emphasizes that the establishment of attitude toward innovation significantly influences the decision-making process for adoption. The role of attitude as a mediator is further reinforced by investigation like Brunsø et al. (2004) and Frambach and Schillewaert (2002), indicating that intention is better predicted by behavioral attitude than any other constructs. Jansson et al. (2017) highlight attitude as context-specific dispositions linking individual perceptions to actual consumption behaviors. Several studies illustrate the indirect association between relative advantages and attitude on purchasing behavior, such as Liu et al. (2020) in using internet banking and Park and Chen (2007) confirm the association between attitudes influenced by observability in the adoption of smartphone. The permission for trial before adoption contributes to the endorsement of attitude, facilitating the adoption process (Rogers, 2003). The study aims to validate the hypothesis concerning the mediating role of attitude in the association between DOI constructs and purchase intention (Aroral et al., 2022).

H14: Attitude mediates the effect of relative advantages on ecosan adoption intention.

H15: Attitude mediates the effect of complexity on ecosan adoption intention.

H16: Attitude mediates the effect of compatibility on ecosan adoption intention.

H17: Attitude mediates the effect of observability on ecosan adoption intention.

H18: Attitude mediates the effect of triability on ecosan adoption intention.

3 Material and methods

3.1 Description of the study area

Established in 1963, Arba Minch City has burgeoned into a thriving urban center, strategically positioned between the "Abaya Dar" forest, "Nechsar" National Park, and the serene shores of Lake Abaya and Lake Chamo. With a population surging from 74,879 in 2007 G.C. to 232,811 in 2022 and estimated to be 246,453 by 2023, the city stands as a rapidly growing urban hub in Ethiopia. Its geographical coordinates span an elongated shape of approximately 24.1 km from north to south and 15.3 km from east to west, maintaining a moderate population density and experiencing a semi-hot climate. Shaped by volcanic and tectonic events, Arba Minch reveals variable topography tilted towards the east, situated at an average elevation of 1250m.a.s.l. amid surrounding mountains. The city embraces its natural surroundings, boasting the highest point at Ganta Meyiche (1960 m.a.s.l.) and the lowest in the southeastern part (1090 m.a.s.l.). Named "forty springs" in Amharic, Arba Minch is rich in cold springs and wetlands, with Nech Sar National Park covering 514 km^2 and Lakes Abaya and

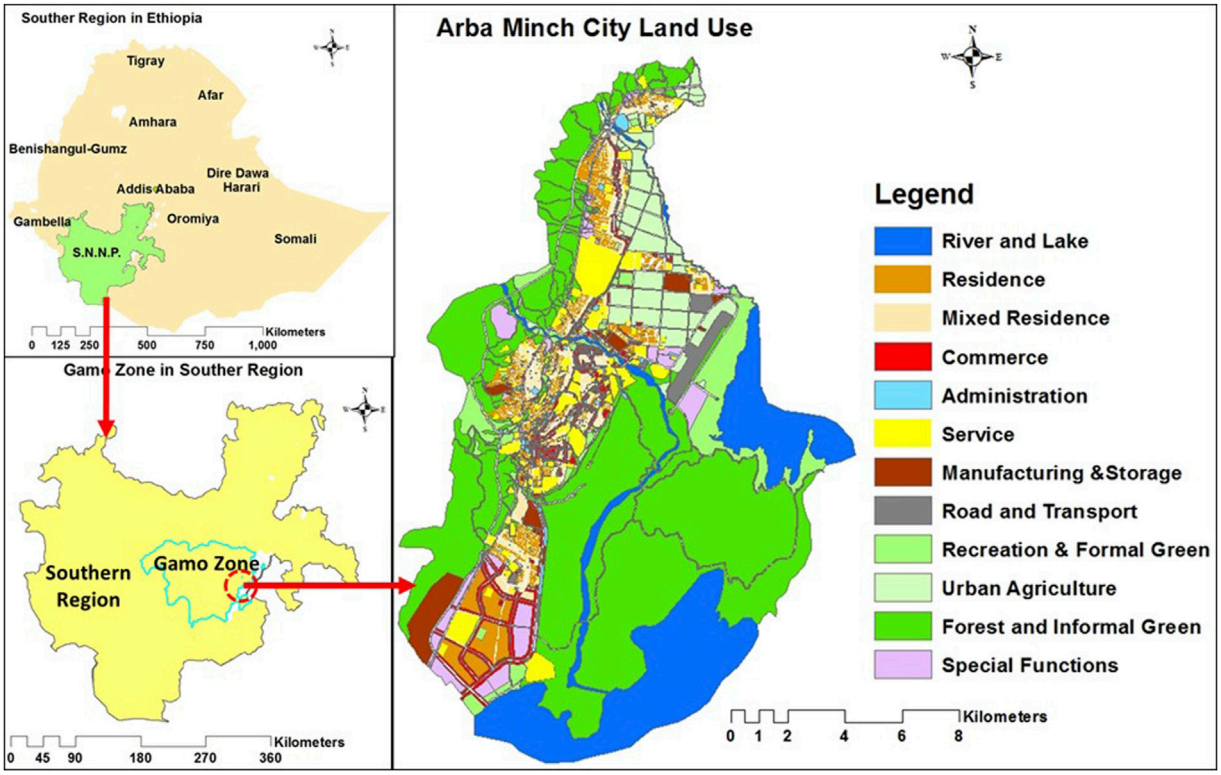

FIGURE 2
Location of Arba Minch City Source: Arba Minch City structural plan (2022).

Chamo contributing to its scenic charm (see Figure 2). However, the city faces liquid waste management challenges, relying on pit latrines and confronting disposal issues (Arba Minch City Administration, 2022). This delicate equilibrium between urban development and preserving natural heritage defines Arba Minch as a testament to sustainable urban living.

In city sanitation and waste management challenges are exacerbated by the economic constraints faced by residents especially in the urban periphery. Arba Minch city contends with a high population growth rate, a common concern shared by many urban centers (ROSA, 2007). One glaring issue is the absence of a liquid waste disposal system, with the waste generated from bathing and domestic washing activities being haphazardly discarded into the streets and nearby river systems (Arba Minch City Administration, 2022). Notably, the city lacks dedicated sites for liquid waste disposal and treatment. The absence of a sewerage system makes pit latrines the predominant method of sewage disposal, with approximately 10,913 individual latrines reported in the city (Arba Minch City Administration, 2022).

In Arba Minch, numerous pit latrines suffer from structural deficiencies, characterized by substandard superstructures, wide pit holes, and improper floors (Kassa, 2009). Even operational pit latrines encounter challenges such as overflow, unpleasant odors, and infestations of flies. The town contends with frequent flooding, exacerbated by the topography, leading to the collapse of pit toilets. Consequently, residents are driven to explore alternative sanitation technologies like ecological sanitation (ecosan), particularly in areas with rocky ground where pit digging is economically impractical (Kassa, 2009). Compounding the sanitation predicament, the municipality has lacked a vacuum truck for sludge disposal since 2017 G.C. As a result, residents in need of desludging services often resort to renting trucks from neighboring Hawassa and Shashemene, incurring substantial costs (Arba Minch City Administration, 2022). Those unable to bear such expenses resort to digging new pits when existing ones reach capacity. Recently, the city's Water Supply and Sewerage Services Enterprise acquired a vacuum truck, supplemented by the university's possession of another (Arba Minch City Administration, 2022). The proximity of farmlands surrounding the town further incentivizes the acceptance of ecosan toilets, particularly due to the fact that there has been a rise in fertilizer costs (Kassa, 2009). The absence of a dedicated desludging truck emerges as a pivotal factor behind the successful integration of ecosan toilets in Arba Minch (Kassa, 2009).

Since then Arba Minch City has undertaken various initiatives to address the lack of proper sanitation facilities, by using ecological way of excreta management such as ecosan. The European Union-funded ROSA (Resource-Oriented Sanitation Concepts for peri-urban areas in Africa) project played a pivotal role in introducing resource-oriented hygiene notions to achieve ecological way of sanitation management and achive the UN Millennium Development Goals (MDGs) (Arba Minch, 2009). Within the 30-month project period, ROSA implemented 65 systems in Arba Minch, including 15 Urine-Diversion Dry Toilets (UDDTs), 28 Fossa Alternas, 9 Arborloos, 7 Greywater Towers, 1 biogas unit, and more than 5 composting schemes, emphasizing resource-oriented solutions. Regarding users of the systems

15 UDDTs serving 447 users, 28 Fossa Alternas with 167 users, 9 Arborloos accommodating 33 users, and 7 Greywater Towers catering to 37 users (ROSA, 2009). The construction and implementation of these units followed a combination of demonstration units for testing and cost-sharing models with households or institutions, showing a commitment to community involvement and financial sustainability (ROSA, 2009).

In parallel, the CLARA project (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas) commenced in 2011, involving partners like Arba Minch University and Arba Minch Water Supply and Sewerage Enterprise. The project aimed to enhance capacity in water and sanitation and included partners from various sectors, such as municipalities, compost production associations, solid waste collectors, and health centers. Additionally, the recent RUNRES project (Establish a Circular economy for Resilient City Region Food System) in Arba Minch, initiated in 2019, emphasizes ecologically sound and innovative sanitation solutions. RUNRES targets improved public health, reduced environmental pollution, increased access to locally sourced soil amendments for agriculture, enhanced value addition in food systems, and improved control of nutrient flows in the rural-urban nexus. Notably, the introduction of the MASSP Urine recycling enterprise is a significant development, focusing on recycling human urine into struvite fertilizer. This innovation involves installing Urine Diverting mobile toilets in high-traffic areas and modifying existing public toilets for source separation. The isolated urine is then transported to the treatment site for processing into struvite. In summary, Arba Minch City's journey in ecosan toilet development has been marked by collaborative projects, community engagement, and a focus on resource-oriented, sustainable sanitation solutions. The integration of research, field implementation, and partnerships reflects a comprehensive approach to addressing sanitation challenges and fostering innovation in the city.

3.2 Research approach

The predominant study method implemented for this study is quantitative, underscoring a systematic and structured examination of numerical data. Nevertheless, the research methodology incorporates a nuanced dimension by integrating qualitative data. Following Creswell's and Creswell (2017) Sequential Mixed Research method, qualitative data were initially gathered, laying the foundation for a more comprehensive investigation enriched by subsequent quantitative data collection. This approach ensures a holistic understanding of the research problem, allowing for a layered exploration of participants' perceptions and attitudes toward adapting ecosan in Arba Minch City. Theoretical frameworks, particularly the combined theory of planned behavior and diffusion of innovation, serve as guiding lenses, influencing the formulation of research questions, participant selection, data collection strategies, and the interpretation of study implications.

3.3 Source of data

The study draws data from a dual set of sources, namely, primary and secondary. Primary data emanates from household heads utilizing various sanitation systems, encompassing ecosan toilets, flash toilets, and pit latrines. This firsthand information provides a direct insight into residents' sanitation practices. Secondary data, on the other hand, is derived from an array of authoritative sources, including books, reports, and both published and unpublished documents from institutions such as Arba Minch University, Arba Minch Municipality, NGOs, and MSSEs. Notably, research outputs from ROSA, CLARA, and SPA projects in Arba Minch City form a substantive component of the secondary data. The integration of satellite imagery further augments secondary data, aiding in the identification and profiling of respondents within the city. This comprehensive approach to data sourcing ensures a robust and multi-faceted foundation for the research study.

3.4 Data collection instruments

The principal data gathering tool employed in this research was a meticulously designed structured survey. Framed by the theoretical foundations of the theory of planned behavior (TPB) and diffusion of innovation (DOI), the questionnaire comprised two comprehensive sections. The initial part focused on gathering socio-economic information and details regarding the types of sanitation systems in use within households in the town. The second section was strategically structured, featuring 15 independent questions for the three constructs of TPB (each construct consisting of 5 questions) and 25 independent questions for the five constructs of the DOI (each construct with 5 questions). Additionally, a single dependent question was incorporated. The questionnaire design was intricately tuned to the study's theme, concentrating on the perception and attitude of ecosan users toward its adoption as an alternative toilet system in Arba Minch City. The formulation of survey items was a result of a comprehensive literature review focusing on users and their perspectives.

Moreover, the formulation of questionnaire items was enriched by an extensive review of literature specifically aimed at elucidating the perception and attitude of adopters concerning ecosan toilets. This approach ensured that the questionnaire captured nuanced insights aligned with the combined theoretical frameworks of the theory of planned behavior and diffusion of innovation within the context of ecosan. To measure variables in the integrated models of TPB and DOI, a four-point Likert Scale (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree) was utilized, with five items recorded for each construct. The inclusion of respondents with prior ecosan experience, as well as those who had not yet adopted ecosan toilets, facilitated a comprehensive understanding of residents' perspectives and demands for potential policy-making in the future.

3.5 Sample design

The study employs a meticulously crafted sample design to ensure a representative and insightful exploration of the research objectives. The town's total population, recorded at 232,811 in 2022 and estimated to rise to 246,453 by 2023, encompasses 46,562 households. Within this demographic, household heads utilize diverse sanitation systems, including the prevalent pit

latrine, flash toilet, and unimproved latrine. A subset of these households possesses prior experience with ecosan adoption. To effectively capture this diversity, the sampling frame targets all household heads in the city who own housing units. Implementing a stratified random sampling approach enhances the precision of data collection. The city is stratified into its smallest administrative units, referred to locally as "Ketenas," amounting to 21 in total. Each Ketena serves as a distinct stratum facilitating efficient data collection. The entire sample of the research is determined to be 384 respondents, with an equitable distribution of 19 respondents selected from each Ketena. The strategic organization of Ketenas, based on the town's block arrangement, streamlines data collection efforts. Within each Ketena, a systematic random sampling technique is applied to identify and survey 19 respondents. This meticulous sample design ensures comprehensive coverage, representing the city's diverse demographic and sanitation practices.

3.6 Data analysis method

The study employed a comprehensive approach to data analysis, utilizing both descriptive and inferential statistics. Descriptive statistics, including mean, frequency, and percentage, were harnessed to get a perspective within the diverse views of toilet users regarding the perception and attitude toward adopting ecosan toilets. In the realm of inferential statistics, Structural Equation Modeling (SEM) played a pivotal role, executed through SPSS 22 and IBM SPSS Amos 22. SEM, a sophisticated analytical tool, facilitated the exploration of complex interactions among multiple variables. The SEM model unfolded in two phases: the initial phase involved evaluating the internal consistency of assessing tools, employing Cronbach's alpha (CR) to ensure reliability. Subsequently, Composite reliability was applied, ensuring the removal of arbitrary measurement errors during the investigation. To discern the variance in latent variables, an examination of Average Variance Extracted (AVE) was conducted. Ensuring the discriminant validity of constructs was paramount, confirming their distinctiveness from one another. The inferential statistics further encompassed the scrutiny of various model fitting metrics, including absolute fit indices (RMSEA and RMR), incremental fit indices (NFI and CFI), and Parsimony fit indices (AGFI and PNFI). Additionally, traditional measures such as Chi-square, degrees of freedom, and probability were meticulously considered. This multifaceted approach to data analysis not only captured the richness of toilet users' perspectives but also delved into the intricate relationships among variables, ensuring the robustness and validity of the findings.

4 Result

4.1 Descriptive statistics

The descriptive statistics provide a broader picture of the social, economic and demographic feature of the surveyed respondents in Arba Minch City, shedding light on factors that may influence decisions related to the adoption of ecosan toilets. The household head gender distribution shows a significant majority of male respondents, comprising 83.3% of the sample, while females account for 16.7%. With regard to age, the significant proportion fall 35–65 age group (83.6%), with smaller proportions in the 18–35 (10.9%) and 65 and above (5.2%) categories. Regarding marital status, the majority are married (89.1%), followed by divorced or separated (3.6%), widowed (3.9%), and unmarried (3.1%). The household population size provides insights into the family structures, with a major share having six and more households (57.2%). Education levels vary, with the illiterate comprising 16.7%, elementary education (41.7%), high school (21.6%), and a smaller percentage holding certificates, diplomas, or degrees (11.5% and 8.3%, respectively). Religious affiliations are predominantly Protestant (57.6%) and Orthodox (40.1%), with smaller representations from the Muslim community (1.8%) and other specified religions (0.5%).

The types of jobs held by household heads indicate a diverse occupational landscape, with private jobs being the most prevalent (51.6%), followed by government jobs (24.2%), daily laborers (12.5%), pensioners (8.1%), and others (3.6%). Monthly income distribution highlights varying financial capacities, with notable percentages falling within the ranges of 1,600 to 3,200 birr (19.3%) and 5,400 to 10,800 birr (26.3%). Lastly, the toilet type used by households demonstrates the prevalence of traditional pit latrines with cement floors (61.7%), followed by pit latrines with mud floors (21.1%), flash toilets (9.1%), and ecosan toilets (5.7%). These tables collectively provide a broad overview of the soial, economic and demographic landscape of the survey households, offering valuable insights for understanding the factors influencing ecosan adoption decisions in Arba Minch City.

4.2 Measurement models (validity and reliability)

This section investigates the reliability and validity aspects of the study, focusing on the critical appraisal of measurement instruments to ensure their accuracy and dependability in gauging the research constructs. The study adapted

Cronbach's alpha so as to decide measurements' internal consistency in addition to depict constructions' dependability. Hence, according to Hair et al. (2022), Cronbach's alpha value must be 0.70 or above are accepted. The result shows that all constructs are above 0.70 except observability that have almost near to the minimum requirement, which includes attitude (0.852), subjective norm (0.789), perceived behavioral control (0.852), relative advantage (0.77), complexity (0.818) compatibility (0.761), trayability (0.826) and observability (0.674). The reliability of this study also ensured by checking the standardized regression weight of each item in latent variable. The standardized factor loading lower than 0.60 is pulled out. Accordingly, item number two and four from subjective norm, item number one and three from relative advantage of the latent variable, item three from complexity, item one and three from compatibility, first item from trayability and item one, two and three from observability are below the minimum factor loading hence they are deleted.

TABLE 1 Cronbach's alpha, composite reliability, average variance extracted and discriminant validity.

Construct	CA	CR	AVE	Discriminant validity							
				Atti.	SN	PBC	RA	Coex.	Copt.	Tray	Obs.
Attitude	0.852	0.872	0.578	**0.762**							
SN	0.789	0.792	0.559	0.611	**0.744**						
PBC	0.852	0.852	0.536	0.767	0.646	**0.731**					
RA	0.77	0.767	0.523	0.695	0.598	0.738	**0.724**				
Complexity	0.818	0.818	0.53	0.643	0.735	0.666	0.648	**0.727**			
Compatibility	0.761	0.759	0.512	0.584	0.674	0.643	0.645	0.832	**0.714**		
Trayability	0.826	0.847	0.581	0.691	0.687	0.717	0.681	0.774	0.762	**0.736**	
Observability	0.674	0.682	0.518	0.646	0.691	0.659	0.625	0.739	0.694	0.701	**0.72**

CA, cronbach alpha; CR, composite reliability; AVE, average variance extracted; Atti, attitude; SN, subjective norm; PBC, perceived behavioral control; RA, relative advantage; Coex., complexity, Copt., compatibility; Tray, Trayability; Obs., observability. Note: In the discriminant validity section, the bold figure represents the result of the square root of the average variance extracted (AVE), which enables the measurement model's robustness and validity to be assessed.

The convergent validity of the study can be checked in three relative analyses which include checking factor lodgings, composite reliability (CR) and average variance extracted (AVE). Standardized factor loadings indicate the level of relationship between measurements elements and the latent variable (Namahoot and Rattanawiboonsom, 2022). Hence, according to Suh and Han (2003) standardized factor loading of each item in latent variables must be above 0.6. The result shows that there are items in each latent variable that are below the minimum requirements and hence they are deleted. The second element of convergent validity is CR which shows the level that all elements are free from random error. As indicated by Hair et al. (2022) the CR values essential to be greater than 0.7, and hence the result of this study depicts that except observability of households to adapt ecosan toilet (0.682) the remaining constructs of both TPB and DOI fulfill the minimum requirements of CR. Accordingly, attitude (0.872), subjective norm (0.792), perceived behavioral control (0.852), relative advantage (0.767), complexity (0.818), compatibility (0.759), and trayability (0.847). Relating to the AVE, it is distinguished for the difference by testing the latent variable for the arbitrary measurement error. According to Fornell and Larcker (1981) AVE should be above 0.5 to be valid for the study. The outcome of the investigation depicts that the AVE in all latent variables fulfill the minimum requirements with attitude (0.578), subjective norm (0.559), perceived behavioral control (0.536), relative advantage (0.523), complexity (0.53), compatibility (0.512), trayability (0.581) and observability (0.518). Based on these data, the convergent validity of the study is fitting with the standard.

According to Hair Junior et al. (2014) discriminant validity refers to the empirical difference among the constructs in a single latent variable. Moreover, it helps to determine the level of differences among the corresponding constructs (Hair Junior et al., 2014). Moreover, the constructs of a latent variable has a superior power to measure variance of its own than the constructs of other latent variables, therefore, the square root of average variance extracted (AVE) have to higher than the latent variables of the correlations in all other constructs (Hair Junior et al., 2014). Based on Fornell-Lacker criteria, the outcome of the research shows overall good results. The square root of attitude AVE (0.762) greater than all other constructs except perceived behavioral control (0.767). Conversely, the square root of perceived behavioral control AVE (0.731) higher than other constructs except attitude (0.767) and relative advantage (0.738) constructs. In case of relative advantage the square root of AVE (0.724) lower in case of perceived behavioral control (0.738). However, in case of complexity, there are discriminant validity problems where the square root of AVE of complexity (0.727), lower than compatibility (0.832), trayability (0.774) and observability (0.739). Regarding compatibility, the square root of AVE is (0.714) showing a superior result than other latent variables except in case of complexity (0.832) and trayability (0.762). The square root of AVE of trayability is (0.736) greater than most constructs except compatibility (0.762) and complexity (0.774). Concerning Observaibility, the square root of AVE is (0.72) which is within the criteria except complexity where the square root of AVE is about (0.739). Generally, the discriminant validity of the study within acceptable range where most of the square root of AVE of each constructs is above the correlation of other latent variables (see Table 1).

4.3 Model fitness index

The aim of model fitness test in this study is to confirm the adequacy of the association among variables and the level of representation of measured variables in the study measurement scale (Ren et al., 2022). The SPSS AMOS results for the fit indices of the model were evaluated to measure the adequacy of the proposed model. The p-value, a crucial indicator, revealed an insignificant result ($p \geq 0.05$), as outlined by Joreskog and Sörbom (1996). Despite the seemingly contradictory nature of this outcome, it aligns with the observation that significant results are not uncommon in research, particularly when dealing with smaller sample sizes. The Chi-square divided by Degree of Freedom (CMIN/df) provided additional insight into model fit, with values ≤3 considered acceptable and ≤5 reasonable. In this study, the calculated ratio of 1.669 falls within the acceptable range, as stipulated by Kline (1998).

The Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) were also considered. According to Hu and Bentler

TABLE 2 Result of structural equation model and hypothesis.

Dependent variable	Independent variable	Estimate	S.E.	C.R.	*p*-value	Result
Attitude	<--Observability	0.888	0.346	2.569	0.010	Accept
	<--Trayability	0.246	0.187	1.320	0.187	Reject
	<--Compatibility	0.106	0.450	0.236	0.814	Reject
	<--Complexity	−0.907	0.436	−2.079	0.038	Accept
	<--Relative advantage	0.607	0.187	3.249	0.001	Accept
Intention	<--Behavioural attitude	0.955	0.238	4.020	0.000	Accept
	<--Perceived behavioural Control	2.309	0.657	3.512	0.000	Accept
	<--Subjective norm	−0.095	0.420	−0.225	0.822	Reject
	<--Observability	−1.370	1.108	−1.237	0.216	Reject
	<--Trayability	−0.667	0.334	−1.994	0.046	Accept
	<--Compatibility	1.423	0.554	2.569	0.010	Accept
	<--Complexity	0.080	0.799	0.101	0.920	Reject
	<--Relative advantage	−1.494	0.618	−2.419	0.016	Accept

S.E., standard error; C.R., critical ration.

(1998), a GFI result of 1 indicates a perfect fit, while values ≥0.95 and ≥0.9 are deemed excellent and acceptable, respectively. The study's GFI of 0.904 aligns with an acceptable fit. Similarly, AGFI, with a threshold of ≥0.90 (Tabachnick and Fidell, 2007), is slightly below at 0.879, yet still close to meeting the minimum fit requirements. The Comparative Fit Index (CFI) was evaluated, with a result of 0.965 surpassing the threshold of 0.95, indicating an excellent fit (Fan et al., 1999; West et al., 2012). The Root Mean Square Error of Approximation (RMSEA) also met the criterion for reasonable fit (≤0.05), as the study recorded an RMSEA result of 0.042 (MacCallum et al., 1996). Additionally, the Root Mean Squared Residual (RMR) and Standardized Root Mean Squared Residual (SRMR) were considered. The RMR result of 0.022 aligns with Steiger's and Rogers (2007) criteria for an acceptable fit (≤0.05). The SRMR, with an acceptable fit threshold of ≤0.05, is within range at 0.0391. In summary, the fit indices collectively recommend an excellent fit for the proposed model in the study, with only minor exceptions. This reinforces the appropriateness of the model for examining the adoption of ecosan toilets in Arba Minch City, Ethiopia.

4.4 Structural equation model and hypothesis testing

In navigating the intricate landscape of users' perceptions and attitudes toward adopting ecosan toilets, our analysis aims to unravel the complex relationships between diffusion of innovation (DOI) constructs, theory of planned behavior (TPB) constructs, and the Behavioral intention of users across various toilet types. Initiating our exploration with the DOI constructs, Observability emerges as a pivotal factor significantly shaping attitude (Estimate = 0.888, p = 0.01 supporting H1) among diverse users. This signifies that the visible aspects of ecosan toilet adoption substantially contribute to users' positive attitudes (see Table 2).

Contrastingly, trayability, while showcasing a direct effect on attitude (Estimate = 0.246, p = 0.187 not upholding H2), does not achieve statistical significance. This nuanced result suggests that the ease of experimentation and adoption may not universally dominate users' attitudes, indicating a need for targeted approaches that consider the diverse preferences and circumstances of users, especially across different toilet types. Regarding the association between attitude and intention, we uncover a robust connection. Attitude significantly influences behavioral intention (Estimate = 0.955, p < 0.001 supporting H3), indicating that users with positive attitudes are more likely to harbor a genuine intent to adopt ecosan toilets. This underscores the pivotal role of attitudes as precursors to concrete behavioral intentions, providing a crucial insight for interventions seeking to promote sustainable sanitation practices.

Delving further into the collective impact of both DOI and TPB constructs on behavioral intention, relative advantage emerges as a potent force, significantly influencing both behavioral attitude (Estimate = 0.607, p = 0.001 supporting H4) and intention (Estimate = −1.494, p = 0.016 supporting H5). This highlights that users perceiving higher relative advantages in adopting ecosan toilets are not only more likely to form positive attitudes but also demonstrate a tangible intent to adopt these sustainable practices. The consistency of this impact across different user groups underscores the overarching importance of emphasizing the tangible benefits of ecosan toilets. However, the DOI construct of complexity introduces a nuanced dimension. While it exerts a notable negative impact on attitude (Estimate = −0.907, p = 0.038 supporting H6), this sentiment does not significantly translate into intention (Estimate = 0.08, p = 0.92 not supporting H7). The negative attitudes resulting from perceived complexity might not directly deter users from intending to adopt ecosan toilets, hinting at a complex interplay between attitudes and intentions that necessitates further exploration.

Shifting our focus to compatibility, its seemingly insignificant influence on attitude (Estimate = 0.106, p = 0.814 not supporting

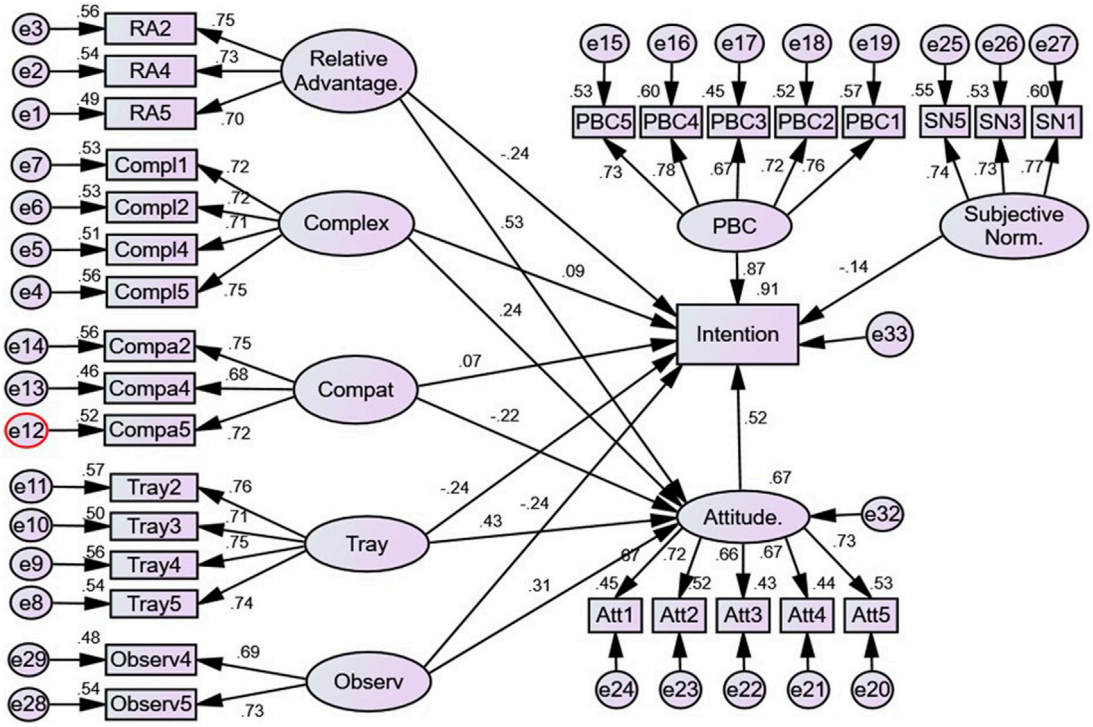

FIGURE 3
Result of structural equation modeling.

H8) across various toilet users warrants a closer examination. Conversely, the impact of Perceived Control on intention stands out significantly (Estimate = 2.309, $p < 0.001$ supporting H9). This suggests that users who perceive greater control over adopting ecosan toilets are more likely to exhibit a positive intention toward embracing this sustainable sanitation practice. Additionally, while subjective norm (Estimate = −0.095, p = 0.822 not supporting H10) appears statistically insignificant, its role in mediating attitudes and intentions necessitates further investigation, acknowledging the social influences on individual decision-making regarding toilet adoption. Regarding trayability, the result shows attitude positively influenced by trayability (Estimate = 0.513, p = 0.123, not supporting H11), and compatibility displayed a seemingly insignificant impact on behavioral intention (Estimate = −0.837, p = 0.612, not supporting H12). Complexity negatively affected behavioral intention (Estimate = −1.141, p = 0.181, not supporting H13), indicating a need for deeper exploration into these relationships within the context of diverse toilet users (see Figure 3).

5 Discussion

This investigation probes the intentions of individual property owners in Arba Minch City, Ethiopia, concerning the adoption of ecosan toilets. The study employs a combined model integrating the Theory of Planned Behaviour (TPB) and diffusion of innovation (DOI) to offer a nuanced outlook on how these theoretical frameworks collectively shape the behavioural intentions of toilet users in this specific context. Despite the existence of ecosan toilets in Ethiopia since 1997, the integration of TPB and DOI in research is notably sparse. This research aim to tie this gap and offer fresh understandings into the multifaceted influences of these theoretical models on users' behavioural intentions.

The outcome of this research reveals a mix of nuanced relationship among variables with the behavioral intention to adopt ecosan toilets. Both attitude and perceived behavioural control emerge as significant determinants in shaping users' intentions. A positive attitude is identified as a key predictor, indicating that users with favourable perceptions are more likely to harbor a genuine intent to adopt ecosan toilets. This aligns with the theoretical underpinning of the TPB, where the influence of attitudes on behavioral intention is significant (Ajzen, 1991). Similarly, perceived behavioural control, reflecting the apparent simplicity or challenges of adopting the innovation, is identified as a critical factor. Users who feel a greater feeling of control over the adoption process are higher probability to exhibit a positive intention toward embracing this sustainable sanitation practice. Again, these findings resonate with Ajzen's (1991) conceptualization of perceived behavioural control as a pivotal element in predicting behavioural intentions.

The impact of attitude on the adoption of ecosan toilets has been corroborated by various studies across different cultural contexts. In European countries, for instance, users expressed satisfaction and a willingness to purchase urine-fertilized food, reflecting a positive attitude toward ecological sanitation practices (Lienert and Larson, 2010). A similar pattern is observed among Swiss farmers, with a majority expressing a favorable attitude toward urine-based fertilizers (Lienert et al., 2003). However, the literature also highlights the existence of cultural nuances influencing users'

attitudes. Studies in Ghana and Zimbabwe, for instance, indicate a belief in the nutrient content of human excreta but a low willingness to use it as fertilizer for crops (Manyanhaire and Mutangadura–Mangeya, 2009; Mariwah and Drangert, 2011). In the Philippines, respondents were aware of the nutrient value but hesitated to use human excreta for fertilizing edible crops (Ignacio et al., 2018). These diverse findings underscore the need for a comprehensive understanding of the contextual factors shaping users' attitudes toward ecological sanitation technologies.

Perceived behavioural control, particularly in the context of adopting ecological sanitation technologies, is strongly influenced by cost considerations. Ignacio et al. (2018) study in the Philippines, for example, highlights the potential high cost as a significant deterrent for installing ecosan toilets in rural areas. The result similar with the outcome of a study by Abraham et al. (2011) and Uddin et al. (2012), who focus on the installation cost of ecological sanitation is perceived as prohibitively expensive, especially for poor families that need to adopt new technology and expected to expend money to install the technology. The issue of affordability emerges as a consistent barrier to the adoption of ecosan, as reiterated by Tadesse (2011) and Uddin et al. (2012). Specifically, the outcomes from the mentioned study confirm that excess cost of eosan is a key challenge excluding user to adopt the new technology, with 71% indicating an inability to afford ecological sanitation. Additionally, social barriers, particularly related to acceptance, come into play, with previous studies consistently showing a decrease in acceptance when willingness to pay is considered (Pahl-Wostl et al., 2003; Lienert and Larsen, 2010; Lamichhane and Babcock, 2013). These findings collectively underscore the critical role of financial considerations and affordability in shaping individuals' perceived control over the adoption of ecological sanitation practices.

The examination of compatibility, relative advantage, and trayability reveals intriguing deviations from anticipated patterns established in the literature. Compatibility, often regarded as a key determinant of technology adoption, exhibits a positive relationship in this study, confirming a broader literature emphasizing the positive result associated with adopting technologies perceived as compatible and simple to apply (Davis, 1989; Rogers, 1995a). In contrast, Chunga (2016) and Morgan and Mekonnen (2013) contribute valuable insights into the perceived incompatibility of ecological sanitation technology, citing issues related to multiple households. These studies underscore the inconvenience of managing excreta and suggest the innovation's unsuitability for plots with numerous residents. While these findings align with the conventional understanding that compatibility is crucial for technology adoption, the positive estimate in the study prompts a closer examination of context-specific factors influencing compatibility.

Relative advantage, on the other hand, presents a surprising negative relationship in this study, contradicting prevailing literature emphasizing the benefits associated with ecological sanitation, such as cost-effective fertilizer production and enhanced safety for children (Bracken et al., 2009; Haq and Cambridge, 2012; Chunga, 2016). Chunga (2016) highlights property owners' strong preference for ecological sanitation due to its permanent nature, reduced likelihood of collapsing, and improved safety for children. However, Morgan and Mekonnen (2013) introduce a critical perspective, acknowledging potential disadvantages arising from insufficient considerations in the technology's design. In exploring trayability, the identified negative relationship introduces a new dimension to the literature, challenging the prevailing notion that water conservation serves as a key motivating factor for the adoption of urine and feces-based fertilizers (Albrecht et al., 2010). Furthermore, there was a significant surge in the acceptance of and interest among relatives regarding the adoption of ecosan toilets. 80% farmers in a village in Indonesia expressing a willingness to use excreta fertilizers on their farmlands. However, it is noteworthy that only 40% of these farmers indicated their intention to inform clients about the specific kind of fertilizer being used (Albrecht et al., 2010).

Regarding subjective norm, which represents the apparent societal influence to adopt an innovation, exhibits an insignificant relationship in this study. This finding, showcasing insignificant results, is in line with the broader literature where the variability in outcomes regarding the influence of subjective norms on technology adoption is apparent. Ejigu and Habtermariam (2023), Ignacio et al. (2018) and Chunga (2016) emphasize the limited influence of subjective norms in specific contexts, while Lienert and Larsen (2006) and Simha et al. (2021) highlight its significance. Chunga's (2016) observation that only a small percentage of respondents felt influenced by others to adopt ecological sanitation contradicts findings from India, where social pressure, particularly from neighbors, played a pivotal role (Simha et al., 2017). The variability in subjective norm effects globally, as indicated by Simha et al. (2021), underscores the need for a nuanced understanding of this construct in diverse cultural and geographical settings. Concerning complexity, the inconclusive results in the study align with existing literature, which reports mixed findings on the perceived complexity of ecological sanitation technology. Ignacio et al. (2018) and Roma et al. (2013) underline complexity as a deterrent, emphasizing the involving operation and maintenance when shared among households. Chunga (2016) presents a nuanced perspective, outlining both positive aspects, such as access to compost, and negative aspects, including the involvement of tasks like adding ash and soil. The multifaceted nature of complexity underscores the importance of addressing specific components of the technology that user may find challenging.

5.1 Mediating effects of attitude

The comprehensive examination of bootstrapping results delineating the direct, indirect, and total effects of diffusion of innovation (DOI) constructs on intention through the mediating variable of attitude offers valuable insights into the complex interplay influencing sanitation practices in Arba Minch City, Ethiopia. Beginning with relative advantage (RA), the analysis reveals a direct effect of −2.357, with an indirect effect of 0.68 and a total effect of −1.678. The confidence interval (CI) for the indirect effect (−0.605–2.428) includes zero, and the p-value of 0.156 indicates no mediation. This suggests that the perceived advantages of specific toilet facilities, as captured by RA, do not significantly rely on individuals' attitudes, implying a direct impact on intention and hence not supporting H14. In contrast, the

TABLE 3 Results of direct, indirect and total effects as attitude a mediating variable.

Relationship	Direct effect	Indirect effect	Total effect	Confidence interval		*p*-value	Conclusion on indirect effects
				Lower	Upper		
RA => Attitude => Intention	−2.357	0.68	−1.678	−0.605	2.428	0.156	No mediation (Zero between upper and lower confidence interval and insignificance *p*-value)
Complexity =>Attitude =>Intention	2.893	−1.584	1.309	−9.948	−0.399	0.008	Full mediation (no zero between upper and lower confidence interval, significance *p*-value and insignificant direct effect)
Compatibility=> Attitude => Intention	2.826	−0.457	2.369	−5.388	0.932	0.366	No mediation (Zero between upper and lower confidence interval and insignificance *p*-value)
Trayability=> Attitude => Intention	−1.265	0.455	−0.81	−0.259	3.153	0.151	No mediation (Zero between upper and lower confidence interval and insignificance *p*-value)
Observability=> Attitude => Intention	−6.344	2.25	−4.094	0.644	10.806	0.005	Full mediation (no zero between upper and lower confidence interval, significance *p*-value and insignificant direct effect)

examination of complexity presents a direct effect of 2.893, an indirect effect of −1.584, and a total effect of 1.309. The CI for the indirect effect (−9.948 to −0.399) does not include zero, and the *p*-value of 0.008 indicates full mediation. This implies that the correlation between perceived complexity and intention is substantially mediated by individuals' attitudes, emphasizing the pivotal role of attitude enhancement in mitigating perceived complexities, therefore it support H15.

Regarding compatibility, the analysis reveals a direct effect of 2.826, an indirect effect of −0.457, and a total effect of 2.369. The confidence interval for the indirect effect (−5.388 to 0.932) includes zero, and the *p*-value of 0.366 suggests no mediation. This underscores that perceived compatibility does not significantly rely on attitudes in shaping intention, emphasizing a direct influence on individuals' intentions and hence not supporting H16. For Trialability, the results show a direct effect of −1.265, an indirect effect of 0.455, and a total effect of −0.81. The confidence interval for the indirect effect (−0.259–3.153) includes zero, and the *p*-value of 0.151 indicates no mediation. This suggests that the association between trialability and intention is not substantially mediated by attitudes, reflecting a direct impact which is not supporting H17. Lastly, the analysis of Observability demonstrates a direct effect of −6.344, an indirect effect of 2.25, and a total effect of −4.094. The confidence interval for the indirect effect (0.644–10.806) does not include zero, and the *p*-value of 0.005 indicates full mediation. This highlights the influential role of attitudes in shaping the relationship between observability and intention, hence it support H18 (see Table 3).

In analyzing the mediating effects of attitude within the context of the diffusion of innovation (DOI) constructs and behavioral intention, the study sheds light on crucial implications for Arba Minch City residents contemplating the adoption of ecosan toilets. The examination of relative advantage (RA) suggests that perceived advantages of specific toilet facilities, as captured by RA, has a negative association with behavioral intention via attitude as a mediating variable. Consequently, the findings imply that residents' intentions to adopt ecosan toilets are primarily determined by the relative advantages of the innovation itself than their attitudes towards it. This underscores the need for targeted interventions that directly address the perceived advantages of ecosan toilets to enhance their adoption in Arba Minch City.

Contrastingly, the study reveals a different scenario for complexity, compatibility, trialability, and observability. Perceived complexity has a positive association with behavioral intention, but this relationship is substantially mediated by individuals' attitudes. The implication here is that efforts to mitigate perceived complexities through attitude enhancement could significantly boost residents' intentions to adopt ecosan toilets. However, in the cases of compatibility and trialability, the study suggests that these DOI constructs have a direct impact on intention, and their influence is not significantly mediated by attitudes. As such, strategies for promoting compatibility and trialability should focus on addressing these specific attributes directly rather than relying on attitude enhancement. Finally, the analysis indicates that observability has a negative association with behavioral intention, and this effect is fully mediated by individuals' attitudes. Consequently, interventions that enhance positive attitudes towards the observability of ecosan toilets may effectively counteract the negative impact on residents' intentions, presenting a nuanced approach for fostering adoption in Arba Minch City.

5.2 Multi group analysis of various toilet users

The multi-group analysis offer valuable insights into the nuanced relationships between users' perceptions, attitudes, and the adoption of ecosan toilets across various types of toilet users. For

users relying on pit toilets with cement floors, the influence of observability on attitude is positive but does not reach statistical significance (Estimate = 0.813, p = 0.243). Complexity, compatibility, and relative advantage exhibit similar trends, showcasing potential influences on attitude without achieving statistical significance. However, trayability introduces a negative impact on attitude (Estimate = −1.343, p = 0.402), indicating that users perceiving the adoption process as less trayable might harbor less positive attitudes. Concerning the association between behavioral intention and attitude for all toilet users, there is a direct and substantial impact of attitude is evident (Estimate = 1.116, p = 0.000), underlining the crucial role of attitudes in shaping the intention to adopt ecosan toilets. Perceived control also makes a significant positive contribution to intention (Estimate = 2.917, p = 0.000), suggesting that users who feel more in control are more likely to express a genuine intention to adopt.

In the context of pit toilets with mud floors, users' perceptions of complexity, observability, trayability, and relative advantage demonstrate positive influences on attitude, with compatibility (Estimate = −1.52, p = 0.039) and relative advantage (Estimate = 1.666, p = 0.026) reaching statistical significance. Notably, users perceive tangible advantages in adopting ecosan toilets, contributing positively to their attitudes. However, intention is not significantly influenced by attitude, revealing a potential discrepancy between attitudes and concrete intentions. Flash toilet users exhibit intriguing dynamics, with complexity, observability, trayability, and relative advantage influencing attitude positively, although none achieve statistical significance. However, the impact of attitude on intention is significant (Estimate = 1.273, p = 0.003), suggesting that positive attitudes substantially contribute to the intention to adopt ecosan toilets. Lastly, among users of ecosan toilets, the impact of observability, trayability, compatibility, complexity, and relative advantage on attitude is evident. While none of these relationships reach statistical significance, the positive effect of attitude on intention is notable (Estimate = 0.818, p = 0.488) although the result is not substantial (see Table 4).

The regression analysis reveals a noteworthy distinction between the aggregated results for all toilet users and the specific categories of pit with cement floor pit with mud floor, flash toilet, and ecosan toilet users. For the comprehensive group of all toilet users, a majority of the relationships between the independent variables (observability, trayability, compatibility, complexity, and relative advantage) and both the dependent variables (behavioral attitude and behavioral intention) are statistically significant. Specifically, observability, complexity, and relative advantage exhibit significant effects on behavioral attitude, while attitude, perceived behavioral control, trayability, compatibility, and relative advantage significantly influence behavioral intention. In contrast, when examining individual toilet user categories, the results diverge. For pit with cement floor users, only attitude significantly affects behavioral intention to adopt ecosan toilets. Pit with mud floor toilet users demonstrate limited statistically significant relationships, with only compatibility significantly impacting attitude. Similarly, flash toilet users exhibit statistical significance only in the correlation between attitude and intention. Intriguingly, for ecosan toilet users, none of the variables reach statistical significance in their impact on perception and attitude towards ecosan toilet adoption. This disparity in significance levels between the broader category of all toilet users and the individual toilet types suggests potential challenges in obtaining statistically meaningful results with smaller sample sizes. This underscores the importance of considering sample size nuances when interpreting regression outcomes for specific user groups.

5.3 Implication and policy consideration

The integration of the Theory of Planned Behavior (TPB) and Diffusion of Innovation (DOI) frameworks in this study provides a significant theoretical contribution to the understanding of ecosan toilet adoption. By combining TPB's focus on psychological factors influencing decision-makers' intentions and behaviors with DOI's emphasis on the perceived features of the technology, the study offers a holistic perspective on the adoption process. This integrated model enhances explanatory power and provides a nuanced understanding of the complexities surrounding the acceptance of new technologies, as highlighted by previous research (Weigel et al., 2014; Acikgoz et al., 2023). Additionally, the inclusion of multi-group analysis adds further depth to the study, allowing for comparisons among different types of toilet users and providing valuable insights for future research. The field survey-based approach employed in this research validates the relationships between various constructs of TPB and DOI with behavioral intention, offering theoretical support and practical guidance for the diffusion of ecosan toilets, particularly in economically poor country like Arba Minch City, Ethiopia. Furthermore, the study's exploration of the moderating effects of attitude on households' adoption intentions of ecosan toilets enhances the depth of understanding and contributes to the advancement of theoretical knowledge in this area.

The output of the study also provide indispensable and hand in tools for both policymakers and practitioners involved in promoting sustainable sanitation practices, particularly the adoption of ecosan toilets, in Arba Minch City, Ethiopia, and other cities and towns in Ethiopia. The nuanced understanding of factors influencing behavioral intentions emphasizes the need for tailored intervention strategies. Policymakers and practitioners should recognize the diversity in users' attitudes, perceived behavioral control, and contextual factors such as compatibility, relative advantage, and trayability. Designing interventions that are context-specific and address the unique challenges and perceptions within Arba Minch City is crucial for success. Moreover, given the central role of attitude in shaping intentions, efforts to promote positive attitudes toward ecosan toilets should be prioritized. Awareness campaigns, community engagement, and educational programs can be designed to highlight the benefits of ecosan toilets, dispel myths or misconceptions, and foster a positive perception of this sustainable sanitation practice.

The study underscores the critical role of financial considerations, especially affordability, in shaping users' perceived control over the adoption of ecosan toilets. Officials have to explore avenues for subsidizing installation costs, providing financial assistance to low-income households, or incentivizing the adoption of ecosan toilets to mitigate economic barriers. Furthermore, the implications of the study emphasize the importance of context-specific strategies. Policymakers and

TABLE 4 Results of multi group analysis among toilet users.

Dependent Variable	Independent Variable	All toilet type		Pit with cement floor		Pit with mud floor		Flash toilet		Ecosan toilet	
		Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value
Intention	<--Attitude	1.116	0.000	0.549	0.31	0.288	0.688	1.273	0.003	0.488	0.818
	<--SN	−0.103	0.831	−0.555	0.719	0.171	0.597	−0.603	0.335	−0.594	0.884
	<--PBC	2.917	0.000	0.550	0.843	1.359	0.252	0.900	0.223	1.300	0.332
	<--RA	−1.750	0.334	−1.393	0.555	−0.818	0.668	−0.755	0.315	0.207	0.933
	<--Complexity	1.071	0.014	−1.393	0.555	1.516	0.191	−1.161	0.070	−0.111	0.884
	<--Compatibility	1.752	0.026	−0.460	0.796	−0.558	0.706	1.374	0.038	0.377	0.873
	<--Trayability	−1.581	0.088	−0.314	0.940	−0.510	0.485	−0.689	0.335	−0.228	0.951
	<--Observability	−2.214	0.149	2.937	0.329	−0.459	0.467	0.340	0.599	−0.061	0.968
Attitude	<--RA	0.531	0.007	1.124	0.097	1.666	0.026	0.310	0.119	0.791	0.40
	<--Complexity	−0.885	0.015	0.058	0.952	0.019	0.990	0.408	0.277	0.437	0.542
	<--Compatibility	−0.178	0.644	0.378	0.383	−1.520	0.039	−0.479	0.177	−0.694	0.551
	<--Trayability	0.500	0.155	−1.343	0.402	0.171	0.719	0.374	0.410	1.414	0.326
	<--Observability	0.974	0.011	0.813	0.243	0.504	0.247	0.277	0.419	−1.028	0.249

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practitioners should not rely on one-size-fits-all approaches but rather tailor interventions to the unique characteristics, preferences, and challenges present in Arba Minch City. This might involve engaging with local communities, understanding cultural nuances, and considering the diverse needs of different user groups. Informing the public about the benefit of excreta as a major source of nutrients and the potential economic benefits can contribute to positive attitudes. Additionally, policies that encourage community engagement can foster a sense of ownership and acceptance. Involving local communities in decision-making processes, addressing their concerns, and incorporating their preferences in the adoption of sanitation plans can enhance the overall success of ecosan toilet adoption.

Policymakers should consider allocating funds to support innovative solutions that enhance the affordability and acceptability of ecosan toilets. This may involve research grants, pilot projects, or partnerships with research institutions and private enterprises to develop cost-effective and culturally sensitive technologies. Finally, establishing a robust monitoring and evaluation framework is crucial for assessing the impact of policies and interventions over time. Regular assessments can help policymakers refine strategies, address emerging challenges, and ensure the sustained adoption of ecosan toilets in Arba Minch City. By integrating these implications and policy considerations, policymakers and practitioners can work towards fostering a positive environment for the widespread adoption of ecosan toilets in Arba Minch City, contributing to better hygiene application and sustainable urban development.

5.4 Limitation and future research direction

This research contributes to understand the challenges of adopting ecosan toilet in Arba Minch City, although there are certain limitations that affect the generalizability and scope of the study output. First and foremost, the study's cross-sectional design provides a snapshot of attitudes, perceptions, and intentions. This limitation affects the capacity to create a correlation among constructs and the ability to determine deviations in a certain period of time. Therefore, upcoming study needs to use longitudinal designs that offer an extra dynamic understanding of how these factors evolve and influence adoption decisions. The study faced challenges related to the sample size, particularly in the context of conducting multi-level analyses to discern nuanced differences among various types of toilet users. The limited sample size for each specific toilet user category, such as pit toilets with cement floors, pit toilets with mud floors, flash toilets, and ecosan toilets, may have contributed to the non-significant findings for certain constructs when analyzed separately. The statistical power to detect significant effects may have been compromised, potentially obscuring meaningful relationships that could exist within each user group. Future research endeavors should consider larger sample sizes for each user category to enhance the robustness and reliability of the analyses conducted at the individual toilet user level.

Another notable drawback of this research is associated with the predominant application of a quantitative approach in data collection. While quantitative methods provide valuable statistical insights into the relationships between variables, the significant reliance on surveys and structured questionnaires might limit the depth and holistic understanding of the factors influencing ecosan toilet adoption. The limited application of qualitative approaches, such as key informant interviews and focus group discussions, could result in overlooking nuanced perspectives, unexplored motivations, and contextual intricacies that might be better captured through qualitative inquiry. The richness of qualitative data, including personal narratives and in-depth responses, could have provided a more comprehensive view of participants' attitudes, perceptions, and experiences related to ecosan toilets. Future research endeavors in this domain should consider incorporating a mixed-methods approach to benefit from the strengths of both quantitative and qualitative data, thereby enriching the overall understanding of the complexities surrounding ecosan toilet adoption in Arba Minch City, Ethiopia.

One crucial avenue for further investigation involves adopting a mixed-methods research design. By integrating qualitative approaches such as interviews, focus group discussions, or case studies with quantitative surveys, researchers can gain a more nuanced and broader knowledge of the factors affecting ecosan toilet acceptance. Qualitative methods would permit for detail examination of participants' attitudes, perceptions, and experiences, capturing the cultural and contextual nuances that might be overlooked in a dominant quantitative analysis. This integration could offer a more complete view of the challenges and facilitators of ecosan toilet adoption, contributing valuable insights for policymakers, practitioners, and researchers. Additionally, future studies could explore the dynamic nature of these factors over time, employing longitudinal designs to track changes in attitudes and intentions toward ecosan toilets. Such longitudinal investigations would offer insights into the temporal aspects of adoption, helping identify patterns and trends that may inform more effective intervention strategies. Finally, research endeavors could extend their scope beyond individual households to encompass community-level dynamics, considering how social networks, community norms, and collective decision-making procedures influence the acceptance of ecological based sanitation methods. Addressing these ways in upcoming study would result in a more robust and comprehensive understanding of ecosan toilet adoption, facilitating the development of targeted and culturally sensitive interventions in Arba Minch City, Ethiopia, and similar contexts.

6 Conclusion

In conclusion, this study delves into the behavioral intentions of individuals in Arba Minch City, Ethiopia, concerning the use of ecological sanitation toilets, employing a combined model of the theory of planned behavior (TPB) and diffusion of innovation (DOI). The combined models of DOI and TPB deliver a robust understanding of complex reasons affecting toilet users' intentions in this specific situation, contributing significantly to the limited research combining TPB and DOI in the adoption of ecosan toilets. The pivotal findings underscore the paramount impact of attitude and perceived behavioral control on users' intentions regarding ecosan toilet adoption. The alignment of positive attitudes with

genuine intentions aligns seamlessly with TPB's foundational principles. Additionally, the significance of perceived behavioral control emphasizes the critical role of users' perceived ease or difficulty in adopting ecosan toilets. These insights accentuate the importance of tailoring interventions to enhance positive attitudes and instill a sense of control among users, thereby fostering a conducive condition towards ecological sanitation system.

The study's exploration of broader contextual factors, including compatibility, relative advantage, and trayability, unveils intriguing deviations from conventional patterns, emphasizing the contextual intricacies in technology adoption processes. The nuanced understanding of these factors, their interplay, and their influence on users' intentions provide valuable insights for crafting targeted and context-specific interventions. Recognizing the diverse attributes shaping users' perceptions is essential for the incorporation of applicable program aimed at promoting ecosan toilet adoption in Arba Minch City and other cities and towns in Ethiopia. Furthermore, the in-depth analysis of attitude as a moderator between DOI constructs and behavioral intention enriches our comprehension of the adoption process. The varied mediation effects observed for constructs such as complexity, compatibility, trialability, and observability underscore the need for tailored strategies. Understanding the nuanced interplay between individual attitudes and DOI constructs is imperative for designing interventions that effectively address specific attributes influencing users' perceptions and behaviors.

The multi-group analysis conducted among various toilet users adds an additional layer of depth, emphasizing the importance of considering diverse perspectives. Different toilet user categories manifest varied relationships between DOI constructs, attitudes, and intentions, underscoring the necessity for tailored approaches for distinct user groups. The output of the study can be an input for the growing body of knowledge on ecosan toilet adoption, providing insights that can inform policy and intervention strategies for promoting sustainable sanitation practices in Arba Minch City and related circumstances. The findings hold relevance not only for academia but also for practitioners, policymakers, and development organizations aiming to enhance sanitation infrastructure and practices in urban areas. In essence, this study extends beyond a conventional exploration of factors influencing ecosan toilet adoption by integrating theoretical frameworks, conducting in-depth analyses, and considering diverse user perspectives. The comprehensive insights generated contribute in addition to the theoretical discourse it also provides practical effects for policymakers, practitioners, and development organizations working towards sustainable sanitation practices in urban areas. As urbanization and sanitation challenges persist, the finding of the research serve as a valuable resource for informed decision-making and strategic interventions, ultimately contributing to broader sustainable development objectives.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

AE: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. KY: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing.

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